International Conference on Active Learning in Engineering Education

"Striving Engineering Education Towards Student Competence Development"

26 - 28 August 2020

Asian Institute of Technology, Pathumthani, Thailand

PAEE/ALE'2020 Proceedings

paee

PROJECT APPROACHES IN ENGINEERING EDUCATION

ALE

TITLE

International Symposium on Project Approaches in Engineering Education
Volume 10 (2020) ISSN 2183-1378

Proceedings of the PAEE/ALE’2020, International Conference on Active Learning in Engineering Education
12th International Symposium on Project Approaches in Engineering Education (PAEE)
17th Active Learning in Engineering Education Workshop (ALE)
Asian Institute of Technology (AIT), Bangkok - Thailand, 26 -28 August 2020

EDITORS

Rui M. Lima, Valquíria Villas-Boas, Pisut Koomsap, Kanchana Sethanan

PUBLISHER

Department of Production and Systems – PAEE association

School of Engineering of University of Minho, Campus de Azurém, 4800-058 Guimarães, Portugal

GRAPHIC DESIGN

AIT – Local Organizing Committee

ISSN

2183-1378

PAEE/ALE’2020, International Conference on Active Learning in Engineering Education, 12th International Symposium on Project Approaches in Engineering Education (PAEE) and 17th Active Learning in Engineering Education Workshop (ALE), was organized by AIT, in collaboration with PAEE – Project Approaches in Engineering Education Association and Active Learning in Engineering Education Network (ALE).

PROJECT APPROACHES IN ENGINEERING EDUCATION

http://paee.dps.uminho.pt/

This is a digital edition.

WELCOME TO PAEE/ALE’2020

Dear Participants,

Welcome to the International Conference on Active Learning in Engineering Education (PAEE/ALE’2020). This is the fifth collaboration of the International Symposium on Project Approaches in Engineering Education (PAEE) and Active Learning in Engineering Education Workshop (ALE), and is the first time in Asia. The theme for the conference is Striving Engineering Education Towards Student Competence Development.

As we are experiencing, technological advancement has created a new landscape for how business functions. All industry sectors at all sizes have been forced to adjust to remain competitive in the circumstance, and this change is reshaping job functions prompting companies to revisit their human capacity building to ensure appropriateness to support the business functions. More importantly, the unprecedented COVID-19 pandemic has expedited the change at a pace that we cannot imagine. Several companies that have not been able to adjust or have resisted this change start disappearing from the picture.

This chain effect ripples back to all academic institutes. As a key supplier, it is inevitable for the academic institutes to adjust how they train their graduates to match the need for a human resource with competence. The conventional lecture style will not be sufficient to build graduate competence. The change urges the academic institutes to not only keep their curricula up-to-date but also equip their instructors with various teaching and learning methods.

As aforementioned, we are in a challenging period. Many other similar events have been disrupted by the COVID 19 pandemic. They have been postponed or canceled. But our community has shown a strong determination all along to make this event possible. The organizing committee has not only introduced a hybrid format for the conference to alleviate hurdles caused by the travel restriction but has also tried to create a good conference atmosphere for the participants to enjoy. Our participants, in return, show a passion and a strong commitment to keeping engineering education up with the change.

We want to express our sincere gratitude to our participants for their strong support. Despite the pandemic, a reasonable number of academic people from different parts of the world have submitted papers and registered for PAEE/ALE' 2020 for both onsite and online participation to exchange their knowledge and ideas on Engineering Education. Furthermore, prominent keynote speakers have accepted to share their visions on education to inspire and to expand the horizon of our participants. Contributions in all aspects from all parties make this PAEE/ALE' 2020 successful. Together we can make our education stronger.

Pisut Koomsap

(Chair of the PAEE/ALE’2020)

PAEE/ALE'2020 Organization

PAEE/ALE'2020 CHAIRS

Honorary Chairs
Eden Y Woon, Asian Institute of Technology, Pathumthani, Thailand

Erik de Graaff, Aalborg University, Denmark

Conference Chair
Pisut Koomsap, Asian Institute of Technology, Pathumthani, Thailand

Program Chairs
Kanchana Sethanan, Khon Kaen University, Thailand

Valquíria Villas-Boas, Universidade de Caxias do Sul, Brazil

Scientific Committee Chairs
Rui M Lima, University of Minho, Guimarães, Portugal

Huynh T Luong, Asian Institute of Technology, Pathumthani, Thailand

Student Session Chairs
Diana Mesquita, University of Minho, Portugal

Jens Myrup Petersen, Aalborg University, Denmark

PAEE/ALE'2020 ORGANISING COMMITTEE

Local Organizing Committee
Apiwat Mutamara, Thammasat University, Thailand

Duangthida Hussadintorn Na Ayutthaya, Asian Institute of Technology, Thailand

Huynh T Luong, Asian Institute of Technology, Thailand

Kanchana Sethanan, Khon Kaen University, Thailand

Pisut Koomsap, Asian Institute of Technology, Thailand

Supapan Chaiprapat, Prince of Songkla University, Thailand

Uttapol Smutkupt, Chiang Mai University

PAEE Organizing Committee
Rui M. Lima, Department of Production and Systems, Algoritmi Center - Engineering School, University of Minho, Guimarães, Portugal

Anabela Alves, Dep. of Production and Systems, Algoritmi Center - Engineering School, University of Minho, Guimarães, Portugal

Diana Mesquita, Institute of Education / Dep. Production Systems - University of Minho, Braga, Portugal

Dinis Carvalho, Dep. of Production and Systems, Algoritmi Center - Engineering School, University of Minho, Guimarães, Portugal

Nélson Costa, Dep. of Production and Systems, Algoritmi Center - Engineering School, University of Minho, Guimarães, Portugal

Rui M. Sousa, Dep. of Production and Systems, Algoritmi Center - Engineering School, University of Minho, Guimarães, Portugal

Sandra Fernandes, Department of Psychology and Education, Portucalense University, Porto, Portugal

ALE Organizing Committee

Valquíria Villas-Boas, Universidade de Caxias do Sul, Brazil (Chair)

Elisabeth Saalman, Engineering Education Research, Chalmers University of Technology, SWEDEN

Erik de Graaff, Department of Development and Planning, Aalborg University, DENMARK

Jennifer De Boer, Purdue University, USA

Jens Myrup Petersen, Aalborg University, Denmark

Lamjed Bettaieb, Deputy General Manager, ESPRIT School of Engineering, Tunisia

Marietjie Havenga, School for Mathematics, Science and Technology Education, North-West University, South Africa

Mauricio Duque Escobar, Universidad de Los Andes, Columbia

Miguel Romá, Signals, University of Alicante, Spain

Patricio Poblete, Escuela de Ingeniería y Ciencias, Universidad de Chile, Chile

Pisut Koomsap, Asian Institute of Technology, Thailand

Rui M Lima, Universidade do Minho, Portugal

PAEE/ALE'2020 SCIENTIFIC COMMITTEE

Scientific Committee	Affiliation
Aida Guerra	Aalborg Centre for PBL on Engineering Education and Sustainability under the auspices of UNESCO, Aalborg University, Denmark
Ana Margarida Veiga Simão	Faculty of Educational Science, University of Lisbon, Portugal
Ana Teresa Ferreira Oliveira	Technology and Management School, Viana do Castelo Polytechnic Institute, Viana do Castelo, Portugal
Anabela Alves	Department of Production and Systems, Engineering School, University of Minho, Guimarães, Portugal
Anderson Assis	Universidade Federal de Itajubá (UNIFEI) - Campus de Itabira, Itabira, Brazil
André Luiz Aquere	Department of Civil and Environmental Engineering, Faculty of Technology, University of Brasília, Brazil
Apiwat Muttamara	Thammasat University, Thailand
Athakorn Kengpol	King Mongkut's University of Technology North Bangkok, Thailand
Benedita Malheiro	Instituto Superior de Engenharia do Porto
Bernd M. Zunk	Institute of Business Economics and Industrial Sociology, Graz University of Technology, Austria
Celina Pinto Leão	Department of Production and Systems, Engineering School, University of Minho, Guimarães, Portugal
Chin-Yin Huang	Tunghai University, Taiwan
Choon Seng Yap	Republic Polytechnic (RP), Singapore
Crediné Menezes	Universidade Federal do Espírito Santo
Cristiano Jesus	Algoritmi Center, University of Minho, Braga, Portugal
Diana Mesquita	Institute of Education / Dep. Production Systems, University of Minho, Braga, Portugal
Dianne M. Viana	Department of Mechanical Engineering, Faculty of Technology, University of Brasília, Brazil
Erik de Graaff	Department of Development and Planning, Aalborg University, Denmark
Faouzi Kamoun	ESPRIT Ingénieur, Tunisia
Filomena Soares	Department of Industrial Electronics, Engineering School, University of Minho, Guimarães, Portugal
Huynh Trung Luong	Asian Institute of Technology, Thailand
Isabel Loureiro	Department of Production and Systems, Engineering School, University of Minho, Guimarães, Portugal
Jaime Salazar	Executive Secretary of ASIBEI, Departamento de Ingeniería Civil y Agrícola, Universidad Nacional de Colombia, Colombia
Jens Myrup Pedersen	Aalborg University, Dept. of Electronic Systems
João Mello da Silva	Production Engineering, Faculty of Technology, University of Brasília, Brazil
Jonte Bernhard	Linköping University, Sweden
Jorge Muniz Jr.	Universidade Estadual Paulista (UNESP)
José Aquiles Grimoni	Universidade de São Paulo (USP), Brazil
José de Souza Rodrigues	Faculdade de Engenharia de Bauru, Universidade Estadual de São Paulo (UNESP)
José Dinis-Carvalho	Department of Production and Systems, Engineering School, University of Minho, Guimarães, Portugal
José Manuel Oliveira	Higher Education Polytechnic School of Águeda, University of Aveiro, Portugal
José Roberto Cardoso	Universidade de São Paulo (USP), Brazil
Kanchana Sethanan	Khon Kaen University, Thailand
Kaouther Akrout	ESPRIT Ingénieur, Tunisia
Leidy Johanna Rendón Castrillón	Centro de Estudios y de Investigación en Biotecnología (CIBIOT), Universidad Pontificia Bolivariana
Luiz Carlos de Campos	Faculty of Science and Technology, PUC São Paulo, Brazil
Marco Antonio Pereira	Escola de Engenharia de Lorena (EEL), Universidade de São Paulo (USP)
Marcos Ghislandi	Universidade Federal Rural de Pernambuco (UFRPE)
Maria Assunção Flores	Institute of Education, University of Minho, Braga, Portugal
Maria Catalina Ramirez Cajiao	Universidad de los Andes, Colombia
Mariem Chaabouni	ESPRIT Ingénieur, Tunisia
Mauricio Duque	Departamento de Ingeniería Eléctrica, Universidad de los Andes, Colombia
Messias Borges Silva	School of Engineering of Lorena, São Paulo University
Michaël Canu	Universidad de Los Andes
Michael Christie	School of Science, Education & Engineering, University of the Sunshine Coast, Australia
Miguel Romá	University of Alicante, Spain
Miren Itzar Zubizarreta	Engineering School, Mondragon University
Mladen Radisic	Industrial Engineering and Management Department, Faculty of Technical Sciences, University of Novi Sad, Serbia
Natascha van Hattum-Janssen	School of Creative Technology, Saxion University of Applied Sciences, Enschede, the Netherlands
Nelson Costa	Department of Production and Systems, Engineering School, University of Minho, Guimarães, Portugal
Nicolae Ionescu	University Politehnica of Bucharest, Romania
Octavio Mattasoglio Neto	Instituto Mauá de Tecnologia, Escola de Engenharia Mauá - São Caetano do Sul - SP - Brazil
Otilia L. de Oliveira Martins Heinig	Universidade Regional de Blumenau (FURB), Blumenau, Brazil
Patrícia Araújo	IPAM Porto/ Universidade Europeia, Laureate International Universities, Porto, Portugal
Patricio Poblete	Escuela de Ingeniería y Ciencias, Universidad de Chile, Chile
Pisut Koomsap	Asian Institute of Technology, Thailand
Renata Chagas Perrenoud	UNISAL - Lorena, Brazil
Rodrigo Cutri	Instituto Mauá de Tecnologia, Brazil
Ronald Ulseth	Iron Range Engineering, USA
Rosane Aragon	Universidade Federal do Rio Grande do Sul (UFRGS), Brazil
Rui M. Lima	Department of Production and Systems, Engineering School, University of Minho, Guimarães, Portugal
Rui M. Sousa	Department of Production and Systems, Engineering School, University of Minho, Guimarães, Portugal
Salah Bousbia	ESPRIT Ingénieur, Tunisia
Sandra Fernandes	Department of Psychology and Education, Portucalense University, Portugal

Scientific Committee	Affiliation
Simone Borges Simão Monteiro	Department of Production Engineering, Faculty of Technology, University of Brasilia (UnB), Brasília, Brazil
Sonia Gomez Puente	Technical University of Eindhoven, The Netherlands
Stefan Grbenic	Institute of Business Economics and Industrial Sociology, Graz University of Technology, Austria
Stevan Stankovski	Industrial Engineering and Management Department, Faculty of Technical Sciences, University of Novi Sad, Serbia
Thanate Ratanawilai	Prince of Songkla University, Thailand
Tomasz Nitkiewicz	Częstochowa University of Technology, Poland
Valquiria Villas-Boas	Centro de Ciências Exatas e Tecnologia, Universidade de Caxias do Sul, Brazil
Walter Nagai	Universidade Federal de Itajubá (UNIFEI) - Campus de Itabira, Itabira, Brazil
Wichai Chattinnawat	Chiang Mai University, Thailand
Zied Alaya	ESPRIT Ingénieur, Tunisia

PAEE/ALE'2020 Invited Speakers

PAEE/ALE'2020 attracted renowned keynote speakers from different sectors to share their viewpoints on the direction of education, especially in engineering education in this new era. We are honoured to have the following inspiring keynote speakers:

- Hon. Abhisit Vejjajiva (Former Thai Prime Minister)
- David Rosen (Georgia Institute of Technology, USA)
- Sampan Silapanad (Western Digital, Thailand)
- Cynthia Finelli (University of Michigan, USA)

HON. ABHISIT VEJJAJIVA

Former Thai Prime Minister

Title of the keynote - Future, We Hear You: Reforming Education for Lifelong Learning

Short bio

Hon. Abhisit Vejjajiva was Thailand's 27th Prime Minister, holding the post from December 2008 to August 2011. He was first elected to Parliament in 1992 and has been reelected eight times. He had served as Government Spokesperson (1992-1994) and as a Minister Attached to the Prime Minister's Office (1997). Over two and a half decades, he has assumed many responsibilities including Deputy Secretary General to the Prime Minister for Political Affairs; Chairman of the House Committee for Education; and as Leader of the Opposition in the House of Representatives for three terms. Within the Democrat Party, he has also assumed many positions: Party Spokesman, Deputy Party Leader; and from 2005-2019, Party Leader. He also served as Chairman of the Council of Asian Liberals and Democrats in 2017-2018. Born in Newcastle-upon-Tyne in the United Kingdom in 1964, after completing his primary education in Thailand, he returned to the United Kingdom to study at Eton College. He later graduated with a Bachelor's Degree in Philosophy, Politics, and Economics (PPE) with 1st class Honours from Oxford University, where he also earned a Master's Degree in Economics. Before entering politics he taught at the Chulachomklao Royal Military Academy from 1987 to 1988 and at the Faculty of Economics, Thammasat University from 1990 to 1991.

DAVID ROSEN

Georgia Institute of Technology, USA

Title of the keynote - Active Transdisciplinary Engineering Education for Competence Development in An Intelligent Manufacturing Era

Short bio

David Rosen is a Professor in the School of Mechanical Engineering at the Georgia Institute of Technology. He is Director of the Rapid Prototyping & Manufacturing Institute at Georgia Tech. Additionally, he is the Research Director of the Digital Manufacturing & Design Centre at the Singapore University of Technology & Design. He received his Ph.D. at the University of Massachusetts in mechanical engineering. His research interests include computer-aided design, additive manufacturing (AM), and design methodology. Most of his research is focused on design for additive manufacturing, including conceptual design methods, lattice structure design, and topology optimization methods. He has industry experience, working as a software engineer at Computervision Corp. and a Visiting Research Scientist at Ford Research Laboratories. He is a Fellow of ASME and has served on the ASME Computers and Information in Engineering Division Executive Committee. He chairs the ASTM F42 subcommittee on design for additive manufacturing. He is the recipient of the 2013 Solid Freeform Fabrication Symposium, International Freeform and Additive Manufacturing Excellence (FAME) Award and is a co-author of a leading textbook on AM.

SAMPAN SILAPANAD

Western Digital, Thailand

Title of the keynote - Be Comfortable in Uncomfortable Zone: Workforce 4.0 will never be the same

Short bio

Sampan Silapanad is Vice President and General Manager of Western Digital, the worldwide leader in Digital Data Storage Device manufacturing. Western Digital had revenues of US$ 19 billion for the fiscal year ending June 2017 and employs more than 70,000 employees worldwide. Sampan graduated with a Bachelor degree in Mechanical Engineering from Kasetsart University, Thailand, a Master degree in Management from Sasin Graduate Institute of Business Administration of Chulalongkorn University, Thailand, and was bestowed an Honorary Doctorate degree in Industrial Engineering by Suranaree University of Technology, Thailand.

Sampan has more than 35 years of experience in executive positions of large firms, mainly in Electronics and Digital Storage industry, including National Semiconductor, Seagate Technology, Hitachi Global Storage Technology, and Western Digital Corporation. Besides, he has a special and keen interest in improvement of Thailand's education and has been working with many governments and international organizations and educational institutions both in Thailand and all over the world on many impactful programs, such as Cooperative Education and Talent Mobility, for the manpower development for Thailand and other countries.

CYNTHIA FINELLI

University of Michigan, USA

Title of the keynote - In Pursuit of Active Learning: Challenges, Insights, and Opportunities

Short bio

Dr. Cynthia Finelli is Professor of Electrical Engineering and Computer Science, Professor of Education, and Director of Engineering Education Research at University of Michigan. In her research she focuses on increasing faculty adoption of evidence-based instruction. Dr. Finelli is a Fellow of the American Society of Engineering Education, Deputy Editor for the Journal of Engineering Education, Associate Editor for the IEEE Transactions on Education, and member of the Governing Board of the Research in Engineering Education Network. She founded the Center for Research on Learning and Teaching in Engineering at University of Michigan in 2003 and served as its Director for 12 years. Dr. Finelli earned the B.S.E., M.S.E., and Ph.D. degrees in Electrical Engineering from University of Michigan.

PAEE/ALE’2020 Programme

Lisbon (GMT +1)	Brasília (GMT -3)	26/ago/20 AIT Center		27/ago/20 AIT Center		28/ago/20 Pinehurst Golf Club & Hotel	
				Learning Future Factory Laboratory Visit		Workshop on LEF-CDD: The Art of Teaching I	
		Lunch		Lunch		Lunch	
7.00 am - 8.30 am		MSIE 4.0 Curriculum Development		P3-1: Research on PBL and Active Learning I		Workshop on LEF-CDD: The Art of Teaching II	
8.30 am - 9.00 am		Coffee Break		Coffee Break		Coffee Break	
9.00 am - 10.30 am	5.00 am - 6.30 am	P1-1: Innovative Experiences in Engineering Education I	P1-2: Interdisciplinarity	P4-1: Student Engagement in Learning	P4-2: Curriculum Design	P6-1: Education for Sustainability I	P6-2: Student Session I
10.30 am - 10.45 am	6.30 am - 6.45 am	Break		Break		Break	
10.45 am - 12.15 pm	6.45 am - 8.15 am	Workshop 1-1: Agile Project Management: An Online Scrum Workshop	Workshop 1-2: Creating Value for Society by Providing Lean Competencies	Workshop 2-1: Application of Two Modules of a Digital Platform for PBL Support & Automation	Workshop 2-2: Learning Outcomes and the Revised Bloom's Taxonomy	P7-1: Education for Sustainability II	P7-2: Student Session II
12.15 pm - 12.30 pm	8.15am - 8.30 am	Dinner		Dinner		Break	
12.30 pm - 1.15 pm	8.30 am - 9.15 am					Cultural Session and Closing Remark	
1.15 pm - 1.30 pm	9.15 am - 9.30 am	Welcome Remark					
1.30 pm - 2.30 pm	9.30 am - 10.30 am	Keynote 1: Hon. Abhisit Vejjajiva		Keynote 3: Dr. Sampan Silapanad		Gala Dinner	
2.30 pm - 3.30 pm	10.30 am - 11.30 am	Keynote2: Prof. David W. Rosen		Keynote 4: Prof. Cynthia J. Finelli			
3.30 pm - 4.00 pm	11.30 am - 12.00 pm	Break		Break			
4.00 pm - 5.50 pm	12.00 pm - 1.50 pm	P2-1: Innovative Experiences in Engineering Education II	P2-2: Active Learning and ICT Support	P5-1: Research on PBL and Active Learning II	P5-2: Student Assessment in PBL and Active Learning		

Hybrid Activities | Online Activities

PAEE/ALE'2020 Paper Sessions, Hands-On Sessions and Students Sessions

DAY 1

Bangkok (GMT +7)	Lisbon (GMT +1)	Brasilia (GMT -3)	26/ago/20 AIT Center	
10.00 am -11.30 am				
11.30 am -1.00 pm			Lunch	
1.00 pm - 2.30 pm	7.00 am - 8.30 am		**MSIE 4.0 Curriculum Development**	
2.30 pm - 3.00 pm	8.30 am - 9.00 am		Coffee Break	
3.00 pm - 4.30 pm	9.00 am - 10.30 am	5.00 am - 6.30 am	**P1-1: Innovative Experiences in Engineering Education I** **Session Chair: Prof. Huynh Trung Luong** Experience with the Accreditation of Technical Studies in Poland and Thailand's (ID 23) Developing Lean Competencies Through Serious Games (ID 29) A Service Leaning Experience with Engineering Students (37) Adapting Problem Based Learning for Human-Centric Design Course (ID 60) Success Factor of Activity-Based Learning Experiences for I4.0 SMART OPERATION Course Design and Implementation (ID 85)	**P1-2: Interdisciplinarity** **Session Chair: Prof. Rui M. Sousa** Interdisciplinary Contents Integration and Key Competences Developed in a Project Work of Industrial Engineering and Management Third Year (ID 4) Design of a New Workstation in a Productive Process: Importance of Multidisciplinary Integration (ID 12) Global PBL: Cross-Cultural Educational Project for Engineering Students (ID 55) Students Feedback on the Forced Transition to Online Classroom During Covid-19 (ID 63) International Student Projects and Sustainable Development Goals: A Perfect Match (ID 70)
4.30 pm - 4.45 pm	10.30 am - 10.45 am	6.30 am - 6.45 am	Break	
4.45 pm - 6.15 pm	10.45 am - 12.15 pm	6.45 am - 8.15 am	**Workshop 1-1: Agile Project Management: An Online Scrum Workshop**	**Workshop 1-2: Creating Value for Society by Providing Lean Competencies**
6.15 pm - 7.15 pm	12.15 pm - 1.15 pm	8.15am - 9.15 am	Dinner	
7.15 pm - 7.30 pm	1.15 pm - 1.30 pm	9.15 am - 9.30 am	**Welcome Remark** **Dr. Eden Y. Woon** **President, Asian Institute of Technology**	
7.30 pm - 8.30 pm	1.30 pm - 2.30 pm	9.30 am - 10.30 am	**Keynote 1: Future, We Hear You: Reforming Education for Lifelong Learning** **Hon. Abhisit Vejjajiva,** **Former Thai Prime Minister** **Session Chair: Prof. Kanchana Sethanan**	
8.30 pm - 9.30 pm	2.30 pm - 3.30 pm	10.30 am - 11.30 am	**Keynote2: Active Transdisciplinary Engineering Education for Competence Development in An Intelligent Manufacturing Era** **Prof. David W. Rosen** **Georgia Institute of Technology, USA** **Session Chair: Dr. Pisut Koomsap**	
9.30 pm - 10.00 pm	3.30 pm - 4.00 pm	11.30 am - 12.00 pm	Break	
10.00 pm - 11.50 pm	4.00 pm - 5.50 pm	12.00 pm - 1.50 pm	**P2-1: Innovative Experiences in Engineering Education II** **Session Chair: Prof. Valquíria Villas-Boas** 360º Educational Robotics Project Management with High Abilities and Gifted Students (ID 15) Application of Educational Games in Professional Training and Its Influence on Productivity in the Sugar-Energy Sector: A Case Study (ID 17) University-Business Cooperation on SMEs: An Intervention Program on Creativity, Critical Thinking and Trust (ID 50) The Role of Partnership in Launching PBL Approach in Cooperation with Network of Social Enterprises – Research Case of Częstochowa University of Technology (ID 51) Curricular and Pedagogic Innovation in a Social Education Programme: Findings From the Implementation of PBL (ID 64) Structuring a Course Based on the Global Engineer (ID 65)	**P2-2: Active Learning and ICT Support** **Session Chair: Prof. Marietjie Havenga** Design and Development of Automated Guided Vehicles for Active Learning in Material Handling Management for Smart Manufacturing Operation (ID 19) Double Degree M.Sc Program on Industrial Safety Engineering with Aerospace Application: A Case Study (ID 36) Peer-Assessment for Holistic Student Development (PAHSD): Implementing a Digital Application on a PBL Platform (ID 43) Team Building through Student's Preferences and Competences (TBSPC): implementation on a PBL platform (ID 44) COVID-19: Transition to Online Problem-based Learning in Robotics – Challenges, Opportunities and Insights (ID 58) The Use of Games as A Support Tool for Active Learning in The Context Of 4.0 Industry (ID 74)

Onsite Activities	Hybrid Activities	Online Activities

DAY 2

Bangkok (GMT +7)	Lisbon (GMT +1)	Brasília (GMT -3)	27/ago/20 AIT Center	
10.00 am -11.30 am			**Learning Future Factory Laboratory Visit**	
11.30 am -1.00 pm			Lunch	
1.00 pm - 2.30 pm	7.00 am - 8.30 am		**P3-1: Research on PBL and Active Learning I** **Session Chair: Prof. Athakorn Kengpol** Bringing PBL to Philippines's Higher Education: How Much Are Teachers Geared for the Transition from Traditional to PBL Approach? (ID 13) Problem-based learning (PBL) Implemented in Manufacturing Processes (ID 27) Collaborative Manufacturing Systems: Active Learning from Its Name (ID 35) Implementing Problem-Based Learning Model for Elevator Spare Part Procurement Planning in a Group of Airport Buildings (ID 61) Community Learning and Engagement of OTOP Product Design (ID84)	
2.30 pm - 3.00 pm	8.30 am - 9.00 am		Coffee Break	
3.00 pm - 4.30 pm	9.00 am - 10.30 am	5.00 am - 6.30 am	**P4-1: Student Engagement in Learning** **Session Chair: Prof. Anabela C. Alves** Make Product Design and Development Beyond Active Learning with 'LOVE' (ID 8) Students' Participation in the Internal Quality Assurance System and Their Role in Enhancing Learning (ID 9) Analyzing Online Learning Behavior and Effectiveness of Blended Learning Using Students' Accessing Timeline (ID10) NPS Better Predict Online Classroom (ID 54) Experiential Learning Through Students Non-Profit Organizations: ESTIEM Case Study (ID 83)	**P4-2: Curriculum Design** **Session Chair: Prof. Tomasz Nitkiewicz** Building a Needs-Based Curriculum in Data Science and Artificial Intelligence: Case Studies in Indonesia, Sri Lanka, and Thailand (ID 14) Design, Implementation, and Improvement of the Course for Master's Degree Program in Industry 4.0: A Case Study in Digital Factory Subject (ID 20) LOVE Model-Based Assessment of Teaching Practices Within Industrial Engineering Master Programs in Poland and Thailand (ID 25) An OBE Curriculum Design for a Manufacturing Engineering Program, from Thai Traditional to Outcome Based Education (ID 52) A Gap Analysis Between the Expectation of Industry 4.0 and the Ability of the Current Industrial Engineering Graduates in Khon Kaen University (ID 81)
4.30 pm - 4.45 pm	10.30 am - 10.45 am	6.30 am - 6.45 am	Break	
4.45 pm - 6.15 pm	10.45 am - 12.15 pm	6.45 am - 8.15 am	**Workshop 2-1: Application of Two Modules of a Digital Platform for PBL Support & Automation**	**Workshop 2-2: Learning Outcomes and the Revised Bloom's Taxonomy**
6.15 pm - 7.30 pm	12.15 pm - 1.30 pm	8.15 am - 9.30 am	Dinner	
7.30 pm - 8.30 pm	1.30 pm - 2.30 pm	9.30 am - 10.30 am	**Keynote 3: Be Comfortable in Uncomfortable Zone: Workforce 4.0 Will Never Be the Same** **Dr. Sampan Silapanad** **Western Digital (Thailand) Company Limited** **Session Chair: Prof. Kanchana Sethanan**	
8.30 pm - 9.30 pm	2.30 pm - 3.30 pm	10.30 am - 11.30 am	**Keynote 4: In Pursuit of Active Learning: Challenges, Insights, and Opportunities** **Prof. Cynthia J. Finelli** **University of Michigan, USA** **Session Chair: Prof. Valquíria Villas-Boas**	
9.30 pm - 10.00 pm	3.30 pm - 4.00 pm	11.30 am - 12.00 pm	Break	
10.00 pm - 11.50 pm	4.00 pm - 5.50 pm	12.00 pm - 1.50 pm	**P5-1: Research on PBL and Active Learning II** **Session Chair: Prof. José Dinis-Carvalho** Learning Experiences from Digital Factory Subject and Communications and People Skills Development for Engineering Leaders Subject (ID 40) Helping Students to Avoid Critical Mistakes/Misunderstands When Using Active Learning/Project-Based Learning Approaches in Teaching Statistical Analysis (ID 7) Do Student Initial Expectations About PBL Match Their Final Perceptions? (ID 5) Science Clubs and Scientific and Technological Fairs: Encouraging Girls in Exact Sciences, Engineering and Information Technology (ID 59) Development of Transversal Skills in an Extracurricular Academic Research Project Through Active Learning in Healthcare - A Case Study (ID 76)	**P5-2: Student Assessment in PBL and Active Learning** **Session Chair: Prof. Joao Mello da Silva** The Impact of the Self- Assessment and Peer-Assessment on an Integrated Project (ID 3) Evaluation of Projects Carried Out in Companies by Second-Year Engineering Students (ID 11) Evaluation of a Pilot Course of Project Management for Industry 4.0 (ID 45) Class Dissatisfaction and Intelligibility of PBL (ID 66) Evaluation Process in the Application of Case Teaching Method in Management Education: A Study in the Perception of Professors from Brazilian Universities (ID 68) Assessment of Student Performance in the Context of Active Learning (ID 75)

Onsite Activities | Hybrid Activities | Online Activities

Day 3

Bangkok (GMT +7)	Lisbon (GMT +1)	Brasília (GMT -3)	28/ago/20 Pinehurst Golf Club & Hotel	
10.00 am - 11.30 am			**Workshop on LEF-CDD: The Art of Teaching I**	
11.30 am - 1.00 pm			Lunch	
1.00 pm - 2.30 pm	7.00 am - 8.30 am		**Workshop on LEF-CDD: The Art of Teaching II**	
2.30 pm - 3.00 pm	8.30 am - 9.00 am		Coffee Break	
3.00 pm - 4.30 pm	9.00 am - 10.30 am	5.00 am - 6.30 am	**P6-1: Education for Sustainability I** **Session Chair: Prof. Thanate Ratanawilai** A Survey of Requirements for Thailand's Industry 4.0: The Perspectives from Academics and Entrepreneurs (ID 21) Standards of Developing Study Program. An Example of Polish legislation in Higher Education (ID 24) International Dual-Degree Programs: Learning Experience in Student's Perspective (ID 32) How to Create Sustainable Future Through Curriculum in Higher Education (ID 33) COVID 19 and Academia Community Cooperation: Skills Development Fostering Diversity, Inclusion and Equal Opportunities (ID 57)	**P6-2: Student Session I** **Session Chair: Prof. Jens Myrup Pedersen** Awareness and Expectation of Industrial Engineering Students on Competences Required Toward Industrial Revolution 4.0 (ID 62) Fully 3D Printed Spring Powered Car: A Project-Based Learning Experience (ID 42) Development of Automated Guided Vehicles for a Smart Factory: A Project-Based Learning Experience (ID 56) A Student Perspective on the Blended Learning Experience in a Project Based Context (ID 22)
4.30 pm - 4.45 pm	10.30 am - 10.45 am	6.30 am - 6.45 am	Break	
4.45 pm - 6.15 pm	10.45 am - 12.15 pm	6.45 am - 8.15 am	**P7-1: Education for Sustainability II** **Session Chair: Prof. Chutiporn Anutariya** Ethics in Engineering - Involving Students and Assessing Institutions (ID 2) "EXTEND" to the "NEXT LEVEL" (ID 86) PBL Student Projects and Sustainable Development Goals: A Case Study (ID 67) Lessons Learned from the Dissemination, Exploitation and Sustainability of the Curriculum Development of Master's Degree Program in Industrial Engineering for Thailand Sustainable Smart Industry (MSIE4.0) (ID 82) A-Cube Way for Research Learning Experience: View of Students (ID 31)	**P7-2: Student Session II** **Session Chair: Dr. Diana Mesquita** Application of Scrum and PM Canvas in a Project-based Learning Approach (ID 47) Communication Tools Used by Distributed Teams in a BIM Learning Project (ID 72) An Overview of Assessment of Competences Based on Publications in Journals (ID 18) Active Learning Workshops Production: Impacts and Benefits for Engineering Students (ID 34)
6.15 pm - 6.30 pm	12.15 pm - 12.30 pm	8.15 am - 8.30 am	Break	
6.30 pm - 7.30 pm	12.30 pm - 1.30 pm	8.30 am - 9.30 am	**Cultural Session and Closing Remark**	
7.30 pm - 10.30 pm			**Gala Dinner** **sponsored by Faculty of Engineering, Khon Kaen University**	

Onsite Activities | Hybrid Activities | Online Activities

List of Authors

Author	Affiliation	Country	#
Adem Ben Zarb	Esprit School of Engineering	Tunisia	43
			88
Afrânio Araujo	Universidade Federal do Rio Grande do Norte	Brazil	68
Amalka Pinidiyaarachchi	University of Peradeniya	Sri Lanka	14
Amine Ayari	Esprit School of Engineering	Tunisia	44
			88
Ana Bouças	Technology and Management School, Viana do Castelo Polytechnic Institute	Portugal	50
Ana Carla B. Reis	University of Brasilia	Brazil	74
			76
Ana Carla Bittencourt Reis	University of Brasilia	Brazil	75
Ana Clara A. Miranda	University of Brasilia	Brazil	76
Ana Cristina Fernandes Lima	Universidade de Brasilia - UNB	Brazil	43
	Universidade de Brasília - UNB	Brazil	88
Ana Pedrosa	University of Minho	Portugal	12
Ana Rita Alves	Psychology School, University of Minho	Portugal	50
Ana Sílvia Albuquerque	Portucalense University	Portugal	64
Ana Sofia Rodrigues	CISAS, Escola Superior Agrária, Instituto Politécnico de Viana do Castelo,	Portugal	57
Ana T. Ferreira-Oliveira	CISAS, Escola de Tecnologia e Gestão, Instituto Politécnico de Viana do Castelo	Portugal	57
	CISAS, Technology and Management School, Viana do Castelo Polytechnic Institute	Portugal	50
Anabela C. Alves	ALGORITMI Centre, Department of Production and Systems, School of Engineering, University of Minho, Guimarães, Portugal	Portugal	4
			5
			29
			53
			55
			83
Anak Khantachawana	King Mongkut's University of Technology Thonburi	Thailand	55
Anatoliy Aleksandrov	Bauman Moscow State Technical University	Russia	36
Anderson Morais	Federal University of Itaiubá	Brazil	47
André Aquere	University of Brasilia	Brazil	47
André Luiz Aquere	Universidade de Brasília	Brazil	45
			72
Aneta Pachura	Częstochowa University of Technology	Poland	51
Anintaya Khamkanya	Thammasat University	Thailand	62
			63
Anirut Chaijaruwanich	Chiang Mai University	Thailand	85
Anna Lyza Felipe	RMIT University	Viet Nam	13
Anna Wiśniewska-Sałek	Czestochowa University of Technology	Poland	24
Anton Rzhvskyi	University of Minho	Slovakia	72
Apiwat Muttamara	Thammasat University	Thailand	27
			54
Ari Melo Mariano	Universidade de Brasília - UNB	Brazil	44
			88
Armin Aragoncillo	The Future University	Sudan	13
Arthur R. Costa	University of Brasília - UnB	Brazil	34
Athakorn Kengpol	King Mongkut's University of Technology North Bangkok, Bangkok	Thailand	20
			21
			40
B. Naduni Hansika Abeywardena	Asian Institute of Technology	Thailand	31
Beatriz Cabral	Universidade Federal do Rio Grande do Norte	Brazil	68
Boonlum Soontorn	Phranakhon si Ayutthaya Rajabhat University, Ayutthaya	Thailand	54
Brenda B. Gewehr	University of Brasilia	Brazil	74
			76
Camila M. A. da Silva	University of Brasilia	Brazil	74
Carina Pimentel	Universidade de Aveiro	Portugal	83
Carla M. C. C. Koike	University of Brasília - UnB	Brazil	15
			34
Celina Pinto Leão	University of Minho	Portugal	5
Chatura Lavanga Mendis	Asian Institute of Technology	Thailand	31
Chawantorn Chanchittakarn	King Mongkut's University of Technology North Bangkok	Thailand	40
Chayanid Sutthasri	Thammasat University	Thailand	62
Chih-Fan Tan	Tunghai University	Taiwan	31
			32

Author	Affiliation	Country	#
Chin-Yin Huang	Tunghai University	Taiwan	32
Chitraka Wickramarachchi	University of Sri Jayewardenepura	Sri Lanka	14
Chitsutha Soomlek	Khon Kaen University	Thailand	14
Christian Hundborg Liboriussen	Aalborg University, Department of Electronic Systems	Denmark	67
Chukree Daesa	Department of Industrial Engineering, Prince of Songkla University	Thailand	52
Chutiporn Anutariya	Asian Institute of Technology	Thailand	10
			14
Costa Ferreira	University of Minho	Portugal	47
Cristiano Jesus	University of Minho	Portugal	45
Cristiano Reis	University of São Paulo	Brazil	11
Dai Watanabe	Shibaura Institute of Technology	Japan	55
Débora Yoshioka	University of São Paulo	Brazil	11
Diana Mesquita	University of Minho	Portugal	38
			45
			73
Dianne M. Viana	University of Brasília - UnB	Brazil	34
Dianne Magalhães Viana	Universidade de Brasilia - UNB	Brazil	43
	Universidade de Brasília - UNB	Brazil	88
Dmitryev Silva	Universidade Federal do Rio Grande do Norte	Brazil	68
Doina Irina Simion	University Politehnica of Bucharest (UPB)	Romania	86
Dorota Jelonek	Czestochowa University of Technology	Poland	24
Douiri Maroua	ESPRIT	Tunisia	3
Duangthida Hussadintorn Na Ayutthaya	Asian Institute of Technology	Thailand	8
			25
			31
			35
Duarte Oliveira	University of Porto	Portugal	83
Edgar Sousa	Portucalense University	Portugal	64
Edyta Kulej-Dudek	Czestochowa University of Technology	Poland	24
Ei Ei Lwin	Asian Institute of Technology	Thailand	31
Elena Soldatova	National Research Mordovia State University	Russia	33
Elisabeth Lazarou	University Politehnica of Bucharest (UPB)	Romania	86
Elzbieta Bil	University of Minho	Poland	72
Elżbieta Wysłocka	Czestochowa University of Technology	Poland	24
Emilly M. B. Cornelio	University of Brasília - UnB	Brazil	34
Estevão Barros	UNESP Faculdade de Ciências Agrárias e Veterinárias - Câmpus de Jaboticabal	Brazil	17
Everaldo Silva Júnior	Universidade de Brasilia - UNB	Brazil	43
			44
	Universidade de Brasília - UNB	Brazil	88
Felienne Hermans	Leiden University	Netherlands	14
Fernanda R. Silva	University of Brasília - UnB	Brazil	34
Filipe A. Batista	University of Brasília - UnB	Brazil	34
Filomena Soares	University of Minho	Portugal	4
Frank Takes	Leiden University	Netherlands	14
Gabriela M. E. F Franco	University of Brasilia	Brazil	76
Gabriela Witeck	ALGORITMI Centre, Department of Production and Systems, School of Engineering, University of Minho, Guimarães, Portugal	Brazil	53
		Portugal	29
			72
Helena Navas	Department of Mechanical and Industrial Engineering (DEMI), FCT NOVA, Caparica, Portugal	Portugal	55
Hermenegildo Baptista	University of Minho	Portugal	47
Hiroshi Hasegawa	Shibaura Institute of Technology (SIT), Kōtō-ku, Japan	Japan	55
Huynh Trung Luong	Asian Institute of Technology	Thailand	7
Iheb Zouaghi	Esprit School of Engineering	Tunisia	43
			88
Isolda Gianni de Lima	Universidade de Caxias do Sul	Brazil	59
Jan Frick	University of Stavanger	Norway	70
Jan van Rijn	Leiden University	Netherlands	14
Jens Myrup Pedersen	Aalborg University, Dept. of Electronic Systems	Denmark	67
			70
Jirawan Kloypayan	Faculty of Engineering, Thammasat University, THAILAND	Thailand	60
Jo Besbord	Green Shoots	South Africa	67
João De Sá Brasil Lima	Instituto Mauá de Tecnologia	Brazil	65
Joao Mello da Silva	Universidade de Brasília - UNB	Brazil	43
			44

Author	Affiliation	Country	#
			75
			88
João Monteiro	University of Minho	Portugal	14
Johannes Kruse Hellmers	Aalborg University	Denmark	22
John G Burgoyne	Lancaster University	United Kingdom	68
José Dinis-Carvalho	University of Minho	Portugal	37
José Granja	University of Minho	Portugal	72
José Rodrigues	UNESP Faculdade de Ciências Agrárias e Veterinárias - Câmpus de Jaboticabal	Brazil	17
Kanchana Sethanan	Research Unit on System Modeling for Industry, Khon Kaen University	Thailand	23
			81
			82
Karakade Buakaew	King Mongkut's University of Technology North Bangkok	Thailand	40
Karolina Wiszumirska	Institute of Quality Science, Poznań University of Economics and Business	Poland	25
Katerina Fraidaki	Athens University of Economics and Business	Greece	14
Khaled Ben Hafaiedh	Esprit School of Engineering	Tunisia	43
			44
			88
Komkrit Pitiruek	Khon Kaen University	Thailand	82
Kunlapat Thongkaew	Department of Industrial Engineering, Prince of Songkla University	Thailand	35
Kunlapat Thongkeaw	Department of Industrial Engineering, Prince of Songkla University	Thailand	52
Larissa P. C. Santos	University of Brasília - UnB	Brazil	34
Laurete Zanol Sauer	Universidade de Caxias do Sul	Brazil	59
Liliane Bernardes Carneiro	University of Brasília	Brazil	15
Magdalena Wojnarowska	Institute of Quality Science and Product Management, Cracow University of Economics	Poland	25
Małgorzata Koszewska	Faculty of Management and Production Engineering, Lodz University of Technology	Poland	25
Marcello Bonsangue	Leiden University	Netherlands	14
Marcin Zawada	Czestochowa University of Technology	Poland	24
Marco Pereira	University of São Paulo	Brazil	11
Marcus J.A. Oliveira	University of Brasília - UnB	Brazil	34
Maria Araujo	Universidade Federal do Rio Grande do Norte	Brazil	68
Maria Brito	Universidade Federal do Rio Gramde dp Norte	Brazil	68
Maria Serodio	Universidade do Porto	Portugal	83
Mariane Souza	Universidade do Minho (UMinho)	Brazil	18
Marietjie Havenga	North-West University	South Africa	58
Marite Kirikova	Riga Technical University	Latvia	70
Mark Swartz	Green Shoots	South Africa	67
Marlete Silva	University of Brasília	Brazil	15
Marta Abelha	Portucalense University	Portugal	64
Marta Simões	University of Minho	Portugal	12
Mateus Halbe Torres	Universidade de Brasilia - UNB	Brazil	43
			44
	Universidade de Brasília - UNB	Brazil	88
Matthew Dailey	Asian Institute of Technology	Thailand	14
Max Brito	Universidade Federal do Rio Grande do Norte	Brazil	68
Mejri Nizar	Esprit School of Engineering	Tunisia	44
			88
Mia Eleazar	University of Santo Tomas	Philippines	13
Miguel Azenha	University of Minho	Portugal	72
Miguel Mendes	University of Minho	Portugal	12
Miguel Romá	University of Alicante	Spain	2
Mikhail Ivanov	Bauman Moscow State Technical University	Russia	36
Mikhail Kuznetsov	Bauman Moscow State Technical University	Russia	36
Milena Rodrigues Santos	University of Brasilia	Brazil	75
Minh Xuan Nguyen	Ho Chi Minh City Open University	Viet Nam	13
Mohamed Aziz Ben Rekaya	Esprit School of Engineering	Tunisia	43
			88
Mohamed Boufaied	Esprit School of Engineering	Tunisia	43
			88
Nader Abdellaoui	Esprit School of Engineering	Tunisia	44
			88
Nanthawat Phakkulhab	King Mongkut's University of Technology North Bangkok	Thailand	21
Naris Charoenporn	Faculty of Engineering, Thammasat University, THAILAND	Thailand	60
Nélson Costa	Department of Production and Systems, School of Engineering, University of Minho	Portugal	60
Nitidetch Koohathongsumrit	Ramkhamhaeng University	Thailand	20
			21
Nongnuch Sukvaree	Kasetsart University	Thailand	10
Nugraha Utama	Institut Teknologi Bandung	Indonesia	14

Author	Affiliation	Country	#
Nyan Linn Htet	Asian Institute of Technology	Thailand	42
Octavio Mattasoglio	Instituto Mauá de Tecnologia	Brazil	66
Octavio Mattasoglio Neto	Instituto Mauá de Tecnologia	Brazil	65
Odilon Giovannini	Universidade de Caxias do Sul	Brazil	59
Olga Ivanova	Bauman Moscow State Technical University	Russia	36
Opim Sitompul	Universitas Sumatera Utara	Indonesia	14
Parichat Chuenwatanakul	Thammasat University	Thailand	63
Patittar Nakwong	Phranakhon si Ayutthaya Rajabhat University	Thailand	27
	Pranakhon si Ayutthaya Rajabhat University	Thailand	54
Paulo Celso Reis	Universidade de Brasília	Brazil	44
	Universidade de Brasília - UNB	Brazil	88
Paulo Henrique Mendes Silva	Instituto Mauá de Tecnologia	Brazil	66
Paulo Martins	University of Minho	Portugal	12
Pichet Trakarnsiri	Department of Industrial Engineering, Prince of Songkla University	Thailand	52
Piriya Utamachant	Asian Institute of Technology	Thailand	10
Pisut Koomsap	Asian Institute of Technology	Thailand	8
			19
			25
			32
			35
			42
			56
Rasmi-Vlad Mahmoud	Aalborg University, Dept. of Electronic Systems	Denmark	67
Rebeka Alves	Universidade Federal do Rio Grande do Norte	Brazil	68
Renan Rubam Barberini	Instituto Mauá de Tecnologia	Brazil	66
Robert Nedergaard Nielsen	Aalborg University	Denmark	22
Robert Ulewicz	Czestochowa University of Technology	Poland	82
	Czestochowa University of Tehnology	Poland	23
Roberto Revetria	University of Genoa	Italy	36
Ronaldo R. Pacheco	University of Brasilia	Brazil	76
Ronaldo Rodrigues Pacheco	University of Brasilia	Brazil	75
Rui M. Lima	University of Minho	Portugal	18
			38
			45
			47
			66
			72
Rui Sousa	University of Minho	Portugal	12
Rujapa Nanthapodej	Nakhon Phanom University	Thailand	81
Sandra Fernandes	Portucalense University	Portugal	5
			37
			64
Sandro Pinto	University of Minho	Portugal	14
Sawat Pararach	Thammasat University	Thailand	27
Senhorinha Teixeira	University of Minho	Portugal	9
Shih-Hsuan Wei	Tunghai University	Taiwan	31
			32
Shune Lae Sandar	Asian Institute of Technology	Thailand	42
Simone Borges Simão Monteiro	Universidade de Brasília - UNB	Brazil	43
			44
			88
Siraphat Sukhobol	Asian Institute of Technology	Thailand	42
Sirorat Pattanapairoj	Khon Kaen University	Thailand	81
			82
Sofia Pereira	University of Minho	Portugal	14
Supapan Chaiprapat	Department of Industrial Engineering, Prince of Songkla University	Thailand	52
Suporn Pongnumkul	National Electronics and Computer Technology Center	Thailand	10
Suratsavadee Korkua	Walailak University	Thailand	14
Suriya Jirasatitsin	Department of Industrial Engineering, Prince of Songkla University	Thailand	52
Suzan Verberne	Leiden University	Netherlands	14
Tanutta Klongakara	Thammasat School of Engineering, Thammasat University	Thailand	61
Tatiana Salimova	National Research Mordovia State University	Russia	33
Taufik Abidin	Syiah Kuala University	Indonesia	14
Thanate Ratanawilai	Department of Industrial Engineering, Prince of Songkla University	Thailand	35
Thitipong Jamrus	Khon Kaen University	Thailand	82
	Khon Kaen University	Thailand	81
Tiago Gomes	University of Minho	Portugal	14

Author	Affiliation	Country	#
Tomasz Nitkiewicz	Częstochowa University of Technology	Poland	25
			51
Uttapol Smutkupt	Chiang Mai University	Thailand	85
Valquíria Villas Boas	Universidade de Caxias do Sul	Brazil	59
Valquiria Villas-Boas	University of Caxias do Sul	Brazil	73
Violeta Carvalho	University of Minho	Portugal	9
Vitoria Bento Botelho	Instituto Mauá de Tecnologia	Brazil	65
Vivianne B. N. da Silva	University of Brasilia	Brazil	74
Walter Nagai	Universidade Federal de Itajubá (UNIFEI) - Campus de Itabira	Brazil	38
Wanida Rattanamanee	Department of Industrial Engineering, Prince of Songkla University	Thailand	35
			52
Warapoj Meethom	King Mongkut's University of Technology North Bangkok	Thailand	21
	King Mongkut's University of Technology North Bangkok, Bangkok	Thailand	20
Wararat Songpan	Khon Kaen University	Thailand	14
Wasawat Nakkiew	Chiang Mai University	Thailand	35
Wichai Chattinnawat	Chiang Mai University	Thailand	84
			85
Wuttinan Nunkaew	Thammasat School of Engineering, Thammasat University	Thailand	61
Yannakorn Suebsawat	Thammasat University	Thailand	62
Yasiru Shikshitha Benaragama	Asian Institute of Technology	Thailand	19
			31
			56
Zied Kouki	Esprit School of Engineering	Tunisia	44
			88

PAEE/ALE'2020 Submissions

The PAEE/ALE'2020, International Conference on Active Learning in Engineering Education, joins the International Symposium on Project Approaches in Engineering Education – PAEE, which is being organized by PAEE association, the Department of Production and Systems Engineering of University of Minho, since 2009, and the ALE workshop, which is being organized by the ALE Network, since 2000. PAEE/ALE'2020 is locally organized by AIT, aiming to join teachers, researchers on Engineering Education, deans of Engineering Schools and professionals concerned with Engineering Education, to enhance engineering education through Active Learning and Project Approaches through workshops and discussion of current practice and research. PAEE/ALE'2020 has three type of submissions in English:

- **Hands-on and Workshop submissions**, aiming to encourage discussion of current practice and research on project approaches.
- **Full Papers** for paper sessions, including standard research submissions, papers of PBL experiences describing implementation issues. Any of these papers can be selected and presented in a Debate Session, in which a set of papers' authors will be invited to discuss a common theme.
- **Abstract submissions**, which is a short submission that may be included in paper session presentations or poster sessions presentations.

All full paper submissions were double reviewed by the PAEE/ALE'2020 scientific committee, and in some cases add a third review. PAEE/ALE use a single blind review procedure. After notification of acceptance authors were invited to submit a final paper of 6 to 8 pages long in Microsoft Word format, using the available template. Accepted contributions were invited to make a presentation at the symposium.

The proceedings are published under the Guidelines on Open Access to Scientific Publications and Research Data in Horizon 2020 (http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/hi/oa_pilot/h2020-hi-oa-pilot-guide_en.pdf): "Open access to scientific publications refers to free of charge online access for any user." The authors retain the copyright of their work.

The publications are responsibility and reflects the views only of the authors, and the organization cannot be held responsible for any use which may be made of the information contained therein.

Publication Ethics and Malpractice Statement

The PAEE/ALE editorial board and scientific committee are committed to preventing publication malpractice, does not accept any kind of unethical behaviour, and does not tolerate any kind of plagiarism. Authors, editors, and reviewers are to be committed with good practice of publications and accept to fulfil the duties and responsibilities as set by the COPE Code of Conduct (http://publicationethics.org/resources/code-conduct). Based on these, PAEE/ALE expects authors, editors, and reviewers to be committed to the following general guidelines:

- Editors take decisions on the acceptance of papers and compose and evaluate the proceedings quality.
- Ensure that all published papers have been fairly reviewed by suitably qualified reviewers.
- Expect original submissions from the authors and discourage misconduct.
- Expect that authors are responsible for language quality.
- Expect that the authors adequately reference the sources of their work.
- Ensure confidentiality of submissions and reviews.
- Reviewers do a fair and detailed review of paper(s) assigned to them.

PAEE/ALE'2020 List of Submissions

PAEE/ALE'2020 FULL PAPERS SUBMISSIONS

Submissions accepted for the PAEE/ALE'2020 papers sessions in English.

Ethics in engineering - Involving students and assessing institutions

Miguel Romá[1]

[1] Signals, Systems and Telecommunications Group – SST. University of Alicante, Spain

Email: miguel.roma@ua.es

Abstract

Ethics in engineering is (or must be) a topic included in the set of transversal competences included in every engineering degree. Notwithstanding, having time for including it in classroom sessions is not an easy task, as the technical contents usually have priority when programming the schedule of courses.

An activity has been designed to introduce the topic in engineering courses. The activity is designed looking for two outcomes. On the one side, to make students aware of the ethical derivations of real-life situations related with the engineering profession. On the other hand, to know, from the students' point of view, the degree of implication of institutions in the inclusion of development of these type of competences in engineering studies.

The results of the study sate that, while students agree with the relevance of having this topic included in the program, there is a lack of including ethics and social implications of the engineering profession in the curriculum.

Keywords: Education for sustainability; Ethics in engineering.

1 Introduction

Ethics in engineering is (or must be) a topic included in the set of transversal competences involved in every engineering degree. This is not a new topic, as there are lots of references about the social implications of engineering, spread over all the history of engineering itself. Just to highlight some of these references, I would like to mention some quotes:

- 'What the engineer is as a man is more important than what he is as an engineer', (Curtis, 1950).
- 'Engineers should realize that they do not practice their craft in a social vacuum', (Hirsh, 1995).
- 'What we do as engineers and why we do it, is based on our underlying values. However, rarely in engineering education is any consideration taken of our values, what they are and where they come from', (Nahar et al., 2009).
- 'Students as well as engineers need to recognize their own values and perspectives and what influences their point of view when they make scientific and engineering judgements', (Nahar et al., 2009).
- We may also include ethical considerations related with how COVID-19 has affected the researching, teaching and learning processes: 'Academia must foster a culture of care, help us refocus on what is most important, and redefine excellence in teaching and research' (Corbera et al., 2020).

Notwithstanding, having time for including it in classroom sessions is not always easy, as the technical contents usually have priority when programming the schedule of courses. But is important to take into account that students themselves are demanding having ethical and social issues included in their learning framework, as can be derive, as one clear example, from the outcomes of the meeting of the Board of European Students of Technology (BEST) symposium on education (BEST, 2006), in which the idea of having a course on ethics was supported by all the participants:

- The necessity of ethics in the engineering education was corroborated by the problems faced by engineers. They will be critical about all the information they will receive. Also they will be more confident when standing up for their own opinion, resisting outer pressure if needed. The critical thinking will be raised with a background on ethics that the engineers will have with this kind of courses. Thus, in everyday situations, the dilemmas will be solved in a better way and the long-term consequences of engineering discoveries will be more carefully evaluated.

- Ethics also have an important role on the gaps that there are inevitably in laws and involve the responsibility of communicating with the society, of presenting, objectively, one person's own work.
- Big need exist for engineers to understand ethical issues that will occur during their carrier, especially as engineers are the ones making the discoveries and they need to stimulate the consequences of those. Engineers have to stand up for their positions in ethically questionable cases.

Another interesting outcome of the BEST meeting was the definition of the role of the person in charge of ethics training, joining the practical and theoretical points of view, considering two different models:

- The person should have not just theoretical knowledge but also a practical background, the person should have experience as working as an engineer or as an option, special training on ethics.
- Cooperation among two persons: engineer who will be practical and philosopher who will be theoretical.

In the particular case of the Sound and Image in Telecommunication Engineering (SITE) degree in the University of Alicante, the general objectives of the program include some specific references to the topic:

- General aim (#4): The ability to solve problems and take decisions with initiative and creativity, and to communicate and transmit knowledge, skills and expertise, adhering at all times to the ethical and professional guidelines applicable to Technical Telecommunications Engineering.
- General aim (#7): The capacity to analyse and assess the social and environmental impact of technical solutions.
- Transversal competence (CT3): Students should have the ability to gather and interpret relevant data (normally within their field of study) to give opinions that include a reflection on important, social, scientific, ethical matters, etc.
- Specific competence (C6): Capacity to conceive, deploy, organise and manage telecommunications networks, systems, services and infrastructures in residential (home, urban and digital communities), business and institutional contexts, as well as understanding their economic and social impact.

But, when taking a detailed reading to the syllabus there is no real inclusion of these goals in any of the degree courses. One of the few exceptions is the 4th year course Advanced Audio-visual Systems that includes the goal '*Students will be concerned about the challenges and social implications of the engineering work*'. Besides, the fact of finding a goal about the topic does not necessarily implies that the problem is considered in the course development.

With these ideas in mind, an activity was designed to make students reflect about the social and ethical implications of engineering that can be included at any level taking a gap between 1,5 and 3 hours of class time. The activity pursues a double objective, on the one hand, to include the reflection about the topic with the students in an explicit way and, on the other hand, to collect information about students' opinion to analyse if issues related to engineering values are (or not) taken into account in the SITE (or any other) degree.

A pilot study was done in 2011 (Romá, 2012) to have a picture about students' opinion about this topic and its results will be used as a reference for the analysis of the results In the present work.

2 Goals

Project goals can be summarized in a series of specific objectives:

- Design and implementation of activities to work in an explicit way general aims #4 and #7 and competencies CT3 and C6 as stated in the SITE degree program.
- Evaluation of SITE degree students' opinion about the necessity of considering the social derivations of the engineering work as a part of their curriculum.
- Assess if general aims #4 and #7 and competences CT3 and C6 are treated in the degree and evaluate possible changes respect the previous study from 2011

3 Method

Even though the activity can be implemented without restrictions with students of any course and any age, in order to fulfil with the last goal, the results that will be presented correspond with the experience carried out with last year students. The data has been collected from almost 40 students enrolled in the course Advanced Audio-visual Systems during the first semester of the 2019-20 academic year.

After running the activity, the main information source comes from a questionnaire complimented as an outcome of the reflection stage.

The most useful tool that has been considered is to face students with realistic situations they would find in their working environment, stimulating, as much as possible, confronted positions. To put these situations into context, the examples have been selected taking into account their relationship with the audio-visual engineering framework.

To ensure a proper debate, the activity is planned as a role game, so students have to take a clear position supporting or refusing the facts presented. It is, obviously, important, that the situations presented to the students facilitate the search of arguments from both points of view. Figure 1 shows the front slide used to present the activity. The idea of the pros and cons of technology or engineering underlying the roles assignment is clearly shown in the image.

Figure 1. Front slide of the presentation of the activity.

Ideally, after a first stage of ‘white or black’ positions the debate will show that a reflexive decision making process is a complex tax that will lead to many derivatives not easy to handle and usually out of control. The background of some of the topics presented are:

- Production deallocation and the debate between final product price vs real production cost and employment generation in the production country vs labour conditions.
- Lack of funds for research projects vs having research funds from arms industry.
- Reduction of manufacturing or maintenance costs of vehicles vs environmental implications.

Students will have a specific and detailed situation to distribute roles related with each one of the mentioned situations.

3.1 Debate stage

As an introduction to the topic, students will first have to answer, individually and in a personal and honest way, to the question '*why did you decided to become an engineering student?*'. After that, the activity is structured as follows;

- A case and a role (supporting or refusing the case) are assigned randomly to each one of the students. Students will have to find, in a personal and honest way, their starting point of view about the designated case.
- Groups are arranged including all the students with the same designated case and role to prepare a list of arguments to support their designated role.
- Rearrangement of groups with students with both roles of the same case for the debate. A list of the most relevant aspects will be prepared after the debate.
- Students join the working teams they use in the course and share debates outcomes. Each group is asked to think about a couple of real life decision making situations in which the ethical background is relevant. Finally they have to answer to the questions 'has this task been useful for you?' and 'have you obtained any new point of view?'

3.2 Reflection stage

After the debate activity, students are asked to answer, individually, a series of reflection questions:

- Prepare a list of aspects related with the topic 'ethics in engineering' that, according to your opinion, should be included in engineering degrees.
- Classify each ones of those aspects in the following categories: 'compulsory', 'important' (but not compulsory), 'expendable'.
- Grade in a 0-3 scale your opinion about the level of inclusion of each one of the aspects in the SITE degree (without taking into account this activity): 0 – not treated, 1 – marginally treated, 2 – treated in an insufficient way, 3 – treated in a sufficient way.

4 Results

This section includes two different aspects. On the one side, some considerations derived from the observation of the debates dynamics. On the other side, the analysis of the outcomes from the questions students answer in the reflection stage.

While all the groups are in the debate stage, it is interesting that the facilitator joins every group to provide new arguments if the debate is in stand-by and to gather information about debate dynamics in each one of the cases. It is remarkable that, in all the cases, as the starting point is well defined with black and white positions, the debates start vividly. As the students delve deeper in their topics they are aware that, in real life situations, the amount of derivatives is so big that having a clear position is not an easy task. Some of the students' most remarkable comments sate the relevance of broadening their own initial point of view or their astonishment when the economic approach is considered to be the only or most relevant one.

An interesting aspect of the results appears when analysing the real-life situations proposed by the students in which the ethical background is relevant. These examples generate a vision of the topics that are interesting for them and can be used as cases in future editions of the activity. The most significant aspects are:

- Robotics and its effect in employment.
- Autonomous vehicles and artificial intelligence systems involved in decision making processes.
- Genetic engineering and dilemma between ethics and health.
- Inequity in labour relationships due to, among others, gender or raze reasons.
- Duality between development and environment.

Regarding students' opinion about the relevant aspects that may be included in the syllabus, the number of different ones has been high. All the mentioned items have been categorized in groups including similar elements for the analysis. Just to make easy the comparison with the results from the pilot study in 2011, in this paper the same six categories are going to be used, even though a more detailed study have been done using specific categories that are more consistent whit the aspects obtained in 2019. Table 1 collects the number of mentions of each category in % obtained in 2011 and 2019 and also the deviation between the two sets of data. As not all the different topics can be clearly included in one of the defined categories, a seventh category includes the topics that cannot be included in the previous ones.

Table 1. Number of mentions of the most remarkable aspects highlighted by the students.

	Topic	2011 (%)	2019 (%)
1	Acting according personal principles	24	19 (-5)
2	Social and environmental effects of own job	21	32 (+11)
3	Personal attitude (confident, personality, effort, ...)	16	11 (-5)
4	Fair labour conditions / work intrusion	12	5 (-7)
5	Economic considerations	9	1 (-8)
6	Professionality	9	12 (+3)
7	Another not classified aspects	9	20 (+11)

It is remarkable the increase in the 'social and environmental effects' category and the reduction in the economic consideration.

As expected, using the categories that were designed in the pilot study and not for the present one, there has been an increase in the not classified category.

Figure 2 summarizes students' opinion about the average value of the relevance index of each one of the categories listed in Table 1 (solid lines), where the 0-2 scale represents 'expendable', 'important' (but not compulsory) and 'compulsory'. The dashed lines represent the average value of the perceive level of inclusion of each category in the SITE degree. The 0-3 scale represents: 0 – not treated, 1 – marginally treated, 2 – treated in an insufficient way, 3 – treated in a sufficient way.

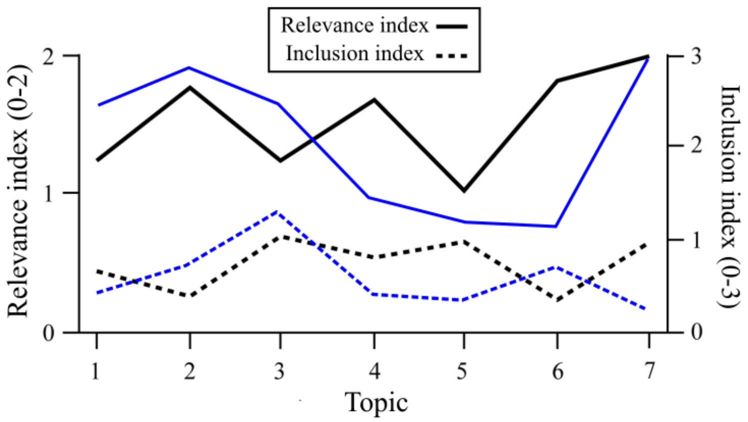


Figure 2. Summary of students' opinion about relevance index (solid) and inclusion index (dashed) for the topics included in Table 1 for 2011 (black) and 2019 (blue).

Even though there is a slight difference in the relevance index between the two sets of data, this is due to the use of the same categories in the analysis and leads to non-significant results. The average relevance index slightly decreases from 1.6 to 1.4 in the 0-2 scale, when the same categories is used in both data series. Comparing the relevance index using the categories designed for 2019, the obtained average value is 1.7.

The bad news come from the inclusion index results. This index indicates students' perception of the inclusion of each one of the topics without taking into account the presented activity. As this activity is performed in the first semester of a 4th year course, in almost 10 years gap there is not a perceived difference, and the index remains in very low levels. The average value of the inclusion index varies from 0.7 in 2011 to 0.5 in 2019 in a 0-3 scale, meaning that the overall result fits between not or marginally treated.

Being aware that the obtained values do not have real statistical significance, the clear outcome is that there is a remarkable gap between the need of having ethical related concepts and the inclusion of those concepts in the SITE degree. In the actual situation, that have been static over the years, the inclusion of ethics in engineering is only supported by individual interests without real implication of author's institution.

5 Conclusion

An activity has been designed to introduce the topic of 'challenges and social implications of the engineering work' that can be carried on in any engineering course, taking between 1.5 and 3 hours.

Students reaction to this proposal is very positive and it expands their vision about the conscious decision making process.

Comparing the results with those obtained in the pilot study, the interest and demand of this topic from the students is maintained but there is a remarkable difference between their demand and their perception of the inclusion of the topic in the degree.

6 References

BEST (2006). Ethics and sustainable development issues in engineering education. Board of European Students of Technology (BEST) Symposium on Education. Madrid, Spain.

Corbera, E., Anguelovski, I., Honey-Rosés, J. & Ruiz-Mallén, I. (2020) Academia in the Time of COVID-19: Towards an Ethics of Care, Planning Theory & Practice, 21:2, 191-199, DOI: 10.1080/14649357.2020.1757891

Curtis, F. J., (1950). Human values in engineering. *J. Chem. Educ.* 1950, 27, 4, 182.

Hirsh, R. F., (1995) Teaching about values and engineering: the American electric utility industry as a case study. *IEEE Frontiers in Education Conference*, Atlanta, GA.

Nahar, Y., Baillie, C., Catalano, G., & Feinblatt, E. (2009). *Engineering values: An approach to explore values in education and practice. Research in engineering education symposium.*

Romá, M., Ballester, J. D. (2012) Using role play to think about ethical issues in engineering education. *Proceedings of the 11th Active learning in engineering education workshop*. Copenhagen, Denmark.

The impact of the Self- Assessment and Peer-Assessment on an integrated project

Maroua Douiri[1]

[1] Esprit School of Engineering, Tunis, Tunisia

Email: maroua.douiri@esprit.tn

Abstract

"Peer assessment" and "self-assessment" are both active evaluation methods used in a C ++ Object-Oriented Programming integrated project, a module taught to second year computer science students at ESPRIT - School of Engineering. These approaches are used to evaluate projects in which work is divided into phases, each phase is followed by a regulatory validation. We opted for peer and self-assessment methods in order to calculate the continuous monitoring average of this module.

In this paper, we will discuss the implementation of these approaches, their impacts on the learner and some recommendations to improve limitations and have better results in the future.

Keywords: Peer Assessment, Moodle Workshop, Object-Oriented Programming C ++, Self-Assessment, Instructor Assessment, Teamwork, Project, Evaluation methods, Engineering Education, Active Learning, Student assessment

1 Introduction

For several years now, many courses and integrated projects have been taught using an active learning approach at ESPRIT namely the module "Object-Oriented Programming C++ Project" (OOP C++Project). The latter consists in a multidisciplinary project where the workload is divided into different sprints with regular control via regulatory validations. It aims at second year common core of IT engineering students. Since the academic year 2019/2020, we have begun to use self and peer-assessment as formative assessment of the project instead of instructor-assessment, in the aim of making this module more active. The final score was included as 30% of the continuous monitoring average.

The students who participated in this study are familiar with active learning approaches such as Project-Based Learning (Alaya, Chemek , Khodjet El Khil, Ben Aissa, & Marzouk, 2016), Problem-Based Learning (Alaya, Khodjet El Khil, & Bettaib, Active Learning for Freshmen Students in a Software Engineering Education, 2015), flipped classroom (Khodjet El Khil, Alaya, & Bettaib, 2016) and Team-Based Learning (Louati, Bettaib, & Derbel, 2014) in their first year.

As a first experience with active methods of assessment in an integrated project, the class was divided into six groups based on a random draw. Teachers of this module chose three active pursuits which are evaluated by different forms of active assessment. The first activity was evaluated by a self-assessment method, the second and the third we opted for peer-assessment. During the first part of the semester, students followed a continuous formative assessment to validate their projects.

Assessment refers to "any methods used to better understand the current knowledge that a student possesses" (Collins & O'Brien, 2003, p.29). Teachers' assessment as the sole assessment tradition in classes is no longer valid nowadays (Leung, 2007)

Various innovations in assessment procedures have been carried out, where the attention to summative assessment has shifted to formative assessment. These innovations involve thinking of alternatives that require questioning the learning process and using learning assessment activities together rather than regular testing methods. Therefore, to overcome the inherent limitations of teachers' assessment, alternative assessment, such as self-assessment and peer assessment, gained momentum in the field of education (Hargreaves, Earl, &Schmidt, 2001).

Self-assessment is conceptualized as "procedures by which the learners themselves evaluate their skills and knowledge" (Bailey, 1998, p. 227). The main merit attributed to self-assessment is that it encourages students to be more actively engaged in the educational process. They are required to reflect on their own performances and encouraged to take greater responsibility in setting goals and making decisions about their own learning (Hughes, & Mylonas, 2002). According to Boud (1995), self-assessment is the technique by which students judge and give feedback on their own performance, which is aimed at improving students' active participation in classroom activities. Boud and Lablin (1983 as cited in Boud 1989) categorized self-assessment as one of the most important processes that can be implemented in undergraduate education because of its potential to develop students' ability to accurately evaluate their own performances and to monitor their own learning.

Peer-assessment is also defined as "an arrangement for peers to consider the level, value, worth, quality or successfulness of the products or outcomes of learning of similar status" (Smith, Swanson, & Elliot, 2000, p. 150). Freeman (1995) highlighted the efficacy of peer-assessment to compensate for weaknesses in many assessment practices that usually fail to foster the development of independent, reflective, critical learners. Similarly, Cheng and Warren asserted that peer-assessment "…provides learners with an opportunity to take responsibility for analyzing, monitoring and evaluating aspects of both the learning process and product of their peers" (2005, p. 94).

Peer and self-assessment, which enable learners to assess themselves and their peers, can potentially encourage them to take greater roles in their own learning by getting engaged with the assessment criteria and reflect on their own performance and that of their peers. Topping (1998) believes that peer-assessment is an arrangement where individuals consider the amount, level, worth, and quality of success of the products or outcomes of learning of peers of similar status. According to Henner-Stanchina and Holec (1985), self-assessment is a technique with which "learners simultaneously generate and undergo the evaluation procedure". Students' assess their peers' performance and work based on their own evaluation criteria under consideration of their learning objectives and expectations.

Overall, considering the results of the above empirical studies and the significance of both peer- and self-assessment, this study investigated the effectiveness of the implementation of self-peer-assessment in an integrated project. In the next paragraph we will describe the module then our approach and how it was implemented. At the end, we will analyze the results and finish with a conclusion.

2 Description of the module

It is a six-credit module which consists of an integrated project entitled Object-Oriented Programming C++ Project (OOP C++ Project). It is taught during the first semester of each academic year. The former is extended for 14 weeks, and 3 hours of face-to-face coaching per week. This module is intended for second year common core IT students whose number is approximately 270 divided into 9 cohorts.

The project integrated four disciplines; Object-Oriented Programming C++, Oracle Database, Unified Modeling Language Diagram and Arduino. The purpose of this project is to develop all the necessary skills to come up with a real prototype of a desktop application. Students are required to implement a desktop application in order to meet the requirements of their real client.

Teachers prepare a Moodle space related to the project where learners can find all the necessary tools and resources in order to follow up with their courses. Teachers upload assignments for students to complete and add a discussion forum for further interaction in addition to other useful links.

3 Description of the approach

In this paragraph, we will provide a thorough description of the strategy we use to implement self and peer - assessment procedures.

The first step in the implementation of the integrated project is to divide into six groups based on a random draw. Each group is composed by five or six students. As teachers, we provide three activities as homework which are evaluated with an active assessment. The first activity consists in each group choosing a client and suggesting an application that meets their needs. This is an individual task, during which each member of each group is required to write a version of the specifications following a meeting with the client and to describe the intended services. The duration of the activity is one week. During the following session, each member of each team should assess their work and then compare it with the team members' works. We opted for self-assessment as a method of evaluation. To assess the work, the assessor has to respect a detailed grid which is already prepared by the tutor and then justify each point in feedback.

Many teachers, parents, and students believe that if students have a chance to mark their own work, they will take advantage and give themselves higher scores regardless of the quality of their performance. We have found that students may do this if left on their own. But, when students are trained to systematically use self-evaluation procedures, their judgment becomes more reliable. Contrary to the beliefs of many students, parents, and teachers, students' propensity to inflate grades decreases when teachers share assessment responsibility and control (Ross, et al., 2000). When students participate in the identification of the criteria that will be used to evaluate in-class production and use those criteria to assess their work, they get a better understanding of what is required. The result is the gap between their assessment and the teacher's role is reduced. And, by focusing on evidence, discrepancies between teacher and self-evaluation can be negotiated in a productive way (Carol Rolheiser and John A. Ross,2013). For this reason, tutors should explain to the students the process of self-assessment, introduce some examples, prepare a grid with detailed evaluation criteria and follow this process in the project session. To improve this skill each team, at the end of this activity, should finalize the project specifications based on the work of each member.

The second activity should be done in groups. Each group is divided into two subgroups. Each subgroup prepares a draft of analysis and design of the application based on the final document of specifications already prepared by the group at the end of the first activity. The duration of the activity is two weeks. This activity consists in a workshop on Moodle Platform. Students should stick to a submission deadline. For the work evaluation, we opted for peer assessment between subgroups of each group. A grid with detailed evaluation criteria was prepared. Assessors and assessees should be part of the same group.

The third activity is also based on teamwork. Each team is required to prepare a prototype of their executable desktop application and submit it on Moodle. The duration of the activity is three weeks. We also plan this activity on Moodle platform as a workshop with a deadline for submission. After the deadline, each group assesses the work of the other groups and gives their feedback. A grid with detailed evaluation criteria is prepared and submitted by the tutors. At the end of this workshop, each team should finalize the application and take notes of their peer-assessor's comments.

According to Bouzidi and Jaillet: « Peer-assessment can be trusted if applied to exams referring to the exact science field and if marked by at least four peers » (Bouzidi & Jaillet, 2009). That's why tutors should interfere to manually verify whether the assigned work submitted by each team is accessible to the other five groups.

For the second and third activities, the deadline to complete the evaluation was three days. After that, tutors verify that assessments are well done and alter scores if necessary. Finally, the results are published to the students.

The score of each activity is included as 10% of the continuous monitoring average. The final continuous monitoring average is 30% of the final score of the integrated project's average.

4 Results

4.1 Method

This study was conducted at the beginning of the second semester of the academic year 2019/2020. Quantitative measures were applied. A total of 270 second year students enrolled in this 6-credit module participated in the study. We asked the students to give us their feedback using a paper survey. The survey was anonymous.

We received 230 responses from 270 registered students which is ~85% of the participation rate. We used Google Sheets to analyze the responses.

4.2 Scholar Results

In Tunisia, learners are evaluated with scores between 0 and 20. To validate a project at ESPRIT, a student has to obtain at least 10 out of 20. The module average is calculated as follows:

Average = 30% Continuous Monitoring (CM) + 70% Final Validation

We apply self and peer assessment to calculate the Continuous Monitoring grade.

We compile some scholar results with final average details in Figure 1 and the continuous Monitoring grade in Figure 2

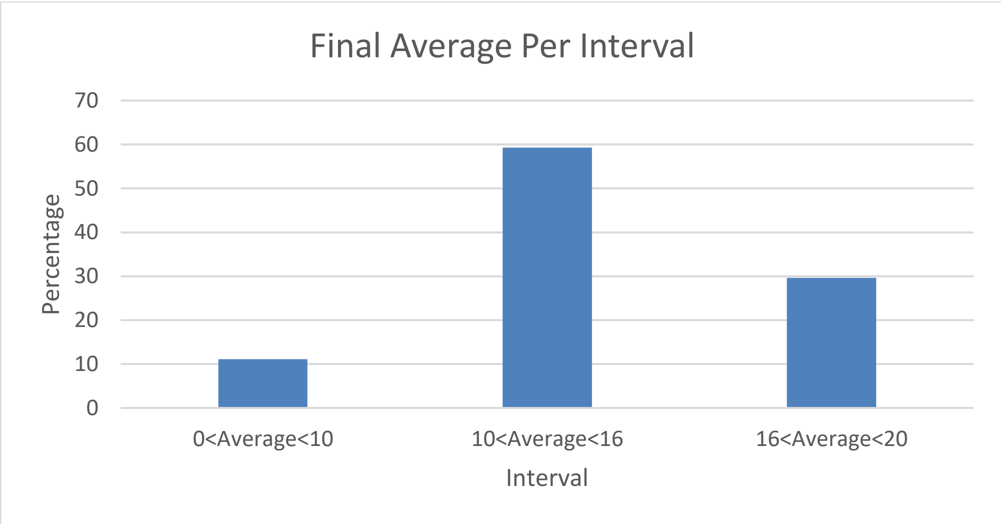


Figure2: Final Average of the project

Figure2 shows the number of students per interval of their averages in 2019-2020. From this figure we can conclude that about 89% of students validated this project similarly to previous years.

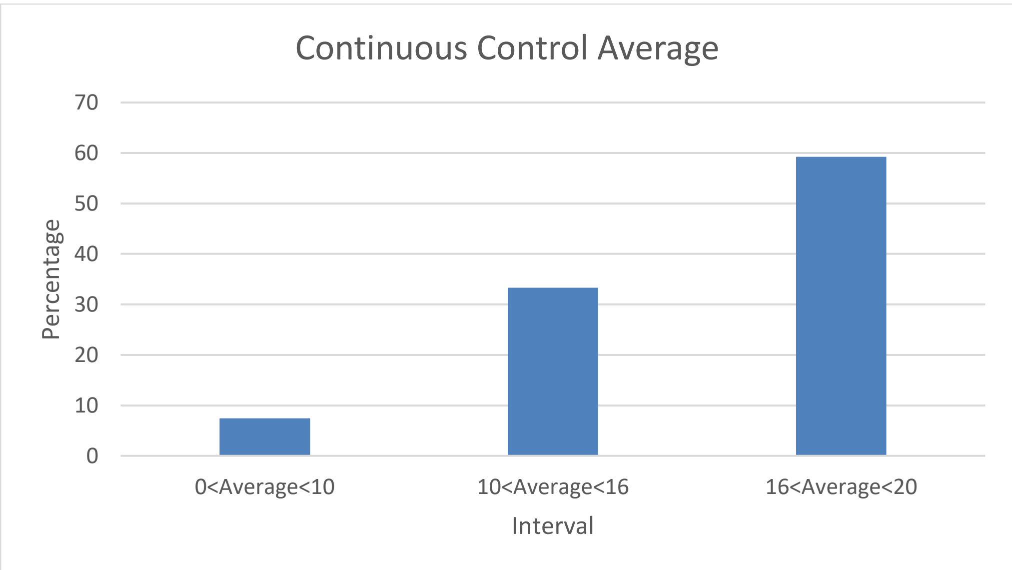


Figure 3: Final Continuous Monitoring Average

Figure 3 shows the number of students per interval of their final continuous monitoring averages in 2019-2020. From this figure we can conclude that about 93% of students validated this part.

Table 1:Results of participation

Legend	Activity 1 (SA)	Activity 2 (PA)	Activity 3 (PA)
Workshop submission on Moodle	80%	78%	83%
Students who did the workshop evaluation	78%	67%	80%
Students who validate the workshop	72%	73%	79%

Table 1 shows that 80% completed the first activity, 78% submitted the second activity and 83% submitted the third activity

Table 1 also shows the number of students who evaluated their peers' submissions. 78% of students completed the self-assessment phase of their workshop, 67% completed the peer-assignment of the second workshop and 80% completed the peer-assignment of the third workshop. It shows also the number of students that validated their workshop (activity 1, 2 and 3) and they obtained at least 10/20. Finally, 72% of students validated the first activity, 73% of students validated the second activity and 79% of students validated the third activity.

In Table 1, We can also see that, compared to activity 1 and 2, the number of students who submitted and peer- assessed activity 3 is bigger. Tutors think that at the end of the semester students are more likely to work harder in order to complete their projects.

We also noticed that the percentage of students who validated their activities using peer-assessment is higher when using than self-assessment. Tutors think that the reason is that students became more familiar with the assessment process and criteria than the first activity which applied self-assessment only.

4.3 Survey Results

The survey included 14 open-ended questions about this experience (experiment). Questions with responses are listed here in four tables Table 2: Self-Assessment (Activity 1), Table 3: Peer Assessment (Activity 2 and 3) and Table 4: Overall Satisfaction.

Table 2: Self-Assessment (Activity 1)

Question	Totally Disagree	Disagree	No opinion	Agree	Fully Agree
The deadline was enough to submit the home work	14,80%	20%	6,20%	25,47%	24,63%
The deadline was enough to evaluate the work	16,35%	17,95%	16,67%	37,5%	9,94%
The evaluation instructions were clear	01,41%	19,88%	21,80%	26,61%	30,30%
The rules and steps of the workshops have been clearly explained by your tutor	10,81%	12,63%	11,20%	25,45%	39,91%
The grid was clearly with detailed evaluation criteria	09,82%	10,01%	5,23%	15,81%	40,87%

According to Table 2, we found out that about 50% are satisfied with the deadline of the first activity and said that it was enough to submit their final work. Only 48% said that the deadline was enough to evaluate the work applying self-assessment, 57% think that the evaluation instructions were clear, 65% said that the rules and steps of the workshops have been clearly explained by their tutor and 57% said that the grid was clearly detailed.

Table 3: Peer Assessment (Activity 2 and 3)

Question	Totally Disagree	Disagree	No opinion	Agree	Fully Agree
The deadline was enough to submit the home work	15,83%	12,71%	20,20%	11,86%	38,47%
The deadline was enough to evaluate the work	16,35%	17,95%	16,67%	9,94%	37,5%
The evaluation instructions were clear	19,56%	19,88%	21,80%	26,61%	9,30%
Course materials provided on Moodle were relevant	33,02%	27,89%	21,16%	12,18%	3,85%
The rules and steps of the workshops have been clearly explained by your tutor	22,76%	11,86%	20,52%	30,77%	11,86%
The grid was clearly with detailed evaluation criteria	07,82%	12,01%	9,23%	11,81%	40,87%

As we can see in Table 3, about 51% are satisfied with the deadline and said that it was enough to submit their final work. Only 48% said that the deadline was enough to evaluate the work applying the peer assessment, 16% are satisfied by the course materials uploaded to Moodle, 43% said that the rules and steps of the workshops have been clearly explained by their tutor and 53% said that the grid was clearly detailed.

We list below some comments extracted from our survey:

"We need more flexibility in terms of deadline "

"More instructors and details about the work required"

"Dispose more clear videos with explanation, more explanations from my tutor"

Since it was our first experience, we can understand the different opinions shared by several students. For the coming year, we planned to work on several points in order to improve this experience. We propose to plan more training sessions to our team of tutors, have some videos on Moodle to explain each phase whether in the self and peer-assessment activities. We should also improve the course materials available on Moodle, explain the steps and rules in the assignments and provide more details about the process.

Table 4: Overall Satisfaction

Questions	Totally Disagree	Disagree	No Opinion	Agree	Fully Agree
The final mark reflects your work done	08,03%	19,20%	5,30%	22,44%	44,70%
The active assessment was a good experience	16,78%	15,65%	9,80%	12,54%	45,23%
Teachers assessment is more reliable	15,67%	51,61%	8,93%	12,45%	11,34%
I feel that I can do better next time	7,38%	2,57%	10,58%	32,06%	45,20%

We can see in Table 4 about 68% are satisfied with their grades and think that it reflects their effort. We can see also that about 58% were satisfied with the experience of active assessment so learning with self and peer assessment was a good experience. 68% don't agree with Teacher-assessment and said that it is less reliable than active assessment. However, less than 10% believe that they cannot do better next time.

We list some comments extracted from our survey:

"Personally, I admired the self-assessment method, it allowed me to learn how to correct my mistakes "

"It is the first time that I feel like a principal actor in the process of my evaluation"

"I think that we must apply the active assessment in all of our courses"

The purpose of using this method is to give the student an opportunity to contribute in the process of their own evaluation.

Thanks to this survey, we detected that self-assessment can encourage students to critically reflect their own learning progress and performance. It enhances their critical-thinking skills mainly when they assess the work of other group members. More feedback can be generated by students compared to one or two teachers. It also helps them become more aware of their weaknesses and strengths. Peer and self-assessment reduce the time and workload of marking for teachers.

On the other hand, we noted that self-assessment can be subjective as students can be unreliable in their grading and may even over-evaluate their own performance. They may also have a tendency to give everyone the same grade, i.e all the groups get goods marks.

For this reason, we decided to offer other unrated activities in order to familiarize students with the evaluation process and control them.

5 Conclusion

In this paper, we presented our implementation of active assessment approaches which are self and peer-assessment in our project using the Moodle Platform. The purpose was to ascertain that this approach represents a viable alternative to traditional assessment methods.

The results of the study showed that these approaches have good impacts on grades and a better assimilation of learning outcomes of the module.

While the results are encouraging, we think that some adjustments should be made to improve the whole experience. Improvements include setting up a communication strategy to better explain the process, designing a detailed grid of each part, adding other resources on Moodle and providing several training sessions for students and tutors in order to familiarize them with the assessment criteria.

References

Alaya, Z., Chemek , A., Khodjet El Khil, G., Ben Aissa, M., & Marzouk, A. (2016). An Integrated Project for Freshmen Students in a Software Engineering Education. In M. Auer, D. Guralnick , & J. Uhomoibhi (Ed.), *ICL 2016. Advances in Intelligent Systems and Computing. 544.* Springer.

Alaya, Z., Khodjet El Khil, G., & Bettaib, L. (2015). Active Learning for Freshmen Students in a Software Engineering Education. *IJCLEE2015, 5th IRSPBL.* Mondragon University, San Sebastian, Spain.

Bailey, K. M. (1998). Learning about language assessment. Cambridge, Heinle & Heinle

Boud, D. (1989). The role of self-assessment in student grading. Assessment and Evaluation in Higher Education, 14, 22-30. https://doi.org/10.1080/0260293890140103

Boud, D. (1992). The use of self-assessment schedules in negotiated learning. Studies in Higher Education, 17, 185-200. https://doi.org/10.1080/03075079212331382657

Boud, D. (1995). Enhancing learning through self-assessment. London: Kogan Page.

Bouzidi, L., & Jaillet, A. (2007, Juin). évaluation par les pairs pourra-t-elle faire de l'examen une vraieactivité pédagogique? *EIAH*. Retrieved 2 26, 2019, from https://hal.archives-ouvertes.fr/file/index/docid/161484/filename/16.pdf

Bouzidi, L., & Jaillet, A. (2009). Can Online Peer Assessment be Trusted? *Educational Technology & Society, 12*, 257-268.

Collins, J.W., and O'Brien, N.P. (Eds.) 2003. Greenwood Dictionary of Education. Westport, CT: Greenwood

Freeman, M. (1995). Peer assessment by groups of group work. Assessment & Evaluation in Higher Education, 20(3), 289-301. https://doi.org/10.1080/0260293950200305

Gielen, S. (2007). Peer assessment as a tool for learning. PhD dissertation, (p. 70). University of Leuven, Belgium. Retrieved 2 25, 2019, from https://lirias.kuleuven.be/handle/1979/1033

Hargreaves, A., Earl, L., & Schimidt, M. (2001). Perspectives on alternative assessment reform. American Educational Research Journal, 39(1), 69-95.https://doi.org/10.3102/00028312039001069

Henner-Stanchina, C., & Holec, H. (1985). Evaluation in an autonomous learning schema. In P. Riley (Ed.), Discourse and learning. London: Longman.

Hsu, T. (2016). Effects of a peer assessment system based on a grid-based knowledge classification approach on computer skills training. Educational Technology & Society, 19(4), 100-111.
Hughes, K., & Mylonas, A. (2002). Developing procedures for implementing peer assessment. Assessment & Evaluation in Higher Education, 27(5), 427-441. https://doi.org/10.1080/0260293022000009302
Khodjet El Khil, G., Alaya, Z., & Bettaib, L. (2016). Application de la classe inversée et l'apprentissage par problème dans un cours de programmation. In E. J. Chair (Ed.), *Colloque SIEST Méditerranée*, *3.* Marseille.
Kim, M., & Ryu, J. (2013). The development and implementation of a web-based formative peer assessment system for enhancing students' metacognitive awareness and performance in ill-structured tasks. *Educational Technology Research and Development, 61*(4), 549--561. doi:10.1007/s11423-012-9266-1
Leung, C. (2007). Dynamic assessment: Assessment for and as teaching? Language Assessment Quarterly, 4(3), 257–278. https://doi.org/10.1080/15434300701481127
Louati, K., Bettaib, L., & Derbel, L. (2014). Team Based Learning in mathematics courses. *SEFI.* Bermingham.
Rey, O., & Feyfant, A. (2014). *Évaluer pour (mieux) faire apprendre.* Dossier de veille de l'IFÉ, n°94, septembre.
Rolheiser, Carol, and John A. Ross. "Student self-evaluation: What research says and what practice shows." Plain talk about kids (2001): 43-57.
Ross, J. A., Rolheiser, C., & Hogaboam-Gray. (1998). Skills training versus action research inservice: Impact on student attitudes on self-evaluation. Teaching and Teacher Education, 14(5), 463-477.
Topping, K. (1998). Peer-assessment between students in colleges and universities. Review of Educational Research, 68, 249-276. https://doi.org/10.3102/00346543068003249
Topping, K., Smith, E., Swanson., I., & Elliot, A. (2000). Formative peer assessment of academic writing. Assessment & Evaluation in Higher Education, 25(2), 149-169. https://doi.org/10.1080/713611428
Topping, K. (2009). Peer Assessment. *Theory Into Practice, 48*(1), 20-27. doi:10.1080/00405840802577569

Interdisciplinary contents integration and key competences developed in a project work of Industrial Engineering and Management third year

Anabela C. Alves[1], Filomena Soares[2]

[1] ALGORITMI Centre, Department of Production and Systems, School of Engineering, University of Minho, Guimarães, Portugal
[2] ALGORITMI Centre, Department of Industrial Electronics, School of Engineering, University of Minho, Guimarães, Portugal

Email: anabela@dps.uminho.pt, fsoares@dei.uminho.pt

Abstract

The traditional curricular structure of organizing courses adopted by many university programmes is not suitable for the students to relate and integrate different interdisciplinary contents. The main consequence of this fixed structure is the students' difficulty of applying these contents in an integrated way to develop a project or just to solve a problem. Industrial Engineering and Management (IEM) programme from the University of Minho, Portugal, is, for a long time, trying to break this paradigm. So, it implements Project-Based Learning (PBL) in three semesters in a five-year programme (ten semesters). Attending to the small sample (three in ten semesters) much more can be done and it does not have to be all the semesters PBL. This was the motivation for the authors of this paper to propose a common project between two courses of the IEM third year, first semester (IEM31): Production Systems Organization I and Process Control and Automation. These two courses have in common the need to design production systems and/or industrial applications to be integrated into these. The main project work objectives were to design a virtual or real-world automated production line/cell and simulate it using a hands-on activity and a cell mock-up in the classroom. Students were organized into teams of seven to ten members. This research was based on a qualitative research (case study) approach through the analysis of an on-line questionnaire. Therefore, the students' feedback to the hands-on activity was registered through the on-line questionnaire and each response was classified to address the key competencies developed by the students. The paper objectives are twofold: 1) describe the teamwork outcomes, showing the contents integration of the two courses and 2) discuss the questionnaire results, highlighting the key competences acquired. This interdisciplinary experience was implemented in two editions (2017_18 and 2019_20) and the students' feedback was very positive in both editions.

Keywords: Industrial Engineering and Management Education; Active Learning; Project work; Hands-on activities.

1 Introduction

The traditional compartmentalized way of course organization do not provided a satisfactory way for engineering students to develop their profession. The engineering students need a holistic view of the system that enables the connections between bodies of knowledge (Flumerfelt et al., 2014). According to Grasso and Martinelli (2007): *"In this evolving world, a new kind of engineer is needed, one who can think broadly across disciplines and consider the human dimensions that are at the heart of every design challenge. In the new order, narrow engineering thinking will not be enough."*

At the same time, engineering students need to be always open to learn, as the world is continuously changing and needing different technologies. In this position they need to learning to learn that has been a concern since last century (Hounsell, 1979). According to UNESCO (2015), due to the volume of information now available on the internet, this was never as important as it is today.

Nevertheless, to have this profile, an engineering student should have competencies. Competencies are more than knowledge and skills (Rychen & Salganik, 2000). It also implies attitudes, recommended the Council of the European Union (Council of the European Union, 2018). Knowledge is related to facts and figures, concepts, ideas and theories which are already established and support the understanding of a certain area or subject. Skills are the ability and capacity to carry out processes and use the existing knowledge to achieve results. Attitudes are the disposition and mind-sets to act or react to ideas, persons or situations (Council of the European Union, 2018, p. 14). This council defined eight key competencies: 1) Literacy; 2) Multilingual; 3) Mathematical, science, technology and engineering; 4) Digital; 5) Personal, social and learning to learn; 6)

Citizenship; 7) Entrepreneurship and; 8) Cultural awareness and expression (2018, p. 15). The key competences are all considered equally important; each of them contributes to a successful life in society. According the same council (2018, p. 14): *"These can be applied in many different contexts and in a variety of combinations. They overlap and interlock; aspects essential to one domain will support competence in another. Skills such as critical thinking, problem solving, teamwork, communication and negotiation skills, analytical skills, creativity, and intercultural skills are embedded throughout the key competences.* " These skills are the most reported for the 21st century (Kang, 2019; The Economist, 2015; UNESCO, 2016; World Economic Forum, 2015).

The competence-oriented education could be promoted in formal context, as well as in informal, through activities promoted by the teacher but also by their peers in a network of collaboration (Zhang et al., 2008). The learning should take place, independently, of the space, time and relations in a fluid approach (Kang, 2019; UNESCO, 2015). In the education system these competencies are promoted by adopting more effective learning methodologies, suitable environment and experiential learning to stimulate these competencies (Anabela C. Alves et al., 2018; Bonwell & Eison, 1991; Felder & Brent, 2006; Fernandes, 2014; Freeman et al., 2014; Gibbs & Habeshaw, 1992; Shapiro, 2014). At the same time, these learning methodologies should be supported by digital technologies (High Level Group on the Modernisation of Higher Education, 2013; Uebe-Mansur et al., 2019; Vicente et al., 2014). Due to the declared COVID-19 pandemic crisis in March of 2020, teachers, students and parents are rapidly learning how to use such digital technologies. This means that such experiential is gained if students are involved in real-world contexts what could be achieved with partnerships with companies and/or active learning contexts (Council of the European Union, 2018; Kang, 2019; Nair et al., 2009; Pellegrino & Hilton, 2012; UNESCO, 2010).

This need to provide active learning environment and conditions for the students to connect the disciplinary contents of different courses was the motivation for the paper authors to offer an interdisciplinary project among two courses of Industrial Engineering and Management third year, first semester (IEM31). This interdisciplinary project was requested as an assignment to do in the context of Production System Organization I and Process Control and Automation. In this paper, this interdisciplinary project is presented with two main purposes: 1) describe the teamwork outcomes, showing the contents integration of the two courses and 2) discusses the questionnaire results, highlighting the key competences developed through examples of students outcomes and knowledge, skills and attitudes assumed by them during the project developed and hands-on activity.

This paper is divided in five sections. After this first introduction, the research methodology is presented. The study context is described in section three, while section four presents the results analysis and discussion. Finally, section five depicts some concluding remarks.

2 Research methodology

The research strategy follows a case study (IEM third year) through a qualitative approach by using questionnaires as the technique for data collection and result analysis. To fulfil the defined objectives for the paper, the teams outcomes related with contents integration of the two courses will be presented. Additionally, to discuss the key competences developed, it was used an on-line questionnaire results and teachers observations and experience. This questionnaire has been used to evaluate the hands-on activity developed in the context of one of the teams' task assignment of PSOI course since 2016_17

The survey included 38 questions: 34 closed questions and four open-ended questions. The closed questions were scored in a Likert scale [1: Totally disagree to 5: Totally agree]. The questions of the questionnaire were in a simple language for the students understanding (e.g. "Question 1: After reading the task/work statement, I was curious and I looking forward immediate material for it execution." or "Question 2: "I did extra work for this task"). They were not settled with the purpose of analyse the competences but there is a strong relation with the competences. So, in a previous study, the authors classified and grouped the 34 closed questions in 15 categories related with competencies as characterized by Rychen and Salganik (2000). These results were presented in Alves and Soares (2020). For the study presented in this paper, it was used the skills embed in the eight key competences proposed by the Council Recommendation on Key Competences for Lifelong Learning (Council of the European Union, 2018), as referred in section 1. For example, question 1 above was related to the attitude of the students when they read the task statement, if they get curious about that and look for material for it execution. This attitude reveals pro-activity, problem-solving skills that are embed in literacy and entrepreneurship competences.

3 Study context

This section gives an overview of Industrial Engineering and Management (IEM) third year (IEM31). The IEM of University of Minho is a Master Integrated programme of five years, 10 semesters. Each semester has 5-6 courses of five European Credit Transfer System (ECTS) each in a total of 30 by semester. In the final of the programme students obtain 300 ECTS. This is so since 2006, when Bologna process was introduced in Portugal (Veiga & Amaral, 2009). With this, some Integrated Projects were included in engineering programmes. In IEM were included three Integrated projects in the first year, first semester and fourth year, both semesters. In a general way, students felt motivated by these and would like to have more projects (A.C. Alves et al., 2018). Others courses are organized in a compartmentalized way (Flumerfelt et al., 2014), with some exceptional interdisciplinary projects, as the one that was presented in Soares and Alves (2019) and it will be detailed in this paper.

3.1 Industrial Engineering and Management – third year, first semester

The third year, first semester of IEM includes the courses presented in Figure 1, being Production System Organization I (PSOI) and Process and Control Automation (PCA) two of them. These are briefly presented below.

S1	Energy, Environment and Industrial Systems	CE	5
S1	Process Control and Automation	CE	5
S1	Production Systems Organization I	CEsp	5
S1	Quality Engineering and Management	CE	5
S1	Stochastic Models of Operational Research	CCp; CEsp	5
S1	**Opção Tecnológica III**		**5**
	Apparel Production Technologies	CE	5
	Introduction to Polymers	CEP	5

Figure 1. Study plan of IEM third year, first semester (UMINHO, 2020)

The PSOI learning outcomes (LO) are settled as:

1. Identify different production paradigms;
2. Distinguish Lean Thinking principles and others methodologies that question the production system adequacy;
3. Distinguish wastes types and their impact on production systems;
4. Classify the production systems relating to different criteria;
5. Distinguish the main production systems type;
6. Project and organize production cells/lines:
   a) Form parts families, using clustering algorithms or others criteria;
   b) Instantiate production cells, calculate machines number;
   c) Instantiate workstations, calculate takt time and operators number;
   d) Balance lines/cells, applying heuristically methods;
   e) Organize intracellular layout, applying layouts methods;
   f) Select the operating mode more adequate and skills matrix;
   g) Organize intercellular layout and integrate the whole system;
7. Simulate the operating modes working of a production cell.

To assess these LO, teacher defined with the students for 2019_20 academic year an assessment methodology that includes three components:

1) three quizzes, five minutes tests done in pairs (weight: 15%, 5% each);
2) two individual tests of one hour each (weight: 30%; 15% each); and
3) two assignments done in teams (weight: 55%; 10% 1st task + 45% 2nd task).

In previous years, the number of components were even higher, but the teacher recognizes that it was too much work, for her and for the students. The second task is the interdisciplinary project work that will be detailed in the next section and it is the base for this paper.

PCA learning outcomes are:

1. Identify the main problems related to industrial automation and control;
2. Distinguish between different input and output transducers, their characteristics and application;
3. Discuss the architectures and characteristics of the programmable logic controllers (PLC);
4. Design combinational controllers;
5. Design sequential controllers in different automation systems using Grafcet.
6. Implement automation problems in ladder diagrams.

In 2019_20 academic year the PCA assessment methodology includes three components:

1. An individual test weighing 50%. The test has a minimum score of 7/20. The written test is carried out without consulting documents (if necessary a form with the main equations is provided). The test will explicitly indicate the contribution, in values, of each question.
2. A group work in simulation, the interdisciplinary project work that will be detailed in the next section and it is the base for this paper, that solves an automation and control problem with a weight of 40%. The work has a minimum grade of 8/20 and can be performed in a) a company selected by the group or b) a "virtual" company defined by the group. The project must include the specifications, selection of sensors and actuators to be used, Grafcet and ladder diagram of the proposed automatic system. The work is mandatory.
3. Activities Flipped Classroom with a weight of 10%. The evaluation of this component takes into account student participation in the Flipped Classroom activities.

The approval grade of the course unit is 9.5 out of 20.

3.2 PSOI and PCA project work organization and assessment

The project work for PSOI and PCA is an assignment that was requested as an interdisciplinary project to the IEM31 students in two academic years: 2017_18 and 2019_20. Due to the sabbatical license of PCA lecturer in 2018_19, the interdisciplinary project work was not requested.

In the case of PSOI, since 2016_17, a similar task assignment has been requested to the IEM31 students as part of their assessment, being one of components assessments (with the highest weight), as explained in section 3.1. Also, in PCA a project work has been part of the assessment since 2014_15. The students had until 2017-18 to develop two different and independent works.

The goal of the project was to design and implement a virtual or real-world (in a company selected by the students) based automated assembly line of a product (designed by the students).

They should design the assembly line/cell by selecting the operating mode, estimating the demand for the product, defining the operations and calculating all the necessary elements, balancing, and the supply mode. Students should also preview an automated line, including the automation project specifications, selection of sensors and actuators, Grafcet and ladder diagram of the proposed system. They should also include other techniques learned from other curricular if necessary.

Students were organized into 11 teams of seven to ten members each. From the 11 teams, nine went to companies to develop the project. Table 1 presents the number of students and teams in each year. In 2019/20 the number of students increased but the number of teams was kept; the teams were bigger. It is worth pointing out that some students were only enrolled in PCA and they were not considered in this analysis.

Table 1. Number of students and teams in each academic year

Academic year	PSOI		PCA	
	º of students	Nº of teams	Nº of students	º of teams
2017/18	72	11	82	11
2019/20	92	11	105	11

As mentioned before, the overall assessment of the work contributes with 40% of the final grade in each course. The criteria used by each curricular unit is presented in the Table 2.

The type of materials submitted for evaluation had no pre-defined format. Students were allowed to choose the type that they considered the best (novelty was valued): video, PowerPoint, simulations, poster, web page, blog, and the traditional report. Students should explicitly state the contribution of each team member in the development of the work.

In the end, a one-day public presentation of the projects was scheduled. The 30-minutes presentation included also the demonstration of the production cells to obtain the designed product, demonstrating and measuring some performance variables by performing the hands-on activity.

Table 2. Assessment criteria of each curricular unit

Criteria PSOI	Criteria PCA	Weight
Preparation and creativity	Automation system design. Presentation of documentation	1
Contents exploration		1
Presentation and exposition	Public presentation	2
Demonstration and simulation	Grafcet and ladder diagram of automatic system	2
Results and discussion	Critical evaluation of final project	1
Materials delivery on time	Materials delivery on time	5

4 Contents integration and key competences developed

This section presents the team outcomes, highlighting contents integration, as well as the analysis of the results obtained through the on-line questionnaire filled by the students.

4.1 Interdisciplinary contents integration: teamwork outcomes

In this edition, teachers used padlet (https://padlet.com/), Figure 2, as a means to share information and as a repository of the project works. Project rules and videos from previous works were publicize in the first column. Each group had a dedicated column where they put in the information related to the project development and considered relevant for evaluation: tasks, meeting outcomes, company visits, work developed, simulations and videos, documents, links to webpages. Padlet is an appropriate means of sharing information, while allowing transparency, and a healthy competition, between teams.

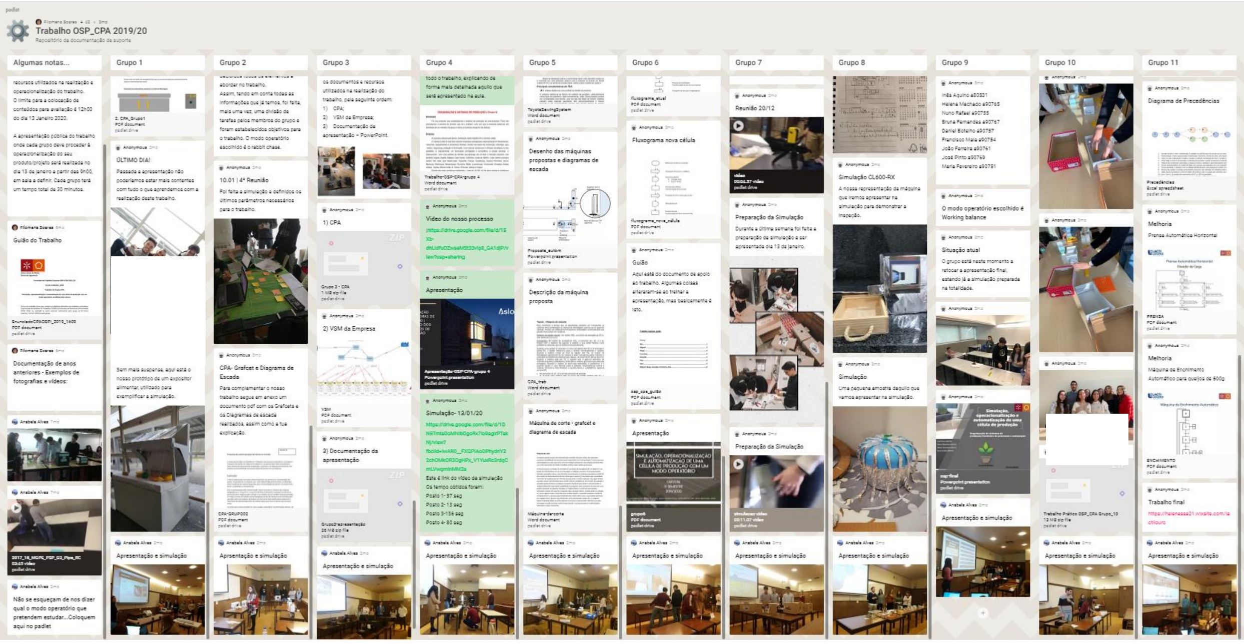


Figure 2. Padlet with the whole vision of teams work and simulations (2019_2020)

All teams simulated the production of a good in a production cell, organizing people in the cell accordingly to a previously selected operating mode. In the cell/line is included automated production subsystem components.

All the teams fulfilled the requisites of integrating PSO I and PCA contents in the designed cell/line production. One example of this integration is presented in Figure 3. The group worked in a real company dedicated to the production of cheese. Students designed the best layout (on the left) in order to optimize production parameters as well as they designed an automated filling machine (on the right).

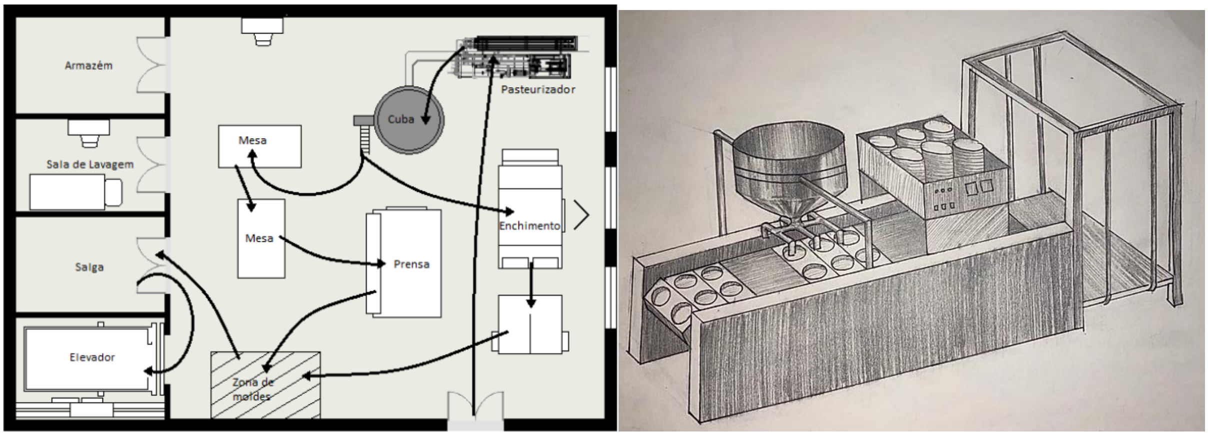


Figure 3. One team project outcome: Cheese production, layout and filling machine draft.

4.2 Key competences developed: on-line questionnaire results

The discussion in this section is based on the key competences and skills defined by the Council of the European Union (2018) and presented in the section 1. This discussion is partially based on the questionnaire questions developed for the hands-on activity, by analyzing the students answers of the academic year 2017/18 and 2019/20. The response rate was of 21% in 2017/18 and in the 2019/20 it was almost 50%.

Attending to the eight skills embed in the eight key competences referred in the Council of the European Union (2018), the 34 questions of the survey were classified and grouped around these eight skills. Because some of the questions were not clear which skill belongs, the paper authors added the “Learning to learn” to this list. After obtaining the average for each question, it was obtained the average for each skill group for each academic year. The results of this study is presented in Figure 4.

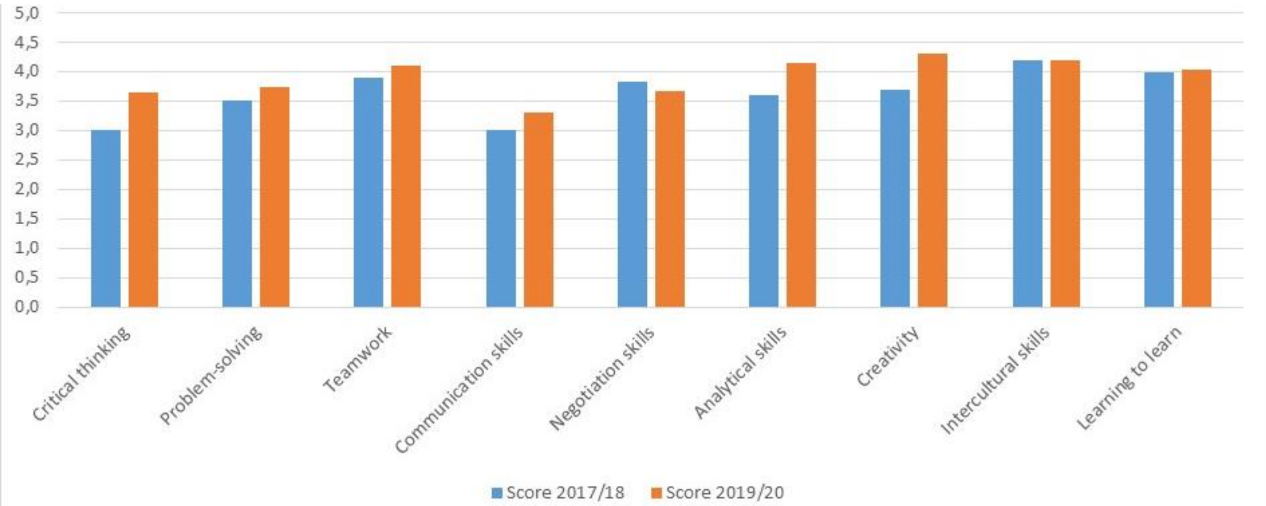
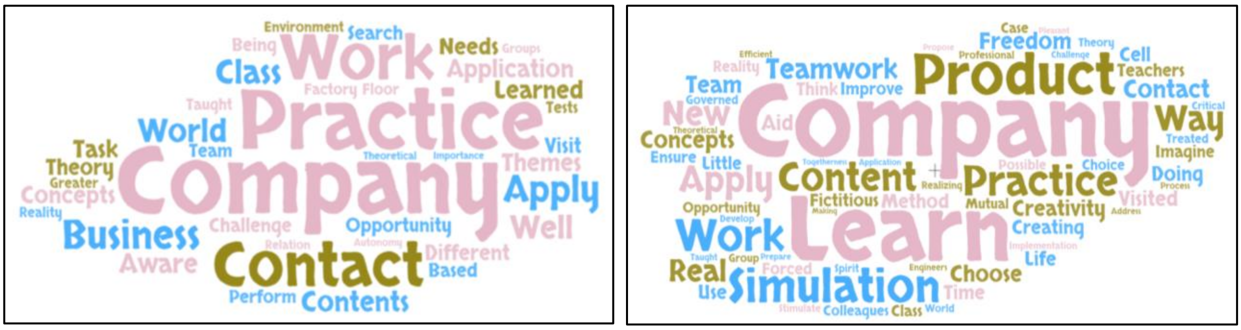


Figure 4. Results of on-line questionnaire results

Some of the questions were not reflected in these skills because they were designed by the negative side, i.e., related with passive attitude of the students. For example, these three were: "The main reason for completing the task was to perform the course requirements", "I did the task to avoid the blame of not doing" or "The classes where I just have to be "present" are the best." The average of these questions received a score of 2,3 that was a low score.

The open questions were related what the students enjoy more in the hands-on activity. The words cloud in Figure 5 shows the most referred words. It is possible to highlight the words *company* and *practice*. Others are much related with the skills referred: teamwork, problem-solving, applied theory, learning to learn, among others.



a) b)

Figure 5. What the students enjoy more in the hands-on activity: a) 2017/18; b) 2019/20

What pleased least in the first edition were the unbalancing workload among all team members, short duration for this assignment, the missing assessment criteria, difficulties to the product presentation in a classroom, the lack of sync among company and teacher objectives, the difficulty in interpreting the task statement (Figure 6).

a) b)

Figure 6. What the students enjoy less in the hands-on activity: a) 2017/18; b) 2019/20

The students were very critical and made some recommendations to improve the task assignment. Some were attended. Other were not attended due to the objectives of the activity defined by the teachers, namely, to have a template for the presentation, to have more specifications for the simulation, to have a previously defined operating mode, have a previous contact with companies made by teachers. Teachers did not attended to suggestions because they did not accomplish the objective of the teachers that want to stimulate students creativity and initiative. Students also recommend more time for the simulation and discussion. Students also pointed out the lack of attention in all presentations (remember that are 11 presentations of 30 minutes each), the team dimension (seven to 10 members), the lack of interest of some team members. Some students (are third graders) continues in an immature state and preferred to be commanded, instead of taking decisions. What is understandable because many people, according to the Theory X of Douglas McGregor (Chapman, 2002), felt more comfortable when someone tells them what to do. More about the survey results could be consulted in Alves and Soares (2020).

Nevertheless, it is important to discuss knowledge, skills and attitudes embed in the competencies. Due to the limited space of the paper, just four out of the eight most striking were chosen and discussed through some examples retrieved from the elements delivered by the students, their presentation and hands-on activity, their attitude in the contact with the companies (it was optional, but nine teams preferred to do the work in companies). Table 3 presents these examples.

Table 3. Examples of knowledge, skills and attitudes related to competencies acquired by the students

Competencies	Knowledge	Skills	Attitudes
Mathematical, science, technology and engineering	Calculate takt time, number of operators, KPI, develop grafcets, transform company data in graphs	Apply the operating mode in the production system designed and design the automated system	Build the products prototypes resemble real companies products
Digital	Be aware of new tools to communicate	Digital tools use (e.g. Padlet, videos)	Initiative to use different tools, to share information
Personal, social and learning to learn	Plan a project and activities, plan, distribute individual and team tasks, establish a contact with a company, public presentation	Go & See in the Gemba (as requested by lean theory), negotiate and solve conflicts, Initiative to present a topic and answer to questions; role-play	Initiative to develop prototypes; communicate with companies, how to act in public
Entrepreneurship	Manage a project with a company and collaborate in a big team; creativity by developing the prototypes; attend meetings with CEOs or technical directors	Build the products prototypes, mobilize resources; Initiative to contact local industries	Stimulus and motivation to make the project, leading with company unavailability

5 Conclusion

This paper presents an interdisciplinary project developed between two courses of IEM third year, first semester. These courses are lectured by teachers belonging to different departments and expertise areas, that complements each other. Nevertheless, students are many times unaware of this complementarity, as the courses have been lectured as silo-discipline. With this project, teachers intended to close this gap, contributing for a more holistic view of the courses, at least of these two. By the perspective of the students, this seems being achieved. Also the evidences of students work, reveals they were beyond the knowledge, acquiring competencies. With this type of project, competences as entrepreneurship, personal and social skills are promoted in parallel to engineering and technical expertise. For future work, the authors have in mind to improve the questionnaire to include more competence-related questions.

Acknowledgments

This work has been supported by FCT – Fundação para a Ciência e Tecnologia within the R&D Units Project Scope: UIDB/00319/2020.

6 References

Alves, A. C., & Soares, F. (2020). Learning engineering contents from different courses through a hands-on activity teamwork. *CISPEE2020 (4th International Conference of the Portuguese Society for Engineering Education*, To be published 2021.

Alves, A.C., Fernandes, S., Leão, C. P., Ferreira, A. T., Sousa, R., & Moreira, F. (2018). Students' perceptions and motivation in an industrial engineering and management program along their academic journey: First results. *International Symposium on Project Approaches in Engineering Education*, *8*, 107–116.

Alves, Anabela C., Leão, C. P., Moreira, F., & Teixeira, S. (2018). Project-Based Learning and its Effects on Freshmen Social Skills in an Engineering Program. In *Human Capital and Competences in Project Management*. InTech. https://doi.org/10.5772/intechopen.72054

Bonwell, C. C., & Eison, J. A. (1991). Active Learning: Creating Excitement in the in the classroom. In *ERIC Digest*. http://files.eric.ed.gov/fulltext/ED340272.pdf

Chapman, A. (2002). *"Theory X" and "Theory Y" management staff*. http://www.businessballs.com/mcgregorxytheorydiagram.pdf

Council of the European Union. (2018). *Proposal for a Council Recommendation on Key Competences for Lifelong Learning*.

Felder, R. M., & Brent, R. (2006). *Active Learning*. University of West Florida.

Fernandes, S. R. G. (2014). Preparing Graduates for Professional Practice: Findings from a Case Study of Project-based Learning (PBL). *Procedia - Social and Behavioral Sciences*, *139*, 219–226. https://doi.org/10.1016/j.sbspro.2014.08.064

Flumerfelt, S., Alves, A. C., & Khalen, F.-J. (2014). Lean Engineering Education: The DNA of Content and Competency. *Proceedings of the 2014 IIE Engineering Lean and Six Sigma Conference, 2014 Lean Educators Conference*.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences*, *111*(23), 8410–8415. https://doi.org/10.1073/pnas.1319030111

Gibbs, G., & Habeshaw, T. (1992). *Preparing to teach: an introduction to effective teaching in higher education* (Second edi). Technical & Educational Services Ltd.

Grasso, D., & Martinelli, D. (2007). Holistic engineering. *The Chronicle of Higher Education, The Chronicle Review*, *53*(28), B8-9.

High Level Group on the Modernisation of Higher Education. (2013). *Improving the quality of teaching and learning in Europe´s higher education institutions* (Issue June). https://doi.org/10.2766/42468

Hounsell, D. (1979). Learning to learn: research and development in student learning. *Higher Education*, *8*, 453–469.

Kang, S. Y. (2019). *To build the workforce of the future, we need to revolutionize how we learn*. World Economic Forum. https://www.weforum.org/agenda/2019/09/to-build-the-workforce-of-the-future-we-need-to-revolutionize-how-we-learn-wecome-to-digital-learning-2-0/

Nair, C. S., Patil, A., & Mertova, P. (2009). Re-engineering graduate skills – a case study. *European Journal of Engineering Education*, *34*(2), 131–139. https://doi.org/10.1080/03043790902829281

Pellegrino, J. W., & Hilton, M. L. (2012). *Education for Life and Work: Developing Transferable Knowledge and Skills in the 21st Century*. The National Academies Press.

Rychen, D. S., & Salganik, L. H. (2000). *Definition and selection of Key competencies*. https://www.oecd.org/edu/skills-beyond-school/41529556.pdf

Shapiro, J. (2014). Competency-Based Degrees: Coming Soon to a Campus Near You. *The Chronicle of Higher Education*, *February*.

Soares, F., & Alves, A. C. (2019). Interdisciplinary Project Work to Learn and Integrate Contents in an Industrial Engineering and Management Programme - First Findings. *The Proceedings of the 7th Annual Conference of the UK & Ireland Engineering Education Research Network: Excellence in Engineering Education for the 21st Century: The Role of Engineering Education Research*, 113–120.

The Economist. (2015). *Driving the skills agenda: Preparing students for the future*.

Uebe-Mansur, A., Alves, A. C., & Torres, R. B. (2019). Trello as Virtual Learning Environment and Active Learning Organiser for PBL Classes: An analysis under Bloom's Taxonomy. *PAEE/ALE2019*.

UMinho. (2020). *Industrial Management and Engineering (Integrated Master's)*. Educational Offer. https://www.uminho.pt/EN/education/educational-offer/_layouts/15/UMinho.PortalUM.UI/Pages/CatalogoCursoDetail.aspx?itemId=3682&catId=11

UNESCO. (2010). *Engineering: Issues Challenges and Opportunities for Development*. http://unesdoc.unesco.org/images/0018/001897/189753e.pdf

UNESCO. (2015). *Rethinking education: Towards a global common good?*

UNESCO. (2016). *Education 2030: Incheon Declaration and Framework for Action for the implementation of Sustainable Development Goal 4*. http://uis.unesco.org/sites/default/files/documents/education-2030-incheon-framework-for-action-implementation-of-sdg4-2016-en_2.pdf

Veiga, A., & Amaral, A. (2009). Survey on the implementation of the Bologna process in Portugal. *Higher Education*, *57*(1), 57–69. https://doi.org/10.1007/s10734-008-9132-6

Vicente, S., Mattarredona, E., & Alves, A. C. (2014). The Importance of Blog as a Communication Tool to Support the Development of Project-Based Learning. *Proceedings of International Symposium of Project Approaches (PAEE2014)*, ID39.1-ID39.9.

World Economic Forum. (2015). *The skills needed in the 21st century*. New Vision for Education - Unlocking the Potential of Technology. https://widgets.weforum.org/nve-2015/chapter1.html

Zhang, Q., Zimmerman, J., Mihelcic, J., & Vanasupa, L. (2008). Civil and Environmental Engineering Education (CEEE) Transformational change: tools and strategies for Sustainability integration and assessment in Engineering Education. *Proceedings of the 2008 American Society for Engineering Education Annual Conference & Exposition*.

Do student initial expectations about PBL match their final perceptions?

Sandra Fernandes[1,2], Anabela C. Alves[3], Celina P. Leão[3]

[1] Portucalense Institute for Human Development, Portucalense University, Porto, Portugal;
[2] Research Centre on Child Studies – CIEC, University of Minho, Portugal
[3] ALGORITMI Centre, Department of Production and Systems, School of Engineering, University of Minho, Guimarães, Portugal

Email: sandraf@upt.pt; anabela@dps.uminho.pt; cpl@dps.uminho.pt

Abstract

This paper presents findings from a PBL approach which takes place in the Integrated Master's degree of Industrial Engineering and Management (IEM), at the University of Minho, Portugal. It is part of a curricular unit in the 1st year of the 1st semester called Integrated Project of Industrial Engineering and Management 1 (IPIEM1). This curricular unit follows PBL approach. In total, 56 students participated in the PBL approach in the academic year 2019/2020, forming six teams of nine to ten students. This paper aims to analyse students´ initial expectations about PBL and compare them with their final perceptions concerning their experience. Data were collected from an online survey, applied at the beginning of the project (n=41), in the 1st week, and at the end of the project (n=33), in the last week. This survey has been used successfully, since the year 2008/2009, to evaluate PBL approaches from students' point of view. In 2019/2020, the survey was adapted to be used for the first time, also at the start of the project, to collect students' initial expectations. Authors understand that the first week of the project is very intense and demanding, as students become aware of the several challenges which they will face throughout the semester. Findings form the comparative analysis of the survey show that teamwork appears as one of the most positive aspects about the PBL experience, but also one of the most challenging issues for students to overcome. Beyond the "normal" students' concerns about teamwork, high workload, and other issues, the second survey revealed interesting insights from students in regard to their understanding of the PBL assessment model, that were not perceived in the first week. Qualitative data from findings will also be explored and discussed in the paper.

Keywords: Industrial Engineering and Management Education; first-year students, student perceptions; project-based learning (PBL).

1 Introduction

Project-based learning (PBL) is an active learning approach where a team of students works together through a period of time to solve large-scale complex open-ended problems (Powell & Weenk, 2003). This author, who designated this approach as Project-led Education (PLE), with its origins in the Engineering Education field in Denmark, describes this methodology as the following: "a team of students tackles the project, provides a solution and delivers by an agreed time (a deadline) a team product such as a prototype and a team report. Students show what they have learned by discussing with staff the team product and reflecting on how they achieved it" (Powell, 2004, p. 221). At the School of Engineering at the University of Minho, PBL has been used in several engineering programmes (Industrial Engineering and Management; Mechanical Engineering; Electrical Engineering; Polymer Engineering; Textile Engineering) as a positive strategy to promote active learning and increase student motivation for learning.

According to Powell (1999), it is important to present a balanced picture of PBL by recognising its advantages and disadvantages. Below, we will present findings about the effectiveness of PBL and the positive and less positive aspects that are related to its implementation. The identification of these characteristics of PBL are important to guide the discussion of this paper, which aims to analyse students' expectations and compare them with their final perceptions about PBL.

Powell (1999, p. 13) identifies a list of advantages of PBL, namely: 1) Students are strongly motivated to work hard and effectively (on projects); 2) Students learn to learn; 3) Students pass rates can improve; 4) There is better communication and teamwork by students; 5) Students build up a learning partnership with each other and (in later years) with staff: learning together; 6) The syllabus is seen in the context of the project; 7) Students find out what they don’t know and can seek what they need; 8) Students learn to work to agreed deadlines; 9) PBL identifies early on those students who are “suitable” for real engineering at academic level; 10) Reasonable group expectations by staff and students put psychological pressure on all students to succeed. Unsuitable and lazy students are thrown out; 11) There are still opportunities for some traditional examinations where depth of understanding in specific subjects can be explored in detail; 12) Teachers must talk to each other about education issues across boundaries, 13) Staff must work together in project planning.

Apparent disadvantages of project-led education, according to Powell (1999, p. 15), include the following: 1) Students do not have precise knowledge of all the most advanced theories; 2) Students do not have a lot of memory knowledge; 3) The atmosphere compels students to work at the group tempo; 4) PBL is frustrating for those students who find it difficult to work in groups; 5) Not all the syllabus can be covered by any project; 6) It is not always easy to motivate students on subjects such as Maths; 7) Assessment is certainly not easy; 8) Project rooms cost money; 9) Tutors need to be open-minded and supportive of student development; 10) Tutor support of groups is a new skill and needs training; 11) There are big challenges for staff when students bring in good but unexpected questions; 12) In later years of the course, tutors cannot always “know everything”, thus we need teams of tutors and recognition of the need to do some redirecting of student questions to other tutors; 13) PBL requires teamwork for tutors, teachers, administrators and integration over the traditional subject boundaries.

Taking in consideration these important remarks about PBL and their implications on students’ and teachers’ role, this paper analysis students’ perceptions about a PBL semester, comparing their initial expectations (after the first week of the project) with their final perceptions (last week of the project), in the first year of an engineering degree programme at the University of Minho, Portugal. The aim of this study is to compare the results before and after the PBL semester, based on the application of an online questionnaire, including both quantitative and qualitative data. After a brief introduction to the definition of PBL and its principles, in the Introduction of this paper, section two describes the context of the study, followed by the research methods in section three. The results are presented and discussed on section four, which is organized based on the quantitative and qualitative data. The last section of the paper presents the conclusions and final remarks.

2 Study context

This section briefly presents the study context by introducing the Industrial Engineering and Management program of the first year, first semester project-based learning (PBL) (IEM11_PBL) developed in the context of the course called “Integrated Project of Industrial Engineering and Management 1” (IPIEM1). An overview of the IEM11_PBL is given, followed by a short description of the first and final week moments, which correspond to moments of high workload for both teacher and students (Alves et al., 2019) and also to the moment when the survey discussed in this paper was applied.

2.1 Description of IEM11_PBL

The first semester of the first year of Industrial Engineering and Management includes six courses and currently such courses are all integrated in PBL. This was not always the case but since the first experience that occurred in the academic year of 2004_2005 (Alves et al., 2007; Lima et al., 2007), it was permanently an endeavour. This was accomplished after some years with a more or less stable team of teachers collaboration that manage the difficulties of this complex educational project (Alves et al., 2016a; Alves et al., 2016b).

Its complexity comes from various factors. One of these factors is the dimension of staff coordination team that includes all teachers from the courses involved, that are from different departments belonging to different schools, tutors and educational researches. The number of European credits is five, equal for each course, in the European Credit Transfer and Accumulation System (ECTS), as the Figure shows. Introduction to IEM (IIEM), IPIEM1 and Algorithms and programming (AP) are from School of Engineering (brick colour), department of Production and Systems (the first two) and Information system (third one). General Chemistry (GC), Linear Algebra (LA) and Calculus (CC) are from School of Sciences (blue colour), department of Chemistry (the first one) and Mathematics department (the last two courses).

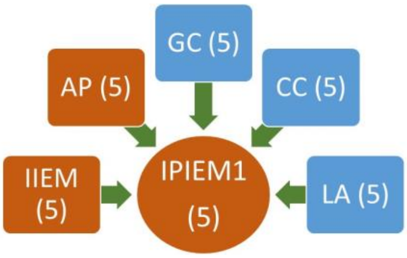


Figure 1. Courses of IEM11_PBL

Some or part of the contents of each course must be included in the project developed in the IPIEM1, according to each teachers guidelines and teaching styles, i.e. by specific task assignments. Students do these tasks in teams, the teacher provides feedback and students show their learning in the presentations, reports and project development. Each course has its own assessment method that could include various components such as tasks grade, written tests, among others. Students, normally, have more than one assessment moment by week of each course and IPIEM1. The main idea is that they work continuously for the project integrating along the semester (from September to February) components of each course in the project (Alves et al., 2019). The following section explains how IPIEM1 is planned.

2.2 Planning and development of IPIEM1

This section details the planning and development of IPIEM1. First of all, it is important to notice that this educational project is managed as a real project where the resources, time and cost are intended to be levelled, being divided in five main phases with the respective durations: 1) preparation (3 months); 2) set-up (1 month); 3) start-up (1 week); 4) execution (6 months); 5) conclusion (1 week) (Alves et al., 2009; Lima et al., 2012). The first two phases just involve staff coordination team. By doing this, students have also an example of how to manage a project, one of the competencies to acquire in IPIEM1. So, the first step is to plan the project and deliver a document, the learning project guide (Equipa de coordenação 2019_20, 2019) to the students with the description of project, i.e., it is similar to a project specification or project charter. This document has 14 pages and includes the following sections for the academic year 2019_20: 1) Introduction; 2) Advantages and challenges of the process; 3) Students; 4) Staff coordination team; 5) Tutor role; 6) Project description (theme, brief description, objectives); 7) Competencies (technical and transversal); 8) Timing (schedule, semester plan, milestones and first week project-pilot organization); 9) Assessment (for IPIEM1 and courses); 10) Physical resources; 11) E-learning platform and 12) Commitment declaration and checklist of space and material requirement. This document is delivered to students in the first presentation from the staff coordinator of semester where the project is presented to the students, which occurs in the start-up phase. After that, students are in conditions to start to develop the project. Each section of the document is a rich part of discussion but for this paper just the activities performed in the first and final week will be deeply discussed in the following sections. Before that, it is important to present, at least, the milestones where teams have some deliverables to send to the staff coordination team and the assessment model. The list, schedule and main deliverables of the milestones are presented in the Table .

Table 1. Milestones and deliverables of academic year 2019_20

Phase	#	Week	Deliverable
Execution	M1	Week 2	14h10 – 17h00: Mini-project presentation (10’ min/team + 5’ discussion).
	M2	Week 6	14h10 – 17h00: Intermediate presentation (10’ min/team + 5’ discussion).
	M3	Week 9	14h10 – 17h00: Extended tutorial (20’ min/team).
	M4	Week 12	18h00 – Deliverable: Preliminary report (maximum of 50 pages).
	M5	Week 16	18h00 – Deliverable: Final Report (maximum of 60 pages) + Prototypes.
Part of Conclusion	M6	Week 18	9h30 – 11h30: Individual written test about the project (2 questions). 9h10 – 13h00: Final presentation & discussion (15’ min/team + 20’ discussion.

The deliverable of M1 and M3 are usually not assessed, all the others are assessed by course teachers. The assessment model and its components (individual and team) are presented in the Figure 2.

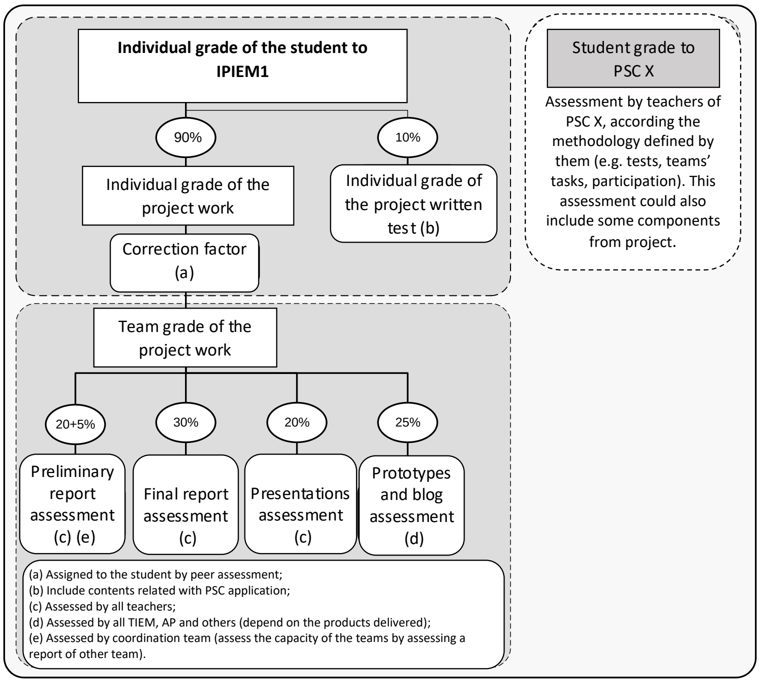


Figure 2. Assessment model of IPIEM1 of academic year 2019_20

2.2.1 First week of the project

The first week represents a high workload for teachers, in particular, for the coordinator, and students. It is a stressful moment but it is also a discovery moment for the students, meeting a new university, new colleagues, and for some, even a new city and country (international students). The students have to process a lot of information given in the first week of classes. During this week, students will have the welcome presentations from the Rector, from the dean of the department, from the course director and finally, from the coordinator of the semester and of the IPIEM1.

In a session organized by staff coordination team, the coordinator presents, through videos and reports from UNESCO, the global changes needing different competencies for the 21st century to contextualize the importance PBL. Then, introduces the IPIEM1, the historical of PBL editions in IEM11_PBL, some alumni testifies in person or written about PBL importance, the staff coordination team, the learning project guide, the tutor role, the milestones, the project theme of this particular year, the assessment model, the project-pilot, the semester plan and schedule, the e-learning tools and finally, the teams formed by one member of staff coordination team before this presentation and the tutors assigned to them. After this, they go with the coordinator and tutors to the projects rooms for them to start working if they want, or at least, to know each other and organize the first assignment as a team. Because there are only six spaces for the teams (two project rooms) only six teams are formed, that will put nine to ten members by team (always dependent on the number of freshman students). Also, IEM is always a programme with many working students (older) and transferred students that are also grouped in teams but do not take part in the PBL project (Alves et al., 2018).

The first-week project-pilot organization is also described in the learning guide project, section 8, and the idea is to pass by all phases of the project in a short period of time. A document of one page is provided to the teams with the description of the pilot project explaining what is expected from the teams, the duration of the activity, how they prepare and when to present and which main points to focus, reflecting also in the learning lessons to retrieve. Mainly, it consists in a week or a little more to prepare a presentation doing a state-of-art of the theme chosen for the specific year. In the academic year 2019_20, the theme was to design a production system to process/valorise organic residues into a valuable product, using composting or other process. An example of a first presentation of a team is shown in Figure 3.

Figure 3. First presentation of a team

The teams must also have to set-up a blog where the team introduces itself and their project. The blog must be updated with diary meetings and tasks that they are doing, the data and information being collected. The objective is to monitor team work. This blog was one of the student assessment components, for the first time this year.

2.2.2 Final week of the project

The final week also represents a lot of work because it is the conclusion of almost six long months of hard work including activities, tasks, tests, training sessions, events, and, of course, "praxe" (activities organized by the third grade students to welcome the freshman). The main deliverables in the last week are the final presentation and discussion done in teams and the individual written test about the project, synthetized in the final report, delivered in two weeks before.

With the final presentation, teams also present videos of production system in Legos Mindstorm demonstration and of the product, physical prototypes of the product, holder names in tags, some flyers of their product/company, among others elements that are optional elements (Figure 4).


Figure 4. Last presentation of the teams: elements bring by them to the presentation

After this last presentation, teams must deliver the project rooms keys. Before that, they must assure everything is clean and took all of their belongings. This does not have been an easy task, so in this academic year they were forced to sign a commitment declaration (section 12 in the learning project guide) where they declare to do this last task before leaving.

The last presentation means the last item for obtaining the grade. After that, the teams will be waiting for the final grades. Meanwhile, they are asked to fill out the questionnaire referred in the following section 3. But one more task is asked of them, the one in participating voluntarily in the final workshop organized by the staff coordination team in order to discuss the semester functioning. What ran well, what did not run well and suggestions for the future. In 2019_20 academic year, the coordinator started the workshop by presenting the summary of all projects, using padlet where all team elements were registered, and a video with all important moments occurred during the workshop. After that, the workshop was organized in four main parts: suggestions given by the students from the previous year and how these were implemented/not implemented and why, open discussion in focus groups about the main dimensions of the PBL questionnaire (as will be presented in the next section), the grades discussion and the questionnaire results. From this workshop, a lot of suggestions are obtained, being collected and used to improve the IEM11_PBL (Alves et al., 2012; Alves et al., 2019; Fernandes et al., 2014; Mesquita et al., 2009). Examples include having only one tutor third year student by team (Alves et al., 2017) and reducing the number of tasks and milestones (Alves et al., 2009; Alves et al., 2019).

3 Methodology

To analyse students perceptions about the PBL semester, data were collected from an online survey, applied at the beginning of the project (n=41), in the 1st week, and at the end of the project (n=33), in the last week. The survey is organized in six sections, including the following topics: i) project theme (D1); ii) learning and competences developed (D2); iii) teamwork (D3); iv) teacher´s role (D4); v) assessment model (D5); vi) PBL as a learning approach (D6), evaluated based on a 5-point agreement Likert scale (1 – strongly disagree to 5 – strongly agree). The online questionnaire also includes a set of open-ended questions for a better identification of the most positive (strengths) and less positive (weakness) aspects and suggestions for improvements. So, for the analysis, both quantitative and qualitative data will be considered. Due to the relevance of the topic, in this paper, the dimension that will be quantitatively analyzed is solely regarding the assessment model (v).

This survey has been used successfully, since the year 2008/2009, to evaluate PBL approaches from students' point of view (e.g. A.C. Alves, Moreira, Fernandes, Leão, & Sousa, 2017; Mesquita et al., 2009). In 2019/2020, the survey was adapted to be used, for the first time, also at the start of the project, to collect students' expectations of PBL. Authors understand that the first week of the project is very intense and demanding, as students become aware of the several challenges which they will face throughout the semester. The last week, where all developed activities and tasks in the project have been fulfilled and finished, allowing students a complete and comprehensive perception of how the semester run. These two moments will allow to understand and evaluate students' perceptions change.

4 Results

This section is divided in two subsections according to the nature of the data in analysis: (1) qualitative data, from the open-ended questions of the questionnaire, which provided an overall perspective of the dimensions most and least positively evaluated by students, as well as suggestions for future improvement; and, 2) quantitative data, based on results from the closed questions using a 5-Likert scale, which are analyzed solely in regard to the "assessment model" dimension (D5) from the questionnaire. The comparative analysis is described based on the results obtained in two different moments: first week and last week of the PBL semester.

4.1 Overall results from the PBL questionnaire – first and last week

Based on a thematic content analysis (Bardin, 2011), qualitative data from the open-ended questions was organized in categories. The frequency of the topic was also included to show the relevance of each category mentioned by students. Table2 presents a summary of the main results achieved.

Table 2. Comparison of qualitative results, before and after the PBL experience

Dimensions	Initial Survey - first week (n_b = 41)	Final Survey - last week (n_a = 33)
Most positive aspects	• **Teamwork (26)** • Project theme (9) • Successful integration at university (2) • Sharing ideas (2) • Presence of all teachers at the Mini-project presentation (1)	• **Development of transversal skills (14)** • Teamwork (9) • Understanding of the curricular units (7) • Successful integration at university (4) • Contact with future professional area (2)
Less positive aspects	• **Teamwork (7)** • Problems with time management (6) • Mini-project presentation (5) • Feeling lost in the first week (4) • Greater support from teachers (1)	• **Workload and tasks (14)** • Teamwork (5) • Stress (5) • Assessment methods (5) • Nothing to refer (3) • Others (3)
Suggestions for improvement	• Review project presentation dates (3) • Better link between project theme and the curricular units (3) • Improve group meetings and organization (3) • Develop more research (1) • Provide lecture about the project theme (1) • More information about the project goals (1) • More presence of teachers in project rooms (1)	• **Review assessment process and methods (21)** • More active role by teachers (6) • Review task deadlines and milestones (6) • Improve the project rooms' conditions (3) • Nothing to refer (2) • Improve the team formation process (1) • Select attractive themes for the project (1)

In general, it is possible to say that students' expectations about PBL in the first week match their final perceptions about the experience. One of the most positive aspects mentioned by students about this experience is definitely teamwork, both at the start (f=26) and also at the end (f=9) of the project. Teamwork has a strong influence on students' work and performance, either in a positive or negative way. These quotes from students' answers, after the first week of the project, confirm the importance of teamwork for students:

- *The sense of feeling that my team can jointly develop something useful considering the qualities of each one.*
- *The work developed with my team throughout the week.*
- *The friendly relationship with team members.*
- *Learn to deal with different personalities and get the best out of each one.*

Also, at the end of the project, students emphasised the importance of teamwork and its role for the project success:

- *During the project, it was difficult, sometimes, to learn to deal with the different opinions of my colleagues, in addition, the pressure to deliver everything on time and to know that it was not just up to me was not easy. I think they are many people on each team and that sometimes becomes difficult to manage.*
- *From the moment that the project was presented to us, there was a strong union between the PBL group members. So, not only did it facilitate our integration at the university, but it also made the work that we knew we had to do more interesting from the start. PBL gave us the possibility to carry out a project from its initial phase to its final phase, so we were able to acquire knowledge that will help us in the future life. In addition, although it can be quite arduous and stressful, it allows us to constantly overcome ourselves, developing many transversal skills.*

As mentioned in this last quote, PBL has a positive impact for the successful integration of 1st year students at the university, which is a great advantage of PBL considering that the transition to higher education is always a difficult and challenging phase of students' life (Araújo, 2017; Casanova, Araújo, & Almeida, 2020).

Concerning the suggestions for improvement, the majority of students (f=21) agree that the assessment method in PBL needs to be reviewed. This is definitely the main suggestion presented by students, who identify problems related to the peer assessment method, the final test of the project and the individual classifications, as issues that require further improvement in the assessment process of PBL.

- *The individual test does not fulfil its purpose! I propose that this test is completely reformulated, because even the members involved in the execution of tasks like WBS did not memorize it. Since the test is so short when compared to the execution of the entire project, in addition to being reformulated, it should have a lower weight in the final classification. Note that the classification obtained in this test was the main differentiator of the final grades of the group! "*
- *The final test does not correctly assess the role of each person in the project and whether or not they were aware of it. Peer assessment is necessary, but it should not count so much because many times our colleagues are unaware of the work underlying the results obtained.*

These qualitative results are in agreement with the quantitative results and express and explain the directions of students' opinions.

The problems concerning the assessment model of PBL are a recurring topic on the evaluation of PBL editions. It is considered the most controversial issue of PBL, both by students and the staff coordination team. The research team at the University of Minho has developed several studies and research projects to better understand this phenomena and develop a continuous improvement process (Alves et al., 2017; Alves et al., 2016a, 2016b; Fernandes et al., 2009, 2012a, 2012b; Lima et al., 2017).

4.2 Results related to the "Assessment Model" dimension

The assessment model dimension considered (D5) 10 items as described in Table 2. For the comparative analysis, the difference between students' mean rates considered was (before – after), assuming that, in average, the results for the assessment PBL project dimension is reduced. In Table 2 also some descriptive statistics (mean (m), standard deviation (sd), median (M), minimum (min), maximum (max)) for all the items considered for the assessment dimension are presented. A total of 41 (=n_b) students answered the online questionnaire in the first week and 33 (=n_a) in the last week. For the data analysis the SPSS statistical tool was used and non-parametric Mann-Whitney test U was considered (as alternative to the t-test for two independent samples), through Z-score value, to analyze differences between students' perceptions by moment, with a significance level of 5%.

Table 3. Descriptive Statistics and difference between students' mean rates (before – after = b – a) for D5.

Dimension	Item	m, sd, M, min, max		Statistics Z-score
		b	a	(b – a)
v. Assessment model	**D5.1** I have read and understood the assessment criteria in the Student Guide.	4.2, .74, 4, 3, 5	4.1, .74, 4, 2, 5	.231, p=.817
	D5.2 The number of milestones during the project should be lower.	4.1, .63, 4, 3, 5	2.9, .76, 3, 1, 5	**5.884, p=.000[a]**
	D5.3 Teacher's feedback on reports and presentations was clear.	4.7, .47, 5, 4, 5	3.5, .87, 4, 1, 5	**5.989, p=.000[a]**
	D5.4 Peer evaluation is an appropriate tool for evaluating teamwork.	4.2, .64, 4, 3, 5	3.4, 1.22, 4, 1, 5	**3.003, p=.003[a]**
	D5.5 The results of the peer evaluation reflect the commitment of each element.	4.3, .59, 4, 3, 5	3.1, 1.26, 3, 1, 5	**4.280, p=.000[a]**
	D5.6 Evaluating another team's report was a useful experience for me and allowed me to learn.	4.3, .60, 4, 3, 5	3.8, .83, 4, 1, 5	**2.971, p=.003[a]**
	D5.7 The final individual test on the project helped me prepare for the final presentation.	4.1, .69, 4, 3, 5	2.1, 1.05, 2, 1, 5	**5.410, p=.000[a]**
	D5.8 The project grade should be the same for all members of the group.	3.1, .98, 3, 1, 5	2.0, .77, 2, 1, 5	**4.779, p=.000[a]**
	D5.9 I think that the weight of the individual test should be lower in the final individual assessment of the student.	3.3, .96, 3, 1, 5	4.0, 1.03, 4, 2, 5	**-2.894, p=.004[a]**
	D5.10 In general, I am satisfied with the results obtained at the project.	4.3, .64, 4, 3, 5	3.5, 1.21, 4, 1, 5	**3.178, p=.001[a]**

[a] Statistically significant

With a single exception (D5.1 I have read an understood the assessment criteria), all students in average have change significantly their opinion during the moments beginning and end of the semester. The values reflect a changing to a more negative opinion regarding the several items in evaluation, showing that in average the initial expectations about PBL were higher than their final perceptions. This trend was particularly steep for D5.7 (The final individual test on the project helped me prepare for the final presentation), D5.3 (Teacher's feedback on reports and presentations was clear) and D5.2 (The number of milestones during the project should be lower). Namely the two last items, D5.3 and D5.2 show, somehow, a dissatisfaction regarding the teachers' feedback and strengthen the importance that the milestones have for the development of the PBL Project, despite the work involved.

However, results show that not everything has been negative or in a negative direction: item D5.9 increased, showing that, in average, students perceived that the weight of the individual test should be lower in the final individual assessment of the student. This issue is recurrent, however, it is teachers believe that this must be a term to be considered in the assessment model. The weight of the individual test on the student's final assessment has been undergoing significant changes over the past years (Anabela Alves et al., 2016a; Sandra Fernandes, Flores, & Lima, 2012).

5 Final remarks

This paper compares the initial expectations of IEM11_PBL students in the first and final week of the PBL phases that are the most intensive hard-working weeks. Although previous research and a number of studies have been developed about this PBL process, it was the first time that the survey was applied in two different moments. Beyond the "normal" and usual concerns about teamwork, high workload, time management and others issues identified by students, which were not, somehow, surprising, the second survey revealed interesting insights about the assessment model, that were not at all perceived by students in the first week. Besides the continuous effort taken every year, by teachers and specially the PBL coordinator, to make students aware of how the PBL semester will impact on their final assessment and learning, this dimension seems to be something that is not entirely clear for students at the start of the semester. At the end of the semester, students certainly take many “lessons learned” from their PBL experience, which helps them to prepare themselves for the second semester in a more conscious and critical way. Based on the findings from our study, it is possible to recognize the major advantages of PBL, as stated in the introduction section of this study, which somehow relief the teachers and PBL coordinator in regard to the aspects that were considered less positive by students. These features are part of students’ learning process and should be seen as an opportunity for their own development. Future work should focus on supporting and improving PBL, following some of the valuable suggestions provided by students in the final survey.

Acknowledgments

This work has been supported by FCT – Fundação para a Ciência e Tecnologia within the R&D Units Project Scope: UIDB/00319/2020.

6 References

Alves, A. C., Moreira, F., Sousa, R., & Lima, R. M. (2009). Teachers’ workload in a project-led engineering education approach. *International Symposium on Innovation and Assessment of Engineering Curricula*, 14. Valladollid.

Alves, A.C., Moreira, F., Fernandes, S., Leão, C. P., & Sousa, R. (2017). PBL in the first year of an industrial engineering and management program: A journey of continuous improvement. *International Symposium on Project Approaches in Engineering Education*, *9*.

Alves, A.C., Moreira, F., Leão, C. P., Pereira, A. C., Pereira-Lima, S. M. M. A., Malheiro, M. T., … Oliveira, S. (2019). Industrial engineering and management PBL implementation: An effortless experience? *International Symposium on Project Approaches in Engineering Education*, *9*, 117–127.

Alves, AC, Moreira, F., & Sousa, R. (2007). O papel dos tutores na aprendizagem baseada em projectos: três anos de experiência na Escola de Engenharia da Universidade do Minho. *Libro de Actas Do Congreso Internacional Galego-Portugués de Psicopedagoxía. A.Coruña/Universidade Da Coruña: Revista Galego-Portuguesa de Psicoloxía e Educación.*, (1), 1759–1770.

Alves, Anabela C., Moreira, F., & Leão, C. P. (2018). Dealing With Student Profile Diversity in an Industrial Engineering and Management Program: PBL vs “Non-PBL.” *Volume 5: Engineering Education*, V005T07A007. https://doi.org/10.1115/IMECE2018-86368

Alves, Anabela C., Moreira, F., Leão, C. P., & Teixeira, S. (2017). Tutoring Experiences in PBL of Industrial Engineering and Management Program: Teachers vs Students. *Volume 5: Education and Globalization*, *5*, V005T06A008. https://doi.org/10.1115/IMECE2017-71306

Alves, Anabela C., Sousa, R. M., Fernandes, S., Cardoso, E., Carvalho, M. A., Figueiredo, J., & Pereira, R. M. S. (2016a). Teacher’s experiences in PBL: implications for practice. *European Journal of Engineering Education*, *41*(2), 123–141. https://doi.org/10.1080/03043797.2015.1023782

Alves, Anabela C, Moreira, F., Mesquita, D., & Fernandes, S. (2012). Project-Based Learning in First Year, First Semester of Industrial Engineering and Management: Some Results. *Proceedings of the ASME 2012 International Mechanical Engineering Congress & Exposition IMECE2012*, 1–10.

Alves, Anabela Carvalho, Moreira, F., Carvalho, M. A., Oliveira, S., Malheiro, M. T., Brito, I., … Teixeira, S. (2019). Integrating Science, Technology, Engineering and Mathematics contents through PBL in an Industrial Engineering and Management first year program. *Production*, *29*(x), 0–0. https://doi.org/10.1590/0103-6513.20180111

Alves, Anabela, Sousa, R., Moreira, F., Carvalho, M. A., Cardoso, E., Pimenta, P., … Mesquita, D. (2016b). Managing PBL difficulties in an industrial engineering and management program. *Journal of Industrial Engineering and Management*, *9*(3), 586. https://doi.org/10.3926/jiem.1816

Araújo, A. M. (2017). Sucesso no Ensino Superior: Uma revisão e conceptualização || Success in Higher Education: A review and conceptualization. *Revista de Estudios e Investigación En Psicología y Educación*. https://doi.org/10.17979/reipe.2017.4.2.3207

Bardin, L. (2011). Análise do Conteúdo. In *Edições 70*.

Casanova, J. R., Araújo, A. M., & Almeida, L. S. (2020). Dificuldades na adaptação académica dos estudantes do 1º ano do Ensino Superior. *Revista E-Psi*, *9*(1), 165–181.

Equipa de coordenação 2019_20. (2019). *Guia do projeto aprendizagem no contexto Project-Based Learning (PBL): Projeto*

Integrado de Engenharia e Gestão Industrial 1 (PIEGI1_MIEGI11).

Fernandes, S., Flores, M. A., & Lima, R. M. (2012a). Student assessment in project based learning. In *Springer* (Vol. 9789460919, pp. 147–159). https://doi.org/10.1007/978-94-6091-958-9_10

Fernandes, S., Flores, M. A., & Lima, R. M. (2012b). Students' views of assessment in project-led engineering education: Findings from a case study in Portugal. *Assessment and Evaluation in Higher Education*, *37*(2). https://doi.org/10.1080/02602938.2010.515015

Fernandes, S., Mesquita, D., & Lima, R. et al. (2009). The impact of peer assessment on teamwork and student evaluation. *Innovation and Assessment of Engineering Curricula*, 125–136.

Fernandes, Sandra, Flores, M. A., & Lima, R. M. (2012). Students' views of assessment in project-led engineering education: Findings from a case study in Portugal. *Assessment and Evaluation in Higher Education*, *37*(2), 163–178. https://doi.org/10.1080/02602938.2010.515015

Fernandes, Sandra, Mesquita, D., Flores, M. A., & Lima, R. M. (2014). Engaging students in learning: Findings from a study of project-led education. *European Journal of Engineering Education*, *39*(1), 55–67. https://doi.org/10.1080/03043797.2013.833170

Lima, R.M., Carvalho, D., Sousa, R. M., Alves, A., Moreira, F., Mesquita, D., & Fernandes, S. (2012). A project management framework for planning and executing interdisciplinary learning projects in engineering education. In *Project Approaches to Learning in Engineering Education: The Practice of Teamwork*. https://doi.org/10.1007/978-94-6091-958-9_5

Lima, R.M., Dinis-Carvalho, J., Sousa, R. M., Alves, A. C., Moreira, F., Fernandes, S., & Mesquita, D. (2017). Ten years of project-based learning (PBL) in industrial engineering and management at the University of Minho. In *PBL in Engineering Education: International Perspectives on Curriculum Change*. https://doi.org/10.1007/978-94-6300-905-8

Lima, Rui M, Carvalho, D., Flores, A., & Van Hattum-Janssen, N. (2007). A case study on project led education in engineering: students and teachers perceptions. *European Journal of Engineering Education*, *32*(3), 337–347. https://doi.org/10.1080/03043790701278599

Mesquita, D., Alves, A., Fernandes, S., Moreira, F., & Lima, R. M. (2009). A First Year and First Semester Project-Led Engineering Education Approach 2 Organization Model. In D. Carvalho, N. van Hattum, & R. M. Lima (Eds.), *Proceedings of the 1st Ibero- American symposium on project approaches in engineering education (PAEE'2009)* (pp. 181–189). Braga, Portugal: Centro de Investigação em Educação, Universidade do Minho.

Powell, P. (1999). From classical to project-led education. In António Sérgio pouzada (Ed.), *Project Based Learning. Project-led Education and Group Learning.* (pp. 11–42). Braga: Thematic Network Plastics in Engineering.

Powell, P. C. (2004). Assessment of team-based projects in project-led education. *European Journal of Engineering Education*, *29*(2), 221–230. https://doi.org/10.1080/03043790310001633205

Powell, P., & Weenk, W. (2003). *Project-Led Engineering Education* (Vol. 53). https://doi.org/10.1017/CBO9781107415324.004

Helping Students to Avoid Critical Mistakes/Misunderstands when Using Active Learning/Project-Based Learning Approaches in Teaching Statistical Analysis

Huynh T. Luong

Asian Institute of Technology, Pathumthani, Thailand

Email: luong@ait.ac.th

Abstract

Nowadays, active learning/problem-based learning/project-based learning approaches are widely used in many academic programs of various institutions all over the world. It is believed that these approaches will help to train students in a better way, especially in building the skills through self-studying process and through dealing with practical problems. However, the use of these modern teaching/learning approaches does not mean that lecture-based approach should be completely ignored. Anyway, the time allocation of lecture-based approach should be reduced. During the limited time where lectures are delivered in the traditional way, the key requirement is how to equip the students with enough background knowledge so that they can proceed with self-studying or working with projects without committing critical mistakes related to theoretical background. From the author's experience of more than 20 years teaching statistical analysis related courses, this paper aims at identifying and sharing the common misunderstands observed from the students when studying statistical analysis course. These experiences can help to deliver statistical analysis related courses in an effective and efficient manner when using active learning/problem-based learning /project-based learning approaches.

Keywords: Active Learning; Statistical Analysis; Statistical Inferences.

1 Introduction

Statistical analysis has become a very important subject in all academic courses related to engineering study, management science and social science, just to name a few. Statistical analysis will help to withdraw useful conclusions from available datasets which can help the decision makers to make appropriate decisions for many practical problems. Due to the importance of statistical analysis, the course related to statistical analysis has been introduced even in secondary high school level in many countries. At universities, statistical analysis has become a required course in most curricula regardless of the field of study the students registered for. However, to most of students who took courses on statistical analysis, understanding and applying many statistical analysis techniques delivered in the course is not that easy, and hence, they might commit with various critical errors when applying these techniques. From the author's experience of more than 20 years teaching statistical analysis related courses, this paper aims at identifying and sharing the common misunderstands observed from the students when studying statistical analysis course. This issue is very important especially when active learning/problem-based learning/project-based learning approaches are used in delivering statistical courses. When the above-mentioned approaches are used, the lecture time is reduced, and the students are encouraged to learn through self-studying and problem solving. Hence, how to help the students avoid making mistakes when analysing practical datasets and to make correct decisions should be aimed at during the very limited lecture hours allocated for the course. This paper aims at identifying and sharing the common misunderstands observed from the students when studying statistical analysis course. These experiences can help to deliver statistical analysis related courses in an effective and efficient manner when using active learning/problem-based learning/project-based learning approaches.

2 Literature Review

Recognising the fact that traditional methods of teaching statistics are not effective and fails to help the students to apply statistical knowledge to deal with practical problems in the real world, Mustafa (1996) proposed the relevant objectives that should be aimed at to help develop competencies in the fields that do not require the students to have a strong mathematical/statistical background. These competences include the ability to link statistics and real-world situations, the knowledge of basic statistical concepts, and the ability to synthesize the components of a statistical study and to communicate the results in a clear manner. To serve this purpose, a revised course design approach has been proposed. In introductory statistics courses, many instructors recommended that the courses should place greater emphasis on data collection, graphical display of data, design of experiments, problem solving, and process improvements (Easton et al., 1988; Snee, 1990; Hogg, 1991; Moore, 1992). Following this recommendation, many courses on statistical analysis started with data analysis directly without introducing the theoretical background of statistical analysis techniques, i.e., probability theory. Even though probability concepts were introduced in some of these courses, the less emphasis on mathematical and probabilistic concepts (such as random variables, probability distributions, conditional probability, etc.) has led to the fact that the students failed to develop a real understanding of many basic statistical concepts, and hence, failed to apply these concepts in dealing with practical problems. However, it should be noted that teaching too much probability in statistical course is not good. It will be good if students have learned about probability theory before taking the course on statistical analysis. Otherwise, only the necessary probabilistic concepts needed to understand the derivations of statistical techniques should be introduced (Moore, 1992). A study by Konold (1995) also indicated that inappropriate instruction on probability concepts might fail to provide students with the skills to master statistical reasoning. Emphasizing on the issue of how to help students understand the concept of variation in statistics, Ballman (1997) recommended to change the traditional way of teaching probability with the use of appropriate topics and activities so that the students can easily capture the characteristics of random variation and relate the application of variation in statistics.

In relation to the use of active learning approach in statistical courses, Anderson-Cook and Dorai-Raj (2001) presented an active learning demonstration on the Internet using Java applets to show a poorly designed experiment and then subsequently a well-designed experiment. The framework demonstrates the concepts of randomization and blocking, as well as the need to carefully consider the objective of a study and how well the data collected answer the question of interest. The activity involves student participation and data collection. Later, Anderson-Cook and Dorai-Raj (2003) also proposed a number of applets to help students understand the role of power in hypothesis testing that allow them to obtain numerical values without having to perform any calculations for a variety of scenarios. These applets are introduced from the observations that the concepts of hypothesis testing, trade-offs between Type I and Type II error, and the use of power in choosing an appropriate sample size based on power are usually included in many introductory statistics courses. However, many students do not really understand these ideas, and hence, are unable to apply them in a correct and effective way in real world problems. Anyway, these applets only help the students to avoid mistakes but cannot help them develop an in-depth understanding about those concepts. Aberson et al. (2002) also derived an interactive Web-based tutorial that supplements instruction on statistical power. This tutorial provides several interactive exercises that guide students as they draw multiple samples from various populations and compare results for populations with differing parameters. The sampling exercises utilize an interactive Java applet that graphically demonstrates relationships between statistical power and effect size, null and alternative populations and sampling distributions, and Type I and II error rates. The applet allows students to manipulate the mean and standard deviation of populations, sample sizes, and Type I error rate. However, the same question on if the students really understand those concepts is still remained.

In other research lines, Alacaci (2004) investigated the knowledge base necessary for choosing appropriate statistical techniques in applied research. In this study, the author compared knowledge used by six experts and six novices in two types of statistical tasks, i.e., comparing research scenarios from the perspective of choosing a statistical technique, and direct comparison of statistical techniques. From the research results, the author recommended that statistical techniques should be taught in relation to relevant research designs, moreover, conceptual connections between statistical techniques should be explicitly taught. Examining the need of collaboration in learning and teaching statistics, Roseth et al. (2008) provided practical examples of how instructors may apply a cooperative framework to classroom teaching and teacher collaboration. This research aimed to persuade statistics instructors who are reluctant to adopt more student-centered teaching approaches, as well as those instructors who have tried these methods but ultimately returned to the traditional teacher-centered instruction. Recently, Da Silva and Moura (2020) addressed the problems of teaching statistical concepts in biostatistics where students often experience anxiety caused by the complexity of statistics and might express negative attitudes towards the subject.

For more literature and resources on teaching statistics, the readers are encouraged to read the review report of Becker (1996). Journal of Statistics Education is also a good resource for this purpose. To the best of my knowledge, most research works conducted in the past did not communicate clearly the common mistakes related to understanding of students when taking statistical courses. So, in the paper written here, I would like to share some experiences related to this issue with the hope that it will help the instructors who are in charge of delivering these courses at their institutions to recognise the problems the students usually faced with when taking statistical courses so that the courses can be delivered in an effective and efficient ways with more fun from the students' viewpoint.

3 Common Misunderstands in Studying Statistical Analysis

In this session, the discussions will be firstly on basic descriptive statistics including measures of central tendency, measure of variability, the z-score, and coefficient of variation. Then, discussions on hypothesis testing will be presented with the focuses on how the set the null hypothesis, what are the valid conclusions, and Type II error as well as how to control Type II error which is an issue that many students feel very confused when facing.

3.1 Measures of Central Tendency

Measures of central tendency yield information about particular places or locations in a group of numbers. The commonly used measures of central tendency in statistical analysis are mean (or weighted average, expected value), mode and median. When learning these measures, the students usually don't know when to use each of them, especially mode and median. It is noted that the mean value is familiar with all students, and later, nearly all statistical analysis techniques will be derived based on the mean. But why the mean is a good representative for a dataset? Why not use mode and median? In which cases, mode and median are better measures instead of the mean? The reason why the mean of a dataset is a good representative of a dataset is because it is an unbiassed estimator of the mean of the population from which the dataset is withdrawn from (i.e., the expectation of the mean of a dataset equals to the mean of the population). This property is a requirement for a good estimator (apart from efficiency and consistency properties of an estimator) which can be used to establish confidence interval and to test hypothesis about the mean of population. However, in some practical situations, the use of mean is not appropriate. For instance, in garment industry there is a need to determine the modal sizes (i.e., S, M, L, XL, XXL) of clothing. If the mean is used, the product will not fit with any customers. In such a situation, the mode should be used instead so that the product produced from modal sizes will fit with many customers in each category. Related to the use of median, this measure is appropriate when there exist extreme values in the dataset. In such a case, the mean will give biased information about the dataset, and hence, it is better to use median because this measure is not affected by extreme values. Anyway, it should be noted that there exist no statistical analysis techniques using mode or median. Therefore, in order to employ the mean for further analysis, the extreme values (or outliers) in the dataset should be excluded. Related to the determination of outliers, many students (and also some statistical software packages) use the range which is defined by three standard deviations from the mean (especially for the case when the population is assumed to follow normal distribution), and any value located outside this range will be considered as outliers. This is a wrong way to determine the outliers that many students committed when studying statistics.

3.2 Measures of Variability

Measures of variability describe the spread or the dispersion of a dataset. The most commonly used measures of variability in statistical analysis are variance and standard deviation. Mathematically, the standard deviation is just the square root of the variance. But why need both? This is a question that most students cannot answer, and hence, they may apply those concepts in a wrong way. It should be noted that the variance of a dataset (or sample) S^2 can be used to approximate the variance of the population σ^2, but the standard deviation of a dataset, S, cannot be used to approximate the standard deviation of the population, σ. The reason behind this is that the expected value of S^2 is exactly the same as the variance of the population σ^2 (i.e., $E[S^2] = \sigma^2$), and hence, S^2 is an unbiassed estimator of σ^2. However, the expected value of S is not the same as the variance of the population σ (i.e., $E[S] \neq \sigma$), and hence, S is not an unbiassed estimator of σ. Anyway, when the sample size is large enough, we will have $E[S] \approx \sigma$, and therefore, σ can be approximated by S.

3.3 The z-score

The z-score (or the standardized value) of a specific value in a dataset is a measure in term of how many standard deviations the value is different from the mean of a dataset. In fact, it is impossible to say that the absolute difference between a specific value and the mean is small, medium, or large. Therefore, to have a clear picture about this difference, the z-score should be used. For instance, if we look at the difference between the monthly salary of an engineer working in a manufacturing plant and the mean salary of the group of engineers working in the same functional department, we cannot say anything about the position of that engineer in the department and his authority in the group. But the z-score of his monthly salary will reveal such an information. If the z-score is negative, that engineer does not perform well; if the z-score is between 0 and 1, the engineer performs normally but he is just a normal engineer in the group; if the z-score is between 1 and 1.5, he is a good engineer; and if his z-score is greater than 1.5, he performs excellently, and hence, some authority has been vested on him. In quality control, the z-score is also usually used to identify if the shift in mean of the proves is small, medium, or large (e.g., <1: small; 1-1.5: medium; >1.5: large). Then, appropriate control charts will be derived to monitor the process (e.g., the Shewhart control charts can be used to help detect medium to large shifts, CUSUM or EWMA control charts can be used to detect small shifts).

3.4 Coefficient of Variation

Coefficient of variation is a measure of relative dispersion in the dataset. It is determined as the ratio of the standard deviation to the mean, expressed as percentage. Similar to the z-score, the coefficient of variation will reveal the true information about variation in the dataset. In many practical problems, using standard deviation alone will not help the analysts to conclude that variation in the dataset if high or low. For instance, when observing records on demand of a product, if the average weekly demand is 100 units/week with the corresponding standard deviation is 20 units/week, then the coefficient of variation is 20% which means that the demand variability is high. However, if the standard deviation of demand is still 20 units/week but the average weekly demand is 1000 units/week, then the coefficient of variation is only 2%. In such a case, the demand rate can be considered as a constant (i.e., not change). Using coefficient of variation will help the students to determine if a deterministic model or a stochastic model should be use when analyzing the dataset.

3.5 Hypothesis Testing

Hypothesis testing can be used to determine whether a statement about the value of a population parameter should or should not be rejected. The common procedure recommended in many textbooks for testing hypothesis is as follows:

- Establish hypotheses: state the null and alternative hypotheses.
- Determine the appropriate statistical test and sampling distribution.
- Specify the Type I error rate $\boldsymbol{\alpha}$
- State the decision rule.
- Gather sample data.
- Calculate the value of the test statistic.
- State the statistical conclusion.

The common mistake that many students made in step 7 is to conclude that "Accept the null hypothesis". It should be noted that the null hypothesis is just an assumption and the ultimate target when conducting the test is to find evidence to reject the null hypothesis. So, if there exists evidence to reject the null hypothesis then the statement in the alternative hypothesis can be confirmed (with the probability of error α, called Type I error). However, in case the null hypothesis cannot be rejected, it should not be accepted. In this situation, the assumption stated in the null hypothesis is still valid, but it is true or not we don't really know. The decision to accept the null hypothesis might lead to a very high error (Type II error β).

Another mistake usually observed from students in social sciences and management is that they usually establish the null hypothesis in a wrong way. For instance, H_0: Price has effect on demand. It should be noted that the assumption in the null hypothesis should point to a unique scenario because we need to have a unique assumed distribution for the population to help conduct the test. The assumption stated in the above null hypothesis does not satisfy this requirement (i.e., has effect! How large???). Instead, the above null hypothesis should be stated as H_0: Price has no effect on demand. It should be also noted here that if the null hypothesis H_0: Price has effect on demand is used in the test, there is no way to confirmed that price is actually has effect on demand (this is usually the target of this test) because we are not allow to say that the null hypothesis is accepted.

One interesting point related to hypothesis testing is also about the one-tailed test. In one-tailed test, such as the right-tailed test for the mean of population $H_0: \mu = \mu_0$; $H_a: \mu > \mu_0$, the students usually did not recognize that this test seems to violate the basic requirement in which the statements in the null hypothesis and the alternative hypothesis must be collectively exhaustive. So, the correct establishment should be $H_0: \mu \leq \mu_0$; $H_a: \mu > \mu_0$. However, the null hypothesis $H_0: \mu \leq \mu_0$ does not refer to a unique scenario, and hence, the test cannot be conducted because the hypothesized distribution of the population is not well-defined. Due to this, the null hypothesis should be revised to $H_0: \mu = \mu_0$. Can we do this? The answer is certainly yes because the test is considered to provide useful conclusion only when the alternative hypothesis is confirmed. So, if we cannot confirm this, it means that the original null hypothesis, i.e., $H_0: \mu \leq \mu_0$, is still a valid assumption. This is similar to the problem where we want to prove that a variable (such as μ) is greater than all values in a set, we need to prove that that variable is greater than the maximum value of the set (i.e., μ_0).

Related to using one-tailed test or two-tailed test, it depends on the nature of the problem at hand. For instance, if we want to test if the lifetime of a battery is not different from the nominal lifetime declared by the manufacturer (null hypothesis), the test should be conducted on both tails of the sampling distribution. However, if we want to test if the concentration of a harmful substance in the outflow of a water treatment plant does not violate the regulation on environmental protection (null hypothesis), the test should be conducted on the right tail of the sampling distribution. But in many practical applications, the analyst might convert a two-tailed test into one-tailed test. The reason for this is to enlarge the rejection region so that it is easier to reject the null hypothesis, and hence, the alternative hypothesis can be confirmed.

3.6 Type II Error

Type II error β is the probability to conclude that the null hypothesis is "accepted" when in fact it is false. Type II error is usually very high and it is not under the control of the analyst, especially when the statement in the null hypothesis is not violated too much, and hence, it is difficult for the analyst to find enough evidence to reject it. When analysing Type II error, many students feel very confused because they don't really understand how to determine Type II error and what is the application of this concept. In the course of statistical analysis, the instructors should spend enough time to help the students understand the derivation of the formula used to determine Type II error for the test. For a two-tailed test, the general formula used for determining Type II error is:

$$\beta = \Phi\left(\frac{\mu_0 - \mu_1}{\sigma/\sqrt{n}} + z_{\alpha/2}\right) - \Phi\left(\frac{\mu_0 - \mu_1}{\sigma/\sqrt{n}} - z_{\alpha/2}\right)$$

From the above formula, it should be noted that even the analyst cannot control Type II error, but the value of Type II error can be manipulated by increasing sample size. Also, a critical shift (i.e., the shift at which we want to reject the null hypothesis with a high probability) $\delta = \mu_0 - \mu_1$ should be defined. Understanding Type II error and how to manipulate it is very important in many practical situations. For instance, in establishing quality control charts, Type II error must be analysed in order to select an appropriate sample size and sampling frequency so that the control charts can help detect the critical shift in an expected time period.

4 How to Help Students to Avoid Mistakes

In the former sessions, the common misunderstands the students usually committed in studying statistical analysis have been shared. How to help students to avoid making mistakes is a very challenging issue. Using traditional teaching/learning approaches with home assignments/exams will not help. In fact, active learning/problem-based learning/project-based learning approaches can be employed for this purpose. Following the above-mentioned learning approaches, it is recommended that the lecturers should request the students to work in groups to deal with practical problems/projects. Through these group projects, the students are encouraged to apply statistical knowledge to analyse the existing problems, find the root causes of the problems based on historical data, test the efficiency/effectiveness of various possible solutions, and finally, select the best solution for the problem at hand with sound statistical evidences. Inappropriate decisions making during the analysis process will become learning lessons for the students and help them to digest the knowledge with the hope that they will not make similar mistakes in their future career.

5 Conclusion

In this paper, some mistakes and misunderstands the students may commit when studying statistical analysis courses are communicated and shared. Helping the students to avoid these mistakes/misunderstands will help to build confidence in them when applying statistics in dealing with practical problems, and also help them to study more complicated statistical analysis techniques without facing any big problems. These experiences are shared with the hope that active learning/problem-based learning/project-based learning approaches can be launched in an efficient and effective manner for courses on statistical analysis.

6 References

Aberson, C.L., Berger, D.E., Healy, M.L., and Romero, V.L. (2002) An Interactive Tutorial for Teaching Statistical Power. *Journal of Statistics Education*, 10(3), DOI: 10.1080/10691898.2002.11910682

Alacaci, C. (2004). Inferential Statistics: Understanding Expert Knowledge and its Implications for Statistics Education. *Journal of Statistics Education*, 12(2), DOI:10.1080/10691898.2004.11910737

Anderson-Cook, C.M., and Dorai-Raj, S. (2001). An Active Learning In-Class Demonstration of Good Experimental Design. *Journal of Statistics Education*, 9(1), DOI:10.1080/10691898.2001.11910645

Anderson-Cook, C.M., and Dorai-Raj, S. (2003) Making the Concepts of Power and Sample Size Relevant and Accessible to Students in Introductory Statistics Courses using Applets. *Journal of Statistics Education*, 11(3), DOI: 10.1080/10691898.2003.11910721

Ballman, K. (1997). Greater Emphasis on Variation in an Introductory Statistics Course. *Journal of Statistics Education*, 5(2), DOI: 10.1080/10691898.1997.11910529

Becker, B.J. (1996). A Look at the Literature (and Other Resources) on Teaching Statistics. *Journal of Educational and Behavioral Statistics*, 21(1), 71-90.

Da Silva, H.A., and Moura, A.S. (2020). Teaching Introductory Statistical Classes in Medical Schools using RStudio and R Statistical Language: Evaluating Technology Acceptance and Change in Attitude towards Statistics. *Journal of Statistics Education*, DOI: 10.1080/10691898.2020.1773354

Easton, G., Roberts, H. V., and Tiao, G. C. (1988). Making Statistics More Effective in Schools of Business. *Journal of Business and Economic Statistics*, 6, 247–260

Hogg, R. V. (1991). Statistical Education: Improvements Are Badly Needed. *The American Statistician*, 45, 342–343.

Konold, C. (1995). Issues in Assessing Conceptual Understanding in Probability and Statistics. *Journal of Statistics Education*, 3(1), DOI:10.1080/10691898.1995.11910479

Moore, D. S. (1992). "Teaching Statistics as a Respectable Subject," in *Statistics for the Twenty-First Century*, eds. Florence Gordon and Sheldon Gordon, MAA Notes No. 26, Washington: Mathematical Association of America, pp. 14–25.

Mustafa, R.Y. (1996). The Challenges of Teaching Statistics to Non-specialists. *Journal of Statistics Education*, 4(1). DOI: 10.1080/10691898.1996.11910504

Roseth, C.J., Garfield, J.B., and Ben-Zvi, D. (2008) Collaboration in Learning and Teaching Statistics. *Journal of Statistics Education*, 16(1), DOI:10.1080/10691898.2008.11889557

Snee, R. D. (1990). Statistical Thinking and Its Contribution to Total Quality. *The American Statistician*, 44, 116–121.

Make Product Design and Development Beyond Active Learning with 'LOVE'

Duangthida Hussadintorn Na Ayutthaya, Pisut Koomsap

A-Cube Research Group, Department of Industrial Systems Engineering, School of Engineering and Technology, Asian Institute of Technology, Thailand

Email: duangthidaHNA@gmail.com, pisut@ait.asia

Abstract

Product Design and Development has become a standard course in engineering and business master programs. The objective of this course is to provide students knowledge on a systematic product design and development process. With the new market trend and dynamic change of customer needs, the course content has been enhanced and put more emphasis on strategic design, creativity, and innovation. These changes have made an impact on the way this course should be taught. Intensive lectures with and without assignments cannot make the learning effective. Project-based learning, game-based learning, and university-industry teaching collaboration are some examples of active learning methods that have been promoted for delivering this course. They aim to provide practical and hands-on learning experiences for students. However, the students may or may not gain the learning experience as expected. Reasons are, for example, improper designed learning activities, improper preparation and execution process, the mismatch between teaching and learning styles, and undesirable learning environments. Therefore, this paper presents a framework of designing learning activities in the view of the student learning experience journey considering three key components of the learning experience: functional component, mechanic component, and humanic component. In order to ensure that the journey is dedicated to the cultivation of a strong learning experience, a recently developed learning experience model, 'LOVE', is incorporated. The proposed framework was implemented through the intensive product design and development course offerings at Tunghai University, Taiwan. Fifteen students attended the course. They were asked to provide feedback at the end of each session to keep track of their learning progress and crosscheck the effectiveness of the proposed process. According to their feedback, various dimensions of the courses were rated on the range of 'most satisfied' and many positive comments were also reported.

Keywords: Effective learning; Learning experience; Student Learning Experience Journey; Learning Experience Component; Product Design and Development; LOVE.

1 Introduction

Product design and development (PDD) has been playing important roles to drive and sustain the growth of businesses. How a product should be designed to be competitive and effectively respond to the customer needs as well as being survived in the fierce market is not easy. It requires a strategic thinking and systematic approach. The impact of well-designed products can also be seen as a mechanism that drives industries and the economy. Therefore, a course on PDD has been taught globally in different schools, from engineering to business at undergraduate and graduate levels. The content of the courses offered in different universities is adjusted according to the education level and the area of specializations.

As the customer needs are always dynamic and the advancement of technology expedites the capability to develop a new product, the course content has always been updated. Academic and practical researches in various dimensions - under the product design and development umbrella - rapidly produce up-to-date topics that can be integrated into the course. Besides the well-accepted literature developed by Ulrich (2003), many new topics, for example, Blue Ocean Strategy, Kano Questionnaire, and Quality Function Deployment (QFD) have been added to the PDD course offered at Department of Industrial Systems Engineering, Asian Institute of Technology, Thailand. The up-to-date course content, however, shall not be considered as the only key element that provides an effective learning experience for students to achieve the course learning outcomes and expected competencies. Teaching and learning methods is another crucial factor. How the course should be taught must also be considered. The regular lecture is perceived to be inadequate for deeper understanding, complex problem-solving skills, and creativity (Sajjad, 2010). According to that, the active learning approach has been promoted (Shekar, 2007). For example, at Gazi University (Turkey), students learned the industrial design course through the project-based learning method. The students were put in teams to collaboratively design an equipment bag for cycling, hiking, and mountain climbing sports with users (Yalman & Yavuzcan, 2015). At the University of Twente (Netherlands), the teaching format used to deliver the course product design was adjusted. In addition to the regular lectures, game-based learning, and practical workshops were also employed to provide practical and hands-on learning experience to students (Becker & Wits, 2014).

However, there are two sides to every coin. The active learning approach also has both pros and cons. Requesting students to play an active role in an activity may produce negative learning experience and lessens the enthusiasm in their learning if, for example, the activity disconnects them to the real-world practice. A student survey on a product design course reveals that students preferred fewer exercises with more depth. They mentioned that they would like to apply tools more on the design of a real product instead of analyzing existing products (Becker & Wits, 2014). This issue can be alleviated by applying the LOVE model (Hussadintorn Na Ayutthaya & Koomsap, 2017) which proposes designing balanced learning activities based not only on the level of student involvement but also on how the activity connects students to the learning process to cultivate a strong learning experience. In addition to that, an execution plan is also important to properly deliver the designed learning activities and avoid undesirable learning environment.

Therefore, this paper proposes a framework, in which the LOVE model is integrated, to design learning activities in the view of the student learning experience journey. The framework also considers three key components of the learning experience: functional component, mechanic component, and humanic component.

The framework was implemented through the intensive product design and development course offered at Tunghai University, Taiwan. To keep track of student learning progress and crosscheck the effectiveness of the proposed framework, fifteen students who attended the course were asked to provide feedback at the end of each session. According to their feedback, various dimensions of the courses were rated on the range of 'most satisfied' and many positive comments were also reported.

The remainder of this paper is structured as follows. In section 2, the LOVE model and its application are presented. The proposed framework is explained in section 3. Section 4 illustrates the implementation of the proposed framework to the intensive product design and development course and the student feedback. Conclusions are provided in section 5.

2 LOVE Model

The LOVE Model (Figure 1) describes that learning experiences along a learning journey are stimulated based on how students involve into a learning activity – depending upon the type of approach used by teachers, methods and tools used, and also on students' attitude – and how the activity connects students to the learning process. These two dimensions termed as student involvement (passive/active involvement) and nature of learning (absorption/immersion). In term of the nature of learning, absorption occurs when a teacher brings knowledge to the students while immersion occurs when students bring themselves to get involved to obtain the knowledge. Learning experience, therefore, is categorized into four realms: L-learner, O-observer, V-visitor, and E-experimenter.

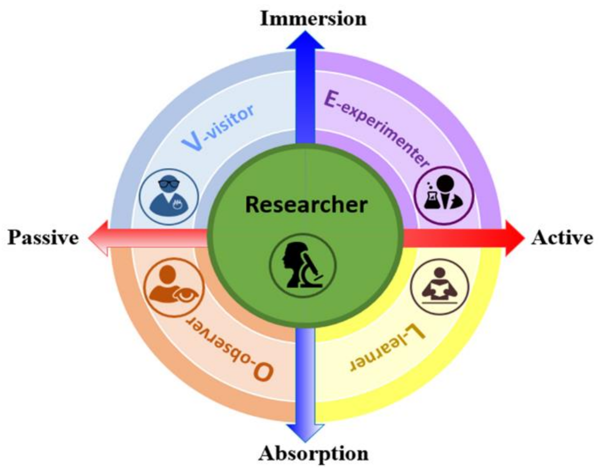


Figure 1. LOVE Model (Hussadintorn Na Ayutthaya and Koomsap, 2017).

Learner role implies active engagement of students but with rather specific, teacher originating, content. Observer role is a passive type of experience that is also made on teacher-based content. Visitor role is also passive but the circumstances are not ordinary ones and students can get immersed with the experience that is not, or not completely, prepared by the teacher. Experimenter role is both active and immerse type of experience that gives students partially or fully opportunity to use its own understanding and competences to participate and create the experience. In order to attain to researcher role, students must gain a variety of experiences which are transformative, influential, practical, effective and memorable to shape their research capability (Hussadintorn Na Ayutthaya & Koomsap, 2018). The outcome of this transformation is changing students from knowledge consumers to knowledge producers (Lovitts, 2005; Gardener, 2008). LOVE model suggests to include all type of experiences in studying programs and in specific courses. Balancing the experiences, which nowadays means including more active and more immersive approaches in education, should give the best results (Prince, 2004; Freeman et al., 2014).

Since some of teaching and learning methods, by their characteristics, share some similarities resulted in providing the same type of learning experience. The teaching and learning methods, collected from literatures, have been classified into four different categories of experiences (Hussadintorn Na Ayutthaya et al., 2019), as illustrated in Figure 2, to assist instructors for the selection of teaching and learning methods.

V-Visiting (passive immersion)	**E-Experimenting** (active immersion)
1. Field classes, trips and excursions 2. Conference 3. Virtual reality	1. Project-based learning (PjBL) 2. Laboratory classes 3. Virtual laboratory
O-Observing (passive absorption)	**L-Learning** (active absorption)
1. Lecture 2. Guided conversation 3. Integrated or interdisciplinary teaching 4. Showing video material 5. Seminars conducted in classes 6. Live lecture from a remote place	1. Discussion 2. Demonstration with exercising 3. Class debate 4. Small groups debate 5. Simulation 6. Problem-based learning (PrBL) 7. Programmed teaching 8. Workshop 9. Brainstorming 10. Case study 11. Online interactive learning 12. Game-based learning 13. Guided practical exercises 14. Role play 15. Assignments 16. Individual presentation

Figure 2. Teaching and Learning Methods on LOVE grid (Hussadintorn Na Ayutthaya et al., 2019).

3 Proposed Framework

An effective learning experience journey that students walkthrough to complete a course to achieve the expected knowledge, skills, and competence is the result of their interactions with the three key components of the learning experience (Figure 3). They are (1.) functional component: proper course content, (2.) humanic component: the ability of instructors to transfer knowledge and implement their teaching ability within a variety of learning activities, (3.) mechanic component: the variety of teaching and learning methods that stimulate the LOVE experience, and desirable learning environments.

If any component is omitted, the learning journey will be undesirable and ineffective. For example, when the course content is up-to-date, but the course is delivered in the traditional lecture-based teaching method. The course, therefore, does not provide any hands-on and practical experience that supports student competence development. In another case, when functional component and mechanic component are properly design, but the instructors cannot implement the designed modern activities. This causes a poor learning journey. The students gain improper learning experiences and have difficulty in completing the course.

Therefore, this paper proposes a design framework that begins with designing proper course content. The content should be up-to-date. The topics are aligned with the course learning outcomes and connect students to theory, tools, applications, and practices. Next is selecting proper teaching and learning methods. The proper result of this step is a set of learning activities that stimulates LOVE learning experience to students. The last step dedicates to the execution plan. The learning environment should support the implementation of designed learning activities. The result of this framework produces an effective learning experience journey for students. The designed journey does not only benefit the instructor to prepare and deliver the course but also assist students to properly prepare themselves to attend the class. The level of student involvement also signals students to be enthusiastic and get involved in the activities.

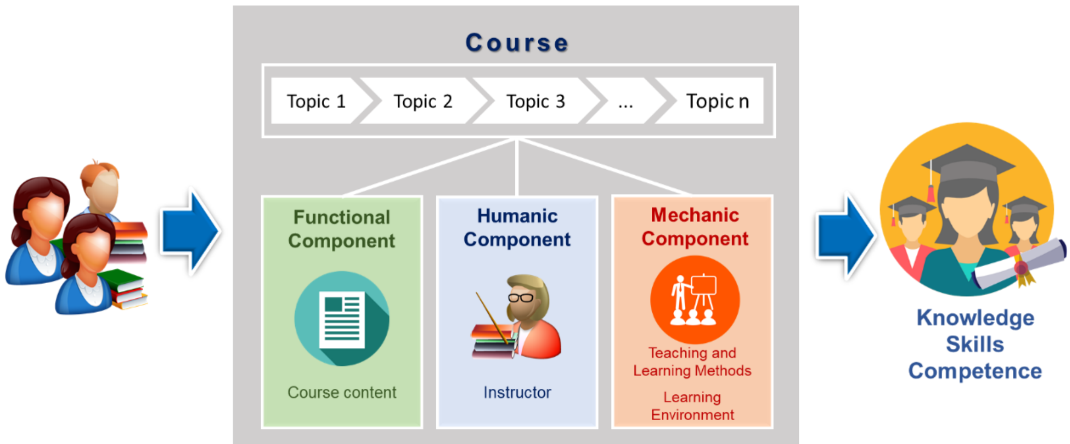


Figure 3. Key components affecting the learning experience.

4 Illustration on Intensive Product Design and Development Course

This section illustrates the implementation of the proposed framework on the intensive product design and development course.

4.1 Product Design and Development Course (PDD)

This is a 1-credit intensive course completed within four days. The course was offered at Tunghai University, Taiwan. The objective of this course is to provide students knowledge on a systematic approach for product design and development process. Students, on the completion of this course, were expected to: (1.) analyze products offered in a market for their effectiveness and (2.) develop a mission statement according to the identified business opportunity. The topics covered in this course are presented in Figure 4. In this course, the students will learn and practice how to systematically design products in a team environment. It is a participant-centered learning course that the students actively involve.

4.2 Designed Learning Experience Journey

As the course content has already been updated, the design process for this intensive course focused on selecting appropriate teaching and learning methods and designing a proper learning environment. The process started with understanding the student profile and background. The majority of students who registered for this course were undergraduate students. A few of them were Ph.D. students. Their areas of specialization were different. This course was new to them. Therefore, the instructor selected a simple product that all students could easily work on for their group project work. It was a vending machine (VM).

The duration of each class was within three hours excepting the class on the 4th day which was separated into two sessions – morning and afternoon. The number of course topics that were taught each day was distributed based on scope, depth, and class duration. Teaching methods used for each class were selected to provide a variety of learning experiences and balance the level of student involvement in the learning activities.

Figure 4 presents the designed learning journey for this intensive course. On the 1st day, the class began with group work on designing a VM. The students assigned into three groups. Without any lecture, each group applied their knowledge to design a VM. Then, the gallery walk was conducted. The class visited each group to listen to its short presentation. The groups received feedback from the instructor and classmates. After that, the groups were asked to discuss among the members and compare their ideas with other groups. The class ended with the lecture on the Introduction to PDD. The students started realizing how a product should be designed and perceived the importance of PDD.

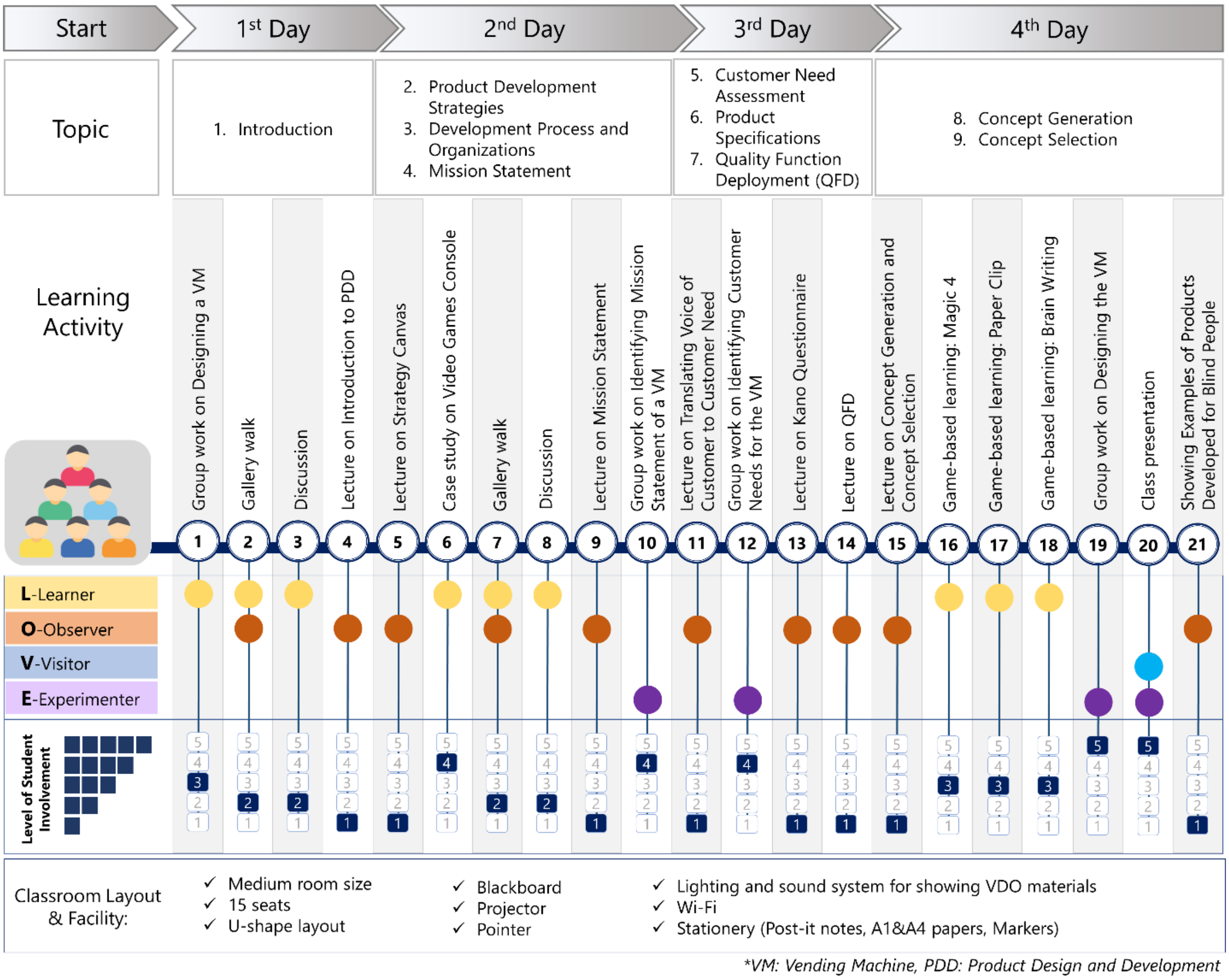


Figure 4. Designed Learning Journey for the Intensive Product Design and Development Course.

On the 2nd day, the class began with a lecture followed by a case study in which the students worked in groups to apply their knowledge gained from the lecture to the case study. Their ideas were presented to other groups through the gallery walk activity. The discussion among the members was the place for them to compare and reflect the pros and cons of their designed strategy canvases. The instructor continued the class with the lecture on the mission statement and asked the students to practice in the groups by identifying the mission statement for their VM. The instructor visited all the groups to provide supervision.

On the 3rd day, the class began with the lecture on translating the voice of the customer to customer need followed by the implementation in their group projects on designing the VM. Supervision from the instructor was provided during the group work. The class ended with the lectures on the Kano questionnaire and QFD. For the last day, the morning session began with the lecture on the last topic of the course. Then, the class played three games related to the PDD. The games aimed to push the students to think outside the box and stimulate their creativity. After lunch, the students were asked to continue on their group project and prepare for the class presentation. After a few hours, each group presented their project to the class. The other groups made comments and the instructor provided feedback to all the group at the end. The last activity was showing examples of products developed for blind people. It aimed to provide the overall picture of the PDD process to the students.

It can be seen that the learning journey provides the four types of the learning experience (LOVE). At the beginning, the students played the roles of learners and observers. When they started working on their group projects, they were immersed in the real applications of the theory. Their roles were changed to be experimenters. When attending the class presentation, their roles lied into two dimensions. Delivering the presentation put them in the experimenter role. Their roles changed to visitors when listening to the other groups’ presentations.

For the level of student involvement – based on the type of learning experience stimulated by different activities, it was varied and fluctuated. The students were demanded low involvement in lecture and gallery walk; medium involvement in the first trial of designing a VM and in the game-based learning activity; high involvement in case study, project work, and class presentation.

In terms of classroom layout and facility, the classroom was arranged in a U-shape layout composing of fifteen seats – five seats on each side. The size of the room was medium to facilitate the discussion and communication during the classes without using microphones. Equipment for lectures was provided. The lighting system and the sound system supported showing video materials. The Wi-Fi connection was available to all. The stationery such as post-it notes, paper sheets, and markers was always available for the students. The designed journey does not only benefit the instructor to prepare and deliver the course but also assist the students to properly prepare themselves before attending the class. The level of student involvement also signals students to be enthusiastic and get involved in the activities.

4.3 Implementation and Student Feedback

The designed journey has been implemented. Fifteen students attended the course. Figure 5 displays the class ambiance from various activities conducted during the classes. The classroom was arranged in a U-shape layout according to the design. All the designed learning activities were conducted. However, the students sometimes were already exhausted from their other classes. In order to have student enthusiastic in collaborating with the designed learning activities, especially for some of the activities that demand high level of involvement, the instructor normally provided refreshment and applied 5-minute or 10-minute breaks. Therefore, the average level of student involvement along the whole journey closed to the expectation.

At the end of each day, the students were asked to complete the online survey developed in each particular class. To keep track of the students' learning progress, they were asked to report what they have gained from each class and their pain points during the class activities. The course teaching assistant collected the data and reported it to the instructor every day. On the first day, some students reported having difficulty in listening because they were not familiar with the instructor's accent and his speaking speed. According to that, the instructor spoke slower. When students reported that they were not clear on some topics, the instructor revisited those topics in the following classes. Table 1 presents the students' reports on what they have obtained from the last session of the course. It can be considered as a reflection which shows that the students could achieve the course learning outcomes.

To monitor the quality of every class, the students were also asked to provide feedbacks on various dimensions covering three aspects: functional component (1. Quality of content), mechanic component (2. Quality of teaching methods, 3. Quality of teaching materials, 4. Quality of classroom infrastructure and facility, 5. Quality of learning environment during the class), and humanic component (6. Performance of the instructor, 7. Style of the instructor). Table 2 shows that, overall, the student satisfaction on this course is very high (1: least satisfied, 5: most satisfied). The overall score of all dimensions increased day by day. The students also rated very high score on recommending this course to their friends.

Figure 5. Class ambiance.

Table 1. What Students Obtained from the Last Session.

No.	Please explain what have you obtained from this session? (at the end of the 4th day)
1	How to make a mission statement, target the market, and design is not as simple as that. If we have a clear design, the next step will be not hard.
2	We finally summarized our mission statement and present our vending machine product design based on the mission statement.
3	The main idea of design is considering the fact of your product.
4	The big picture of how to design and develop the product.
5	Teamwork on product design.
6	Good at thinking.
7	Really helpful!
8	Know what costumer need is the most important thing about product design.
9	What is the difference between my vision and others'.
10	To know what customers want, to design what they really need.
11	I have learned about how important teamwork is, and how difficult a team to make desicon and make it happen.
12	I understand that when working on product design, I must put aside my prejudices and think about multi-faceted or cross-disciplinary possibilities.
13	How to design a good product for customer.

Table 2. Student Satisfaction on the Intensive Product Design and Development Course.

Dimension	1st day	2nd day	3rd day	4th day
	n=15	n=12	n=13	n=13
1. Quality of content	4.53	4.75	4.85	4.85
2. Quality of teaching methods	4.60	4.83	4.77	4.77
3. Quality of teaching materials	4.33	4.83	4.69	4.69
4. Quality of classroom infrastructure and facility	4.33	4.50	4.69	4.77
5. Quality of learning environment during the class	4.40	4.75	4.69	4.62
6. Performance of the instructor	4.67	4.67	4.85	4.77
7. Style of the instructor	4.47	4.75	4.85	4.85
8. How likely are you to recommend this course to your friends or colleagues?	0 1 2 3 4 5 6 7 8 9 10			9.54

5 Conclusions

The student learning journey-based design framework has been developed. In order to ensure that students do achieve the course learning outcomes, their learning experience journey must be properly designed. The journey shall be designed to provide the four learning experience types (LOVE) and balance the level of student involvement in the designed activities. Many key components that contribute to stimulating learning experience have to be considered, from course content, teaching and learning methods, learning environments to the role and style of the instructor. The designed journey does not only benefit the instructor to better prepare and deliver the course but also provide a guideline for students to properly prepare themselves before attending the class. The level of student involvement also stimulates student self-regulation and raises their awareness in collaboration along the learning journey.

The proposed framework, according to the implementation and results of the student survey, presents its effectiveness and potential to be applied in other courses.

6 Acknowledgements

The authors would like to express sincere gratitude to the Ministry of Science and Technology (MOST) of the Republic of China (Taiwan) for providing a traveling grant to deliver the course and a seminar at Tunghai University, Taiwan. The authors would like to also thank Prof. Chin-Yin Huang and the Department of Industrial Engineering and Enterprise Information, Tunghai University, for the kindly arrangement of the activities.

7 References

Becker, J. J., & Wits, W. (2014). An Experience-Based Approach to Teaching Product Design. In DS 78: Proceedings of the 16th International conference on Engineering and Product Design Education (E&PDE14), Design Education and Human Technology Relations, University of Twente, The Netherlands, 04-05.09. 2014 (pp. 688-693).

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. Proceedings of the National Academy of Sciences, 111(23), 8410-8415. doi:10.1073/pnas.1319030111

Gardner, S. K. (2008). “What's too much and what's too little?”: the process of becoming an independent researcher in doctoral education, The Journal of Higher Education, vol. 79(3), 2008, pp. 326–350.

Hussadintorn Na Ayutthaya, D., & Koomsap, P. (2017). Assessment of student learning experience with 'LOVE', In: 11th International Technology, Education and Development Conference, Valencia, pp.1973-1982.
Hussadintorn Na Ayutthaya, D., & Koomsap, P. (2018). An Application of 'LOVE' Model for Assessing Research Experience, In M. Peruzzini (Ed.), Trandisciplinary Engineering Methods for Social Innovation of Industry 4.0 (pp. 712-720). doi: 10.3233/978-1-61499-898-3-712
Hussadintorn Na Ayutthaya, D., Koomsap, P., Lima, R. M., & Nitkiewicz, T. (2019). Learning Experience from Teaching and Learning Methods in Engineering Education: Instructors' Viewpoint, In: 13th International Technology, Education and Development Conference, Valencia.
Lovitts*, B. E. (2005). Being a good course-taker is not enough: a theoretical perspective on the transition to independent research, Studies in higher education, vol. 30(2), 2005, pp. 137–154.
Prince, M. (2004). Does Active Learning Work? A review of the Research. Journal of Engineering Education, 93(3), 223-231.
Sajjad, S. (2010). Effective teaching methods at higher education level, Pakistan Journal of Special Education, vol. 11, pp. 29–43.
Shekar, A. (2007). Active learning and reflection in product development engineering education. European Journal of Engineering Education, 32(2), 125-133. doi: 10.1080/03043790601118705
Ulrich, K. T. (2003). Product design and development. Tata McGraw-Hill Education.
Yalman, Z., & Yavuzcan, H. G. (2015). Co-Design Practice in Industrial Design Education in Turkey A Participatory Design Project. Procedia-Social and Behavioral Sciences, 197, 2244-2250.

Students' participation in the internal quality assurance system and their role in enhancing learning

Violeta Carvalho[1], Senhorinha F.C.F. Teixeira[1]

[1] Department of Production and Systems, ALGORITMI Centre, School of Engineering, University of Minho, Guimarães, Portugal

Email: violetacarvalho_97@hotmail.com, st@dps.uminho.pt

Abstract

Quality assurance has seen many improvements since the Bologna Process in 1999 and internal quality assurance (IQA) systems have been emerging in Higher Education Institutions (HEIs), looking forward to the transparency and accreditation of study programs across Europe. Furthermore, quality systems should be focused on the improvement of students' experiences and, therefore, their learning. In this context, the effective involvement of students in the internal quality assurance system is vital to assure the enhancement process of teaching and learning and, consequently, the overall educational process.

Despite the variety of ways to obtain students' feedback, the most commonly used method by IQA systems is the pedagogical questionnaires. These have become an increasingly established way for students to have their voices taken into account. In this way, students can share their point of view, which is fundamental, because they have a clear and transparent perception of what is going well, as well as what is lacking in their study cycles, providing useful information for the IQA system. For this reason, these questionnaires are extremely important, and only with students' contribution, HEIs can act towards to improve.

Given the new developments of quality assurance, the purpose of the present paper is to emphasize the importance of students' involvement in the internal quality assurance system and propose methods to achieve it. Firstly, to understand the students' opinions regarding the pedagogical questionnaires, simple questions were applied to students of the University of Minho. The results showed that almost half of the students are unaware of the importance of their role in enhancing the quality of their HEI. To overcome this problem, HEIs might need to adjust their methodologies and processes to increase students' involvement in quality assurance. To this end, new strategies to capture students' attention and to improve the quality assessment are proposed.

Keywords: Higher education institutions; Internal quality assurance; Pedagogical questionnaires; Student engagement; Quality management.

1 Introduction

The concept of quality in Higher Education (HE) has become an increasingly important matter for institutions. Over the past fifty years, European HE has been undergoing reforms, however, since the late 1990s, the pace of change has significantly accelerated, mainly driven by the Bologna Process in 1999 (Diogo, 2014; Prisacariu, 2015). This is an intergovernmental HE reform process that emerged, mainly, to enhance the quality and recognition of European HE systems globally, encouraging a coherent and continuous development of quality (Reis, Formosinho and Lobo, 1974; Veiga and Amaral, 2009; Huet *et al.*, 2011; Diogo, 2014; Campanini and Bicocca, 2015; Fedeli, 2016).

Given this changing context, it is extremely important to implement a successful quality assurance system to guarantee and enhance the quality of Higher Education Institutions (HEIs). This can be reached through Internal Quality Assurance (IQA) and External Quality Assurance (EQA) (Figure 1). The first one occurs when the HEI carries out its own assessment using internal staff (e.g students) to check if policies and procedures set to ensure quality, meet the standards. The second one occurs when entities (governmental, para-state, or private agencies) carry out the assessment of the HEI (Keçetep and Özkan, 2014; Fedeli, 2016; Matei and Iwinska, 2016; Overberg *et al.*, 2019). In Portugal, the institution in charge of accrediting HEIs and courses is the *Agência de Avaliação e Acreditação do Ensino Superior* (A3ES). This is an autonomous institution, that aims to guarantee the quality of HEIs in Portugal, through evaluation and accreditation of its study cycles (Santos, 2011).

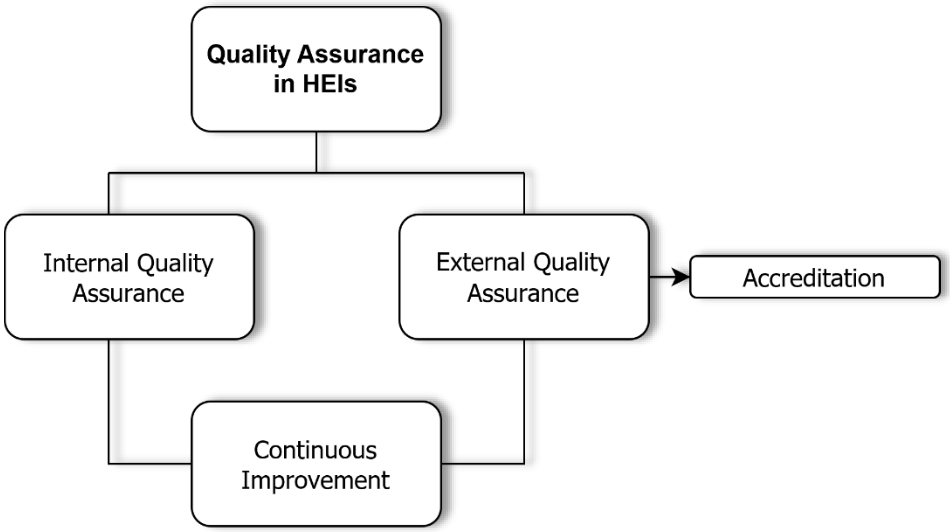


Figure 1. Quality assurance practices in HEIs.

Students are important stakeholders in the quality monitoring and assessment processes, and their participation in both external and internal quality assurance is vital (Alaniska *et al.*, 2006; Harvey, 2010). Currently, their involvement is mainly at the level of definition and political coordination of the evaluation process, in the pedagogical questionnaires, and in the participation in the audits managed by the external commission of evaluation (art. 12º and 19º Law 38/2007) (Lidice and Saglam, 2013).

Focusing on internal quality processes, HEIs implemented its own IQA system, which consists, mainly, of questionnaires that have to be filled in by students. These can be used for a quick gathering of information that helps the maintenance and improvement of the HEI quality (Friend-Pereira, Lutz and Heerens, 2002). Nevertheless, there is an ever-present difficulty that HEIs frequently deal with, caused by the lack of answers of students to this type of questionnaire. This led to the development of different studies on this matter (Little *et al.*, 2009; Lizzio and Wilson, 2009; Coffey and Gibbs, 2010; Little and Williams, 2010; Ryan, 2015). For instance, Elassy (Elassy, 2013) presented an interesting study where a model to increase students' involvement in QA was addressed, with great points to overcome this problem. Another interesting study was undertaken by Overbeg and her team (Overberg et al., 2019), where a new procedure for internal quality management focusing on students' competences was considered and the questionnaires played an important role. Other authors only have shown that the role played by students is inevitably important. For instance, Lidice and Saglam (Lidice and Saglam, 2013) studied the students' perspective by asking them to comment and evaluate the educational quality, course objectives, the performance of their instructor, their learning, learning support they received, among other important factors. Their findings provided some useful insights and revealed certain action points for the development of the teaching program.

As can be seen, the students' participation in the IQA system is crucial. Their insight is a powerful tool in maintaining quality and enhancing learning, due to their engagement in the study cycles' processes. For this reason, they hold a perspective on teaching and learning that cannot be drawn from any other source (Ryan, 2015). Despite the different studies about the desirability of increasing student involvement in the QA systems, very few existing studies have focused on the particular issue of student involvement in the IQA system by showing new strategies to overcome the devaluation and position of indifference that students face the IQA system. In this regard, an important focus of this work lies on giving an overview of students' perspectives about the pedagogical questionnaires and explaining the necessity of developing new methodologies to capture their attention and involvement in evaluating and enhancing the quality of their HEI. Additionally, another strategy to guarantee quality maintenance is presented.

2 Students' role in the IQA system and improvement proposals

Students' involvement in evaluating and enhancing the quality of their HEI is carried out through various specific activities. Nevertheless, one of the thoroughly developed and most widely used method by the IQA systems to obtain students' feedback, is the pedagogical questionnaires (Ryan, 2015). These are extremely important to evaluate the teaching quality and educational performance of teachers, providing direct student input into decision-making and discussions about the study cycles and institutional development. In this way, students can openly share their opinion and suggest what should be improved, since only they know how they have reached their learning outcomes and how the teaching has assisted them in this process. (Little and Williams, 2010).

Students have the ability to evaluate the situation from the learner's perspective, which others may not be able to take into account and, since they have a special interest in the quality of the academic program, their statement is crucial (Alaniska et al., 2006). Also, involving students in IQA initiatives is beneficial because of their transparency, i.e. all participants see the outcomes and subsequent changes and, therefore, provide an important contribution for quality assurance in HEIs (Lidice and Saglam, 2013; Ryan, 2015; Akareem and Hossain, 2016).

Nevertheless, most students tend to ignore these questionnaires, making it difficult to correctly and completely evaluate a curricular unit (CU). To overcome this problem, the IQA system of the University of Minho (UM) opted to impose consequences on students who do not answer the questionnaires, making this process mandatory. To understand the students' opinion regarding the pedagogical questionnaires and if this mandatory process is actually needed, the following questions were made:

1. If it was not mandatory to answer the pedagogical questionnaires, would you still answer?
2. If you think that your study cycle needs improvements, do you write in the suggestions of the pedagogical questionnaires or ignore them? Justify your answer.

It is important to note here that this study was applied to all students of UM and only 25 answered. The results obtained for each question are represented in Figure 2 and Table 1, respectively.

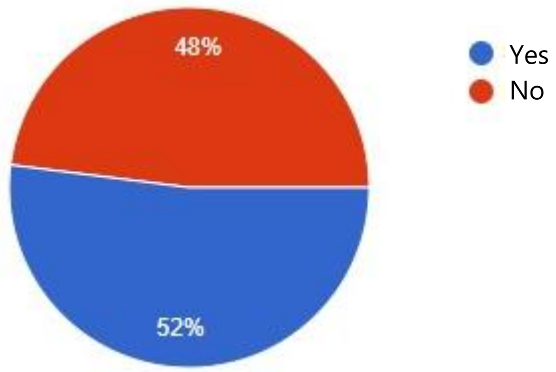


Figure 2. Percent of answers to question 1.

Looking at Figure 1, it can be observed that 48 % of students would not answer the questionnaires if it did not involve consequences. The results show that, in fact, the measure implemented by the IQA system of UM seems to be necessary. Otherwise, almost half of the students would not answer the questionnaires.

Table 1. Examples of answers obtained in the second question.

	Positive answers	Negative answers
Statements	"Yes, it is one of the few ways that we have to express ourselves in a simple way"	"I think that our opinion is not taken seriously. If so, there would be serious improvements between years and complaints from past years would not be repeated. I think that if they took full advantage of our opinions as students, it would be essential."
	"Yes, this way the University will know about the failures of the course which will enable their improvement."	"I ignore because the measures suggested by students to improve the quality of teaching are not put into practice by the university or department."
	"Yes, since it is a way to better evaluate our CUs and consequently the teachers"	"I usually ignore because I think who analyzes the results are not interested in what the students really think or say. Because many times, people complain but no change is visible."
	"Yes, because there are always aspects to improve in the CUs"	"I ignore it for a matter of time. Sometimes I am not willing to waste time on questionnaires."
	"Yes. Because it is an opportunity for students to show their perspective of their CUs"	"I ignore because I don't think anyone will read that"
	"Yes, but only when something bothered me a lot."	"No, because if I have a complaint, I stop going to those classes."
	"Yes, when I vividly remember points to improve."	"No, because they do not change anything."

Despite the few data obtained, an overview of students' perspectives of quality in HE was obtained, and by observing Table 1, it can be concluded that the second question was ignored by most students, and only fourteen statements were obtained. This shows clearly that HEIs must act and promote students' participation. The biggest problem lies in students' lack of knowledge about the importance of their contribution to improving the quality of their HEI. One of the main reasons for this problem may be that the HEI does not adequately convey what it is doing to meet students' needs. In fact, UM shares the quality report of each study cycle with their students, however the measures they are willing to take to improve it, are missing, but more importantly, students are unaware of the existence of such documents. It should be highlighted that, to surpass this problem, the University of Minho has made some improvements, for instance, the website now presents all the necessary information on quality assurance processes. They even created a flyer that contains all the instruments and mechanisms used. Even so, students are still not aware of the importance of quality assurance in HEIs. To overcome this problem, it is necessary to communicate to students the importance of their answers to the quality assurance system and that their contribution is, effectively, considered.

Note that, although students are a remarkable part of the IQA, professors play a fundamental role as well, and, accordingly, at the University of Minho they have also to answer specific questionnaires developed for them. Moreover, course commissions are also important, because make a direct connection between the perspective of students and professors.

3 Strategies to capture students' attention for its role in enhancing learning and to improve the quality maintenance

Given the important role of students in quality assurance, the development of strategic plans is crucial in the student-centered education context. In this sense, aiming to capture students' attention for its role in enhancing learning, new strategies are suggested. This can be achieved in many different ways and in a simple manner. For instance by sending an institutional email to students stressing the importance of their contribution, instead of merely informing the deadline to answer. Another powerful tool is the role of professors' testimony. They should work on persuading students about the importance of their views. Similarly, the delegate of each year must also take an active role in this matter, having the possibility to encourage students to answer the surveys and emphasize their role on IQA. The delegate can also transmit to the remaining colleagues the value of their participation, for instance, by means of social media, which nowadays, is the most powerful tool.

Additionally, another strategy that can attract students' attention is proposed, which is depicted in Figure 3. The idea would be to hold a meeting at the end of each year, in which the Course Director exposes to students the results from questionnaires and the measures they are considering implementing in the following year. Moreover, sharing measurements previously implemented by the study cycle would be of importance. This way, students would have the opportunity to actively contribute to improve their study cycle and see that, effectively, their opinions are taken seriously by the HEI and that is effective in the decision-making process.

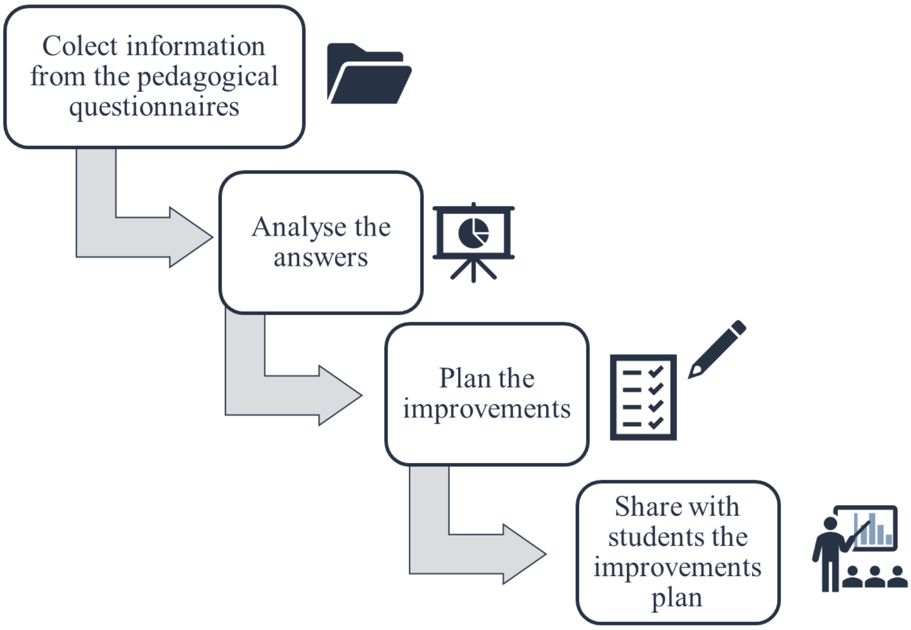


Figure 3. Schematic methodology to encourage students' participation in the IQA system.

Although the previous strategies are important, it is fundamental to use the information contained in the pedagogical questionnaires wisely. In Portugal, when the HE institution performs its auto-evaluation reports, the SWOT analysis is one of the tools applied. However, an extra methodology could be applied by having in consideration the Juran trilogy (Figure 4) applied in this context, i.e taking the students as costumers.

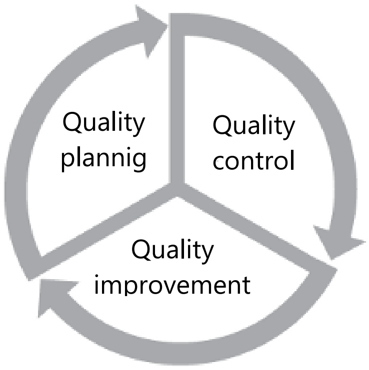


Figure 4. Juran Trilogy. Adapted from (McGrath and Bates, 2017).

According to Juran, quality is "fitness of use" and the emphasis should be on the customer. In this sense, the purpose of quality systems in higher education should act taking into account the enhancement of student experiences, by taking them as costumers (Santos, 2011). In this regard, after the SWOT analysis is completed, it is important to plan, control, and improve quality.

Firstly, the HEI should identify the student's needs, based on the questionnaires and, then use that information to create processes that can fully satisfy the students' needs. It should be developed and put in place the strategic and tactical goals that must be achieved. Note that this has already to be present in the auto-evaluation reports.

Secondly, during the implementation of reforms, the HEI should prevent or correct unwanted or unexpected changes, through periodic checks, measuring quality performance against expectations, identifying where the gaps are. This can be obtained by applying the same questionnaire in the middle of each semester and analyze the results.

Thirdly, quality planning could fail to meet student requirements and it is necessary to act in order to rectify any deficiencies and, therefore, improve the quality (McGrath and Bates, 2017). Establishing these steps, it is easier for the HEIs to improve the weaknesses and plan how to overcome the threats presented. It should be noted that this requires hard work from the HEIs since it is necessary to control the quality over the year, and it is not a task easy to take. However, it seems to be a powerful way to ensure that the HEI is effectively improving their quality by attending to students' needs.

4 Conclusions

Quality Assurance is one of the key elements of the Bologna Process and IQA systems have been emerging in HEIs aiming to achieve the transparency and accreditation of study programs across higher education systems. In this context, the effective involvement of students in IQA is crucial to assure the improvement process of teaching and learning within the study cycles. Their view offers very useful information resource for IQA and has a great impact in shaping vision and encouraging HEIs to adapt and improve their services. Nevertheless, the results presented in this study showed that almost half of the students are unaware of the importance of their contribution through the pedagogical questionnaires and, therefore, in the IQA system. This is worrisome since students' evaluation is a vital assessment instrument used for stimulating the quality enhancement of HEIs and without their active participation, this is difficult to achieve. This can be due to the feedback that HEI gives on the matter lacks details on what improvements they are prone to do and to what extent students' opinion is considered. By applying the strategies proposed, changes are expected in students' perception of quality and also in the quality evaluation process. Mainly, the strategy that involves holding a meeting at the end of each year with the students and the course director, is promising, because they can share their opinions and suggestions, and discuss the actions that should be implemented in the following year to enhance the quality of its study cycle. Despite the proposals presented in this study are based on the analysis of results obtained only at the University of Minho, they can be applied, if needed, at a national and international level in order to enhance the quality management of HEIs. As previously mentioned, this will imply further work for all those involved in IQA, namely professors and course directors. Nevertheless, other perspectives should also be taken into consideration to improve the quality assessment process involved in HEIs. Thus, it is necessary to make use of multi-faceted approaches to the evaluation of HEIs' quality.

Acknowledgements

This work has been supported by FCT – Fundação para a Ciência e Tecnologia within the R&D Units Project Scope: UIDB/00319/2020.

5 References

Akareem, H. S. and Hossain, S. S. (2016) 'Open Review of Educational Research Determinants of education quality: what makes students ' perception different?' Taylor & Francis, 5507. doi: 10.1080/23265507.2016.1155167.

Alaniska, H. et al. (2006) Student involvement in the processes of quality assurance agencies DG Education and Culture, The International Network for Quality Assurance Agencies in Higher Education(INQAAHE) Conference in Abu Dhabi, United Arab Emirates. Available at: http://www.enqa.eu/pubs.lasso.

Campanini, A. and Bicocca, M. (2015) Bologna Process. Second Edi, International Encyclopedia of Social & Behavioral Sciences. Second Edi. Elsevier. doi: 10.1016/B978-0-08-097086-8.28010-0.

Coffey, M. and Gibbs, G. (2010) 'The Evaluation of the Student Evaluation of Educational Quality Questionnaire (SEEQ) in UK Higher Education', Assessment & Evaluation in Higher Education, 26(1), pp. 89–93. doi: 10.1080/02602930020022318.

Diogo, S. M. A. (2014) 'Implementing the Bologna Process in Portugal and in Finland: National and Institutional Realities in Perspective', Journal of the European Higher Education Area, (1), pp. 35–54.

Elassy, N. (2013) 'A model of student involvement in the quality assurance system at institutional level', Quality Assurance in Education, 21(2), pp. 162–198. doi: 10.1108/09684881311310692.

Fedeli, L. (2016) 'Comparative Study on Students Involvement in Quality Assurance'.

Friend-Pereira, J., Lutz, K. and Heerens, N. (2002) 'European Student Handbook on Quality Assurance in Higher Education', The National Unions of Students of Europe, pp. 1–80.

Harvey, L. (2010) 'Student Feedback', Quality in Higher Education, 9(1), pp. 3–20. doi: 10.1080/13538320308164.

Huet, I. et al. (2011) 'Linking a research dimension to an Internal Quality Assurance System to enhance Teaching and Learning in higher education', Procedia - Social and Behavioral Sciences. Elsevier B.V., 29, pp. 947–956. doi: 10.1016/j.sbspro.2011.11.327.

Keçetep, İ. and Özkan, İ. (2014) 'Quality Assurance in the European Higher Education Area', Procedia - Social and Behavioral Sciences, 141, pp. 660–664. doi: 10.1016/j.sbspro.2014.05.115.

Lidice, A. and Saglam, G. (2013) 'Using Students' Evaluations to Measure Educational Quality', Procedia - Social and Behavioral Sciences. Elsevier B.V., 70, pp. 1009–1015. doi: 10.1016/j.sbspro.2013.01.152.

Little, B. et al. (2009) 'Report to HEFCE on student engagement', Higher Education, 4(February), p. 7. Available at: http://www.hefce.ac.uk/pubs/rdreports/2009/rd03_09/.

Little, B. and Williams, R. (2010) 'Quality in Higher Education and in Enhancing Learning: Is There a Students ' Roles in Maintaining Quality and in Enhancing Learning: Is There a Tension?', (October 2014), pp. 37–41. doi: 10.1080/13538322.2010.485740.

Lizzio, A. and Wilson, K. (2009) 'Student participation in university governance: The role conceptions and sense of efficacy of student representatives on departmental committees', Studies in Higher Education, 34(1), pp. 69–84. doi: 10.1080/03075070802602000.

Matei, L. and Iwinska, J. (2016) 'Quality Assurance in Higher Education: A Practical Handbook', Central European University. Available at: https://elkanacenter.ceu.edu.

McGrath, J. and Bates, B. (2017) The little book of big management theories ... and how to use them. Second. Pearson.

Overberg, J. et al. (2019) 'Internal quality management in competence-based higher education – An interdisciplinary pilot study conducted in a postgraduate programme in renewable energy', Solar Energy. Elsevier, 177(October 2018), pp. 337–346. doi: 10.1016/j.solener.2018.11.009.

Prisacariu, A. (2015) 'New Perspectives of Quality Assurance in European Higher Education', Procedia - Social and Behavioral Sciences. Elsevier B.V., 180(November 2014), pp. 119–126. doi: 10.1016/j.sbspro.2015.02.094.

Reis, C. S., Formosinho, M. and Lobo, C. C. (1974) 'Higher Education In Portugal: From Expansion To Quality Assessment', The Online Journal of New Horizons in Education, 4(4), pp. 1–10.

Ryan, T. (2015) 'Quality assurance in higher education: A review of literature', Higher Learning Research Communications, 5(4). doi: 10.18870/hlrc.v5i4.257.

Santos, S. M. (2011) 'Comparative Analysis Of European Processes For Assessment And Certification Of Internal Quality Assurance Systems'. A3ES.

Veiga, A. and Amaral, A. (2009) 'Survey on the Implementation of the Bologna Process in Portugal', Higher Education, 57(1), pp. 57–69. doi: 10.1007/s10734-008-9132-6.

Analyzing Online Learning Behavior and Effectiveness of Blended Learning using Students' Accessing Timeline

Piriya Utamachant[1], Chutiporn Anutariya[1], Suporn Pongnumkul[2], Nongnuch Sukvaree[3]

[1] Asian Institute of Technology, Thailand
[2] National Electronics and Computer Technology Center (NECTEC), Thailand
[3] Kasetsart University, Thailand

Email: piriya.utamachant@gmail.com, chutiporn@ait.ac.th, suporn.pongnumkul@nectec.or.th, fscinos@ku.ac.th

Abstract

Fundamental courses in most engineering curricula usually retain high enrollment rate, yet they induce several challenges on the course delivery such as learner differentiation, low interactions between learners and instructors, and thus leading to poor studying performance. This paper investigates and analyzes the effectiveness of applying a blended learning approach to overcome such important challenges. We applied a blended learning approach to the design and delivery of an engineering mathematics course to the first-year engineering students at a university in Thailand. The students' online learning behavior and learning performance have been analyzed using learning analytics and visualization techniques, resulting in two groups: i) Attentive students, who learned the online materials in parallel with the contents taught in classroom; and ii) Bypass students, who accessed merely online tests just before the course ending. The analysis found that most high performers were attentive students, while the majority of low performers were bypass students. The correlation between the student performance and the ratio of attentive to bypass students could be used as fundamental factors to evaluate the effectiveness of the blended learning approach for courses in the similar setting.

1 Introduction

Principal engineering subjects such as mathematics, physics and chemistry have been standing courses in most undergraduate engineering curricula for early-year students. Those course contents are basic knowledge essential for engineering and rarely change overtime. Blended learning is considered an effective pedagogy improvement over typical classroom methods since it can provide students extended learning supports by incorporating online learning tools and materials. To-date there exist several models to implement and deliver blended learning depending on the nature of the course and the learning environment (Blended Learning Universe, 2020). A 'Station Rotation model' rotates students through stations where at least one of them is online learning which is suitable for courses that have lab works or activities. 'Flex model' has online learning as a backbone while teachers provide support and instructions as needed. 'Flipped-classroom model' requires students to learn from online lectures and join the classroom for activities. 'Wrapped course' (Bruff et al., 2013), is a model where instructors "wrap" their courses around existing MOOCs. Students participate in part or in whole in a MOOC hosted at another institution, while teachers conduct face-to-face, classroom interactions. 'Online-as-a-supplementary' model uses face-to-face classroom as a core delivery while students are encouraged to study from online as a supplementary.

This research studied an engineering mathematics course which applied 'online-as-a-supplementary' approach. The online materials were designed as a MOOC course mimicking the classroom content and contained quizzes and assessments. The instructors announced that the MOOC score will be used as incentive scores, which counts as a part of the class final scores in order to promote student's usage of the MOOC. This strategy is effective to ensure students' engagement but some students merely participated to gain the incentive score without an intention to learn from it. Therefore, it is difficult for the instructors to evaluate the effectiveness of the blended learning.

Our research investigated student's behaviors in terms of efforts spent and accessing timeline on online materials in order to identify student's learning intentions and to evaluate the effectiveness of blended learning. The study revealed that most high performance students appropriately adopted the new methodology as they spent considerable efforts on online materials along with the classroom teaching period. On the other hand, most low performance students were stuck with traditional classroom teaching and attended online assessments just before the course ending period aiming to gain the incentive score. The different ratio between 2 intention groups can infer the effectiveness of the application of blended learning.

This paper is organized as follows. First, the background and structure of selected course are described. Second, the instructors' concerns on student's learning intentions and effectiveness of blended learning are explained. Next, the analysis results and recommendations for blended learning instructional design are discussed. Finally, the conclusion is presented.

2 Applying Blended Learning to Engineering Mathematics II

2.1 Background

'Engineering Mathematic II' is a fundamental engineering course in the undergraduate engineering curriculum of Kasetsart University. It is a standing course scheduled for the first-year students. The number of enrolled students is approximately 1,500 yearly. The course content covers advanced mathematics e.g. vector and quadric surface in 3D, partial derivative, multiple integrals and vector calculus. Because of the challenging contents and the variety of background knowledge, certain students struggled to catch up. The instructors also had trouble adapting their pace to ensure that students understand the contents well in the large classrooms setting. As a result, a number of students failed or unenrolled from the course. The course has been offered every semester for reattempting.

Thus, the instructors adopted the online-as-a-supplementary blended learning model, and published the online course on the Thai MOOC platform (www.thaimooc.org) in 2018 with the following objectives:

- Students who miss or do not catch up in class can access the course and replay as they wish.
- Students who seek to extend their understanding from the classroom content can find additional examples.
- Instructors can use certain online materials in classroom teaching e.g. 3D animations or quizzes.
- Students can practice mathematical problem solving to prepare for their exams. The online materials also provide valid resolutions with detailed explanation.
- Students can download classroom sheets and extra materials that the instructors prepared, e.g., formula summary or cheat sheet.

2.2 Course Structure and Delivery Method

The online materials were designed to mimic the classroom content, which comprised 5 chapters with the total of 165 video clips, 41 readings and 250 problems. Each chapter started with a pre-test, followed by an introduction video and contents (videos and readings), then ended with a quiz session and a post-test respectively. All videos had the duration between 2 – 10 minutes. Most readings were lecture slides that the instructors used in the classroom teaching. Problems on pre-tests, post-tests and quizzes had the same difficulty level. The grading policy were defined to consider the scores from classroom exams and from the online quizzes. The proportion can be broken down as shown in Figure 1a.

The course was launched in the inter-semester 2018 during June to August. There were 2 classrooms with 168 and 113 students. Most students were freshmen from the Faculty of Engineering. The online materials were hosted in Thai MOOC platform, based on Open edX. The suggested online learning effort was 5 hours/week with the total of 45 hours. The instructors spent their first session informing their classes about the online materials, its objectives including scoring policy as well as how to enroll and learn online. Throughout the semester, the instructors consistently motivated students to watch videos for additional detail on what he/she had taught. Students were encouraged to practice online problems when the instructors finished the lecture of each chapter. A week before the final exam, the instructors advised students to practice the MOOC post-test to get a direction of the final exam problems.

2.3 Learning Intentions and Blended Learning's Effectiveness: the Concerns

The instructors promoted the utilization of the online materials by including a score of the MOOC as 25% of the total course score. This incentive scheme is commonly used to stimulate student's engagement on online content. Surprisingly, to the best of our knowledge, there was no study on learning behaviors affected by such a scheme.

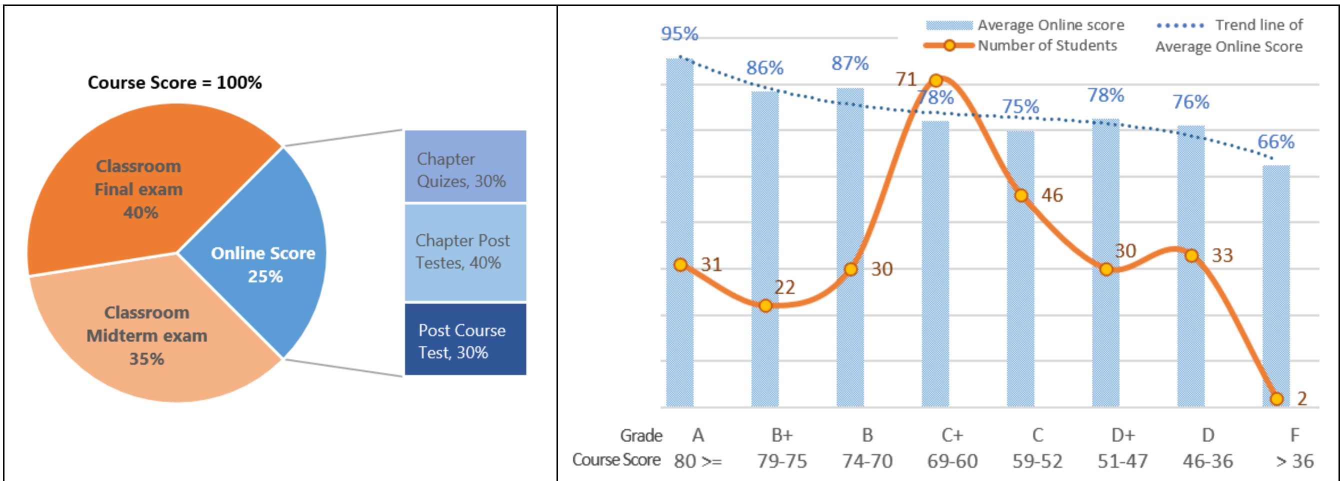
The instructors had two concerns:

1) Using incentives unavoidably diverse students' learning intentions. There were 2 groups of students; 'Attentive students' who utilized the online materials in order to gain more understanding, and 'Bypass students' who merely focused on earning the incentive score without an intention to learn from it. These learning intentions can be linked to the classic learning approaches introduced by Duff et al (2004): i) 'deep approach' which refers to behavior of students who seek to understand, ii) 'surface approach' which is based on behavior of memorization, and iii) 'strategic approach' which refers to student with the attitude to achieve the highest grades. Since the mathematics course is hardly memorizable, the 'attentive' and 'bypass' intentions concerned by the instructors in this course are associated with 'deep' and 'strategic' learning approaches in Duff's research accordingly. The instructors had a requirement to distinguish students by these intentions to be able to understand the student's nature and to adapt delivery strategy appropriately.
2) Since it was the first time to introduce the blended learning approach in their classes, the instructors needed a method to evaluate its effectiveness. In our review of literature, many researches on blended learning evaluation were based on qualitative approaches which using questionnaires and surveys. Bowyer and Chambers (2017) concluded a blended learning evaluation framework from many researchers containing elements and a rubric to measure its effectiveness in multiple dimensions. Israel (2015) studied a model of integrating MOOC into traditional classrooms and analyzed passing rates between different categories of learners. Kenny and Newcombe (2011) compared the score difference between students in a blended and a non-blended learning environment. As far as we know, there was no evaluation that were quantitative or based on student's behavior in previous research.

We believed the analysis of specific students' learning behaviors could be an indicator of their learning intentions and could reflect the effectiveness of the blended learning. In a blended learning environment, where the learning pace was controlled by the instructors, attentive students accessed the online materials during the period that the topics were taught in the classroom, and spent an appropriate amount of time in learning and problem practice. On the other hand, bypass students accessed the scored tests near the deadline, and spent less effort since they may know the correct answers from their friends. In other words, attentive students fully utilized blended learning while bypass students mostly depend on classroom teaching and rarely benefit from the online materials. If we could identify the relationship between students' performance and attentive / bypass student behaviors, we could verify the effectiveness of blended learning.

3 Analysis of Online Learning Behavior and Blended Learning Effectiveness

The research studied student behaviors from their efforts and accessing timeline. The event logs on Thai MOOC were passed through the ETL process and analyzed in combination with learner's performance. This section explored general statistics and the relationship between the learner's behaviors and their performances.



(a) Course score policy

(b) Student performance distribution

Figure 1. Course score policy (a) and Student performance distribution (b).

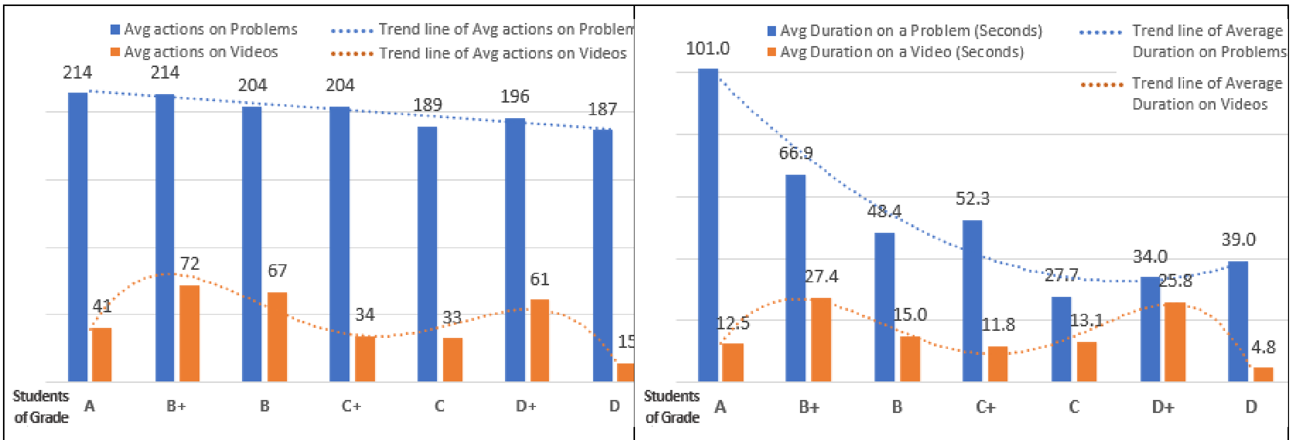
3.1 Score Distribution: MOOC Scores vs. Final Grades

Figure 1b illustrates the number of students by their final performances. The instructors partitioned student's final grades with normal distribution as shown in the orange line. The average online scores for each grade were plotted along. We found a direct variation between average online score and final grades. Note that there were only 2 students with the 'F' grade which were insufficient to make a meaningful analysis, and thus excluded from the study.

3.2 Student Effort Analysis

Student efforts were analyzed for each grade in two aspects: 1) the number of actions a student performed, and 2) the duration a student spent on online materials. For the first aspect, we calculated the average number of actions a student in each grade performed on problems and videos. The action type for problems was answer submission, while the video actions included all media controls i.e. play, seek, pause, stop and speed change. With the incentive score offering, most students had completed all scored problems and since most problems allowed only one attempt, the average number of actions on problems among students were in the close range (denoted by the blue bars of Figure 2a). The blue dotted trendline with a linear decline pattern (R-squared=0.87) indicates students with higher grades have a higher action rate.

Considering the second aspect, i.e., the duration spent, the timestamp of the first action and the last action that a student performed consequently on each topic were calculated and cumulated. There were cases that students left their PC or browser without logging out which caused the duration to overrun (too long). We replaced such values with an upper bound duration that the instructor expected a student to spend on that material which, for this course, were 2x of video's length for videos and 15 minutes for problems. A polynomial trend line was applied on the average duration on the problem shown as the blue dotted lines in Figure 2b. The trend line presented an obvious decline pattern (R-squared=0.93) illustrating that high performance students spent more effort on a problem practice compared to low performance students.



(a) Average actions on courseware (b) Average duration spent on courseware

Figure 2. Student's Effort by Grades

The effort trend lines on video (the orange dotted lines) fluctuated. The average durations spent on videos among student of various grades showed insignificant difference when compared to the actual video length (average of 464 seconds). This is because of very few student engagements on videos. A majority of students (83%) watched less than 25% of total videos. Almost half of students (44%) did not watch any video at all. This concurred with some research that low attention in video content is a common student's behavior. Gil and Williams (2017) revealed that the average video watching duration is 3 minutes. Ho et al., (2014) found a similar rate of content engagement; 56% of students engaged about a quarter of content while 35% never visited at all. The results illustrated that the more students utilized the online problems, the better learning performance they gained. This is correlated with the result of Albrecht et al., (2018) which studied blended learning in an introductory programming course.

3.3 Online Material Access Timeline Analysis

To enable us to analyze online material access timeline, the number of students accessing a courseware in each chapter grouped by date was extracted. In our analysis, students were categorized into 3 groups based on their performance: high performers (A, B+ grades; n=53), middle performers (B, C+, C grades; n=147), and low performers (D+, D grades; n=63). Since the total number of students in each group were unequal, the number of daily accessing students were normalized to percentage for comparison. Polynomial equation was applied to reduce fluctuations of the original data and visualize the trend lines. We found the 6th order polynomial trend lines was the best fit with R-squared values ranged from 0.4 in early chapters to 0.84 in late chapters. Even though they were not statistically satisfied, the trend lines let us visualize and distinguish clearly the patterns among groups of students.

As the instructors regularly reminded students to watch videos and practice on the online problems, we hypothesized high access rates on videos and problems in parallel with the topic taught in the classroom for attentive students. On the other hand, we also hypothesized a high access rate near the course deadline from bypass students who tried to complete all online problems for the incentive score.

The results in Figure 3 revealed the correlation of students' accessing timeline with their performance. Our analysis considered the highest peak as the access date of each student group. The blue trend lines represent high performance students (A, B+ grades). They accessed videos and problems earlier on every chapter with the most intensive rate which match the behavior of attentive students. The gray trend lines are low performance students (D+, D grades). They accessed the online materials later especially on problems which is the behavior of bypass students.

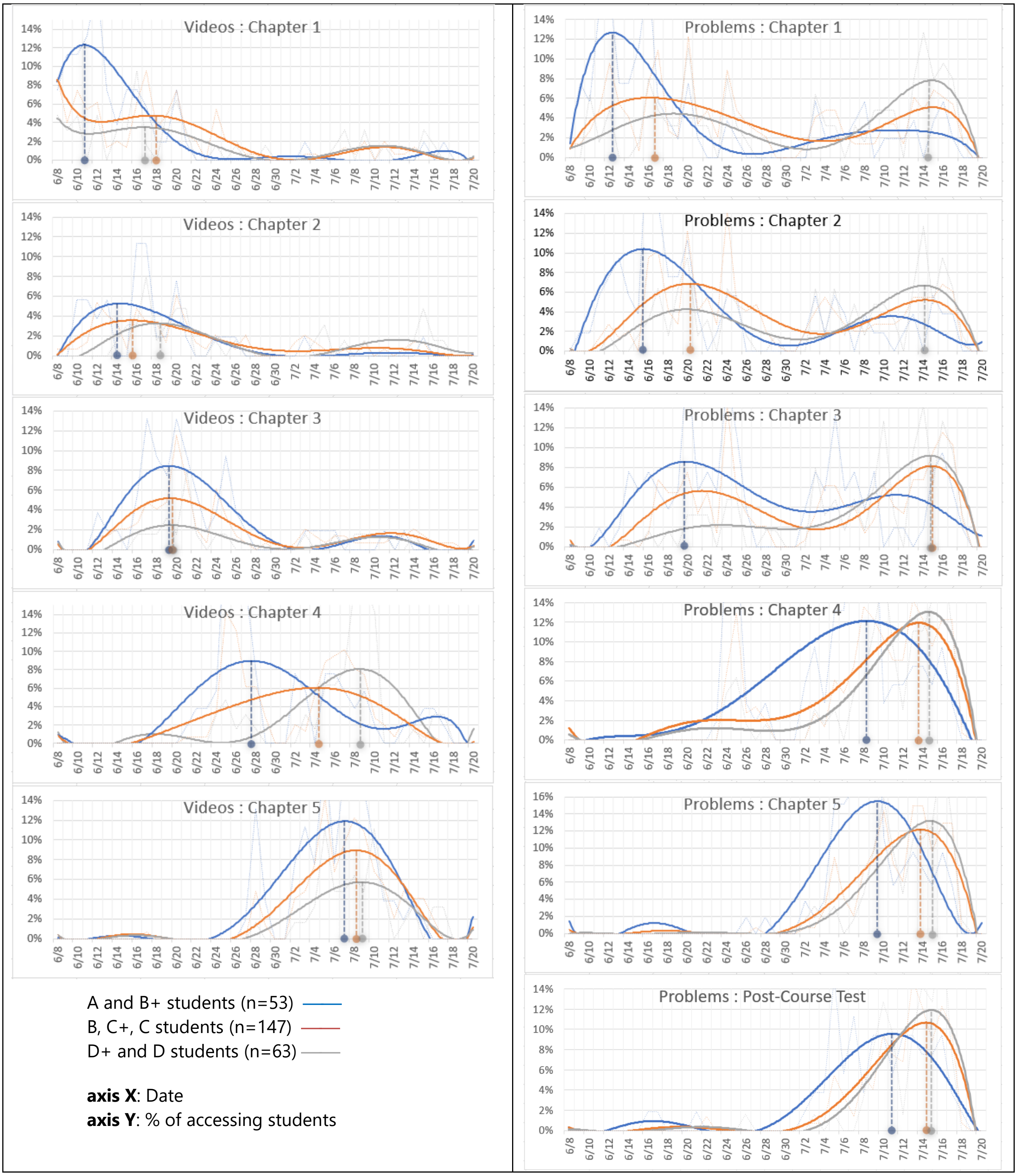


Figure 3. Online material accessing timeline on videos (left) and on problems (right)

The midterm exam contained the content of Chapters 1 and 2 Note that problem accessing trend lines of both chapters have two humps. The first one on the same period as the topic taught in the classroom demonstrated a group of students who intended to learn from online materials. The later hump is closing to the end date illustrated another group of students who tried to complete early chapters' problems with a clear intention to gain incentive scores since those chapters were already tested in the midterm exam and would not recur on the final exam. The trend line for Chapter 3 also has two humps but was not included in our analysis since the content was taught both before and after midterm exam. The trend lines of Chapters 4 and 5 have only one hump since the teaching was close to the end date causing students to access the chapters crowded in one period.

3.4 Blended Learning Effectiveness Analysis

From the results, the distinctive behaviors on online materials indicate clearly whether or not students had adopted the blended learning approach. The relation between these behaviors and students' performance reflects the effectiveness of blended learning. The effort analysis in Subsection 3.2 depicts that the more effort students spent on problem practicing, the better course score they gained. The online problem accessing behaviors in Subsection 3.3 also shows the correlation with student's performance. The blue trend lines of pre-midterm chapters in Figure 3 with higher first humps clearly stated that most high performers were attentive students who adopted the blended learning. On the other hand, the gray trend lines with higher second humps depict that most of the low performers were bypass students who did not adopt the blended learning approach.

The study extended further to calculate the ratio of attentive and bypass students by performances. We classified students who completed more than 50% of problems in Chapter 1 and 2 before midterm exam as 'attentive' and students who start accessing those problems after the exam as 'bypass'. Figure 4 demonstrates the ratio of attentive and bypass students by performance. Ratio of attentive students was significantly high for good performers (81% for A grade) and reduced according to the performances (17% for D grade). On the contrary, ratio of bypass students raised on lower performers.

We believe the ratio of attentive/bypass students by performance and student effort by performance can be further developed to be a behavior-base data-driven approach for evaluate effectiveness of blended learning courses in the similar setting.

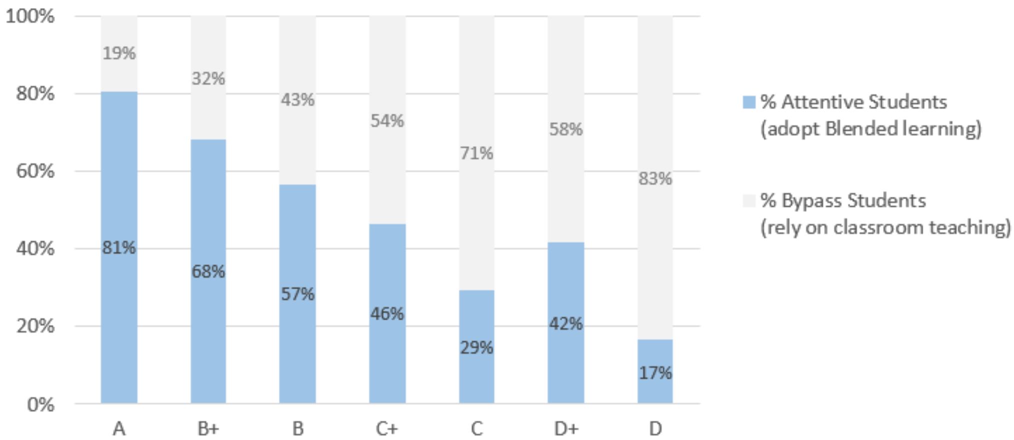


Figure 4. Ratio of student intention by performance

4 Blended Learning Instructional Design: Recommendations

Founded on the analyzed results presented in the previous section together with the observation obtained during the classroom instruction, the course instructors have made the following suggestions regarding the blended learning instructional design of a similar course:

1) The online materials in blended learning should be laid out to complement with content the instructors teach in the classroom, not to produce as a complete course with the similar content.
2) For engineering-related courses, self-practice problems with solutions in online materials can help promote student's learning.
3) To effectively implement the incentive score strategy, the number of available online problems should be properly considered and be separated into problems for learning and practice purpose, and problems for assessment purpose. Students should be encouraged to work on the practice problems without any restriction in terms of time and number of attempts, while the assessment problems should be randomized with the limitation on the number of attempts and the time to ensure a valid evaluation.

5 Conclusion

This paper explored a fundamental engineering course that applied blended learning with an incentive score from online materials. This strategy was shown to be effective for promoting the online material utilization. However, it unavoidably diversified students into 2 groups: i) 'attentive students' who utilized the online materials according to the designed approach, and ii) 'bypass students' who relied on classroom teaching and took advantage of the online materials merely to gain the incentive score.

The study analyzed the following specific learner's behaviors on the online materials which can indicate their learning intention: i) student's effort including the number of online actions and time spent, and ii) students' accessing timeline. The analysis result yielded two interesting online behavioral patterns of the students. The first group is the students who accessed online materials in parallel with the content taught in the classroom with reasonable amount of effort; hence matching the profile of attentive students. The other group of students completed only the provided assessment near to the course ending period with considerably less effort spent; and thus matching the bypass student's profile.

Taking student's performance into account, the research found a distinctive ratio of attentive and bypass students as follows. Low performance students had a significant ratio of bypass over attentive behavior. On the other hand, high performance students had an outstanding proportion of attentive behavior over bypass. We believe this data-driven and behavior-based approach could be applied to evaluate the effectiveness of other courses in the similar setting. Further research is required in order to establish a plausible quantitative mechanism and incorporate with traditional qualitative methods, e.g., questionnaires and surveys to enhance the effectiveness evaluation for blended learning.

6 References

Albrecht, E, Gumz, F, Grobowski, J. "Experiences in Introducing Blended Learning in an Introductory Programming Course." *Proceedings of the 3rd European Conference of Software Engineering Education, Association for Computing Machinery*, 2018, pp. 93–101.

Blended Learning Universe. (2020, May19). Blended Learning Models. http://www.blendedlearning.org/models/

Bowyer, J. and Chambers, L. (2017). Evaluating blended learning: Bringing the elements together. Research Matters: *A Cambridge Assessment publication*, 23, 17-26.

Bruff, D. O., Fisher, D. H., McEwen, K. E., & Smith, B. E. (2013). Wrapping a MOOC: Student perceptions of an experiment in blended learning. *Journal of Online Learning and Teaching*, 9(2), 187-199.

Duff, A., Boyle, E., Dunleavy, K., & Ferguson, J. (2004). The relationship between personality, approach to learning and academic performance. *Personality and Individual Differences*, 44(8), 1907–1920.

Ho, A, Chuang, I, Reich, J, Coleman, C, Whitehill, J, Northcutt, C, Williams, J, Hansen, J, Lopez, G, Petersen, R. (2015) HarvardX and MITx: Two Years of Open Online Courses Fall 2012-Summer 2014, *SSRN Electronic Journal, 2015*. DOI.org

Israel, M. (2015). Effectiveness of Integrating MOOCs in Traditional Classrooms for Undergraduate Students. *International Review of Research in Open and Distributed Learning*, 16(5)

Jodie M. Gil, Vern,W. (2017). Byte-Sized Learning: A Reviw of Video Tutorial Engagement in a Digital Media Skills Course. *Teaching Journalism and Mass Communication*, 7(1), 14-21.

Kenney, J., & Newcombe, E. (2011). Adopting a blended learning approach: Challenges, encountered and lessons learned in an action research study. *Journal of Asynchronous Learning Networks*, 15(1), 45–57.

Evaluation of projects carried out in companies by second-year Engineering students

Marco A. C. Pereira[1], Cristiano E. R. Reis[2], Débora A. I. Yoshioka[1]

[1]School of Engineering of Lorena, University of São Paulo (USP), Brazil
[2] EARTH University, Costa Rica.

Email: marcopereira@usp.br, crodrigues@earth.ac.cr; debora_yoshioka@usp.br

Abstract

The realm of Engineering education has great challenges; one of them being related to taking the students to real-life situations that can simulate the future challenges of their profession. Second-year Industrial Engineering students from the Engineering School of Lorena at the University of São Paulo (Brazil) were challenged to work on projects in companies of different areas and sizes. All projects were related to improvement opportunities identified in the companies. As a quantitative outcome, the students were asked to answer questionnaires at the end of their project by the end of the semester, in which they needed to assess the development of their individual skills and to evaluate the project carried out. The qualitative methodology applied to this study, thus, evaluated through a case-study some core concepts on behalf of the students through a questionnaire. The self-assessment demonstrated a positive development of technical and transversal skills by the students that are likely to have been useful in the development phase of the project development. Students highlighted on the project side that clarity on the definition and expectation is essential, as well as previous technical knowledge relevant to the development of the activities throughout the semester. They also stressed the fact that a deep skillset on project management, coupled with quality tools and methods, are desirable, if not, essential to a fruitful pace of activities. From a summary among all the obtained data, the greatest learning for the coordination of the discipline was the importance of receiving a critical analysis from the students at the end of the project.

Keywords: Project-Based Learning; Engineering Education; Second-year Engineering students

1 Project-Based Learning: Fundamentals

The long-standing tradition of Engineering courses taught through professor-oriented classes in a passive-learning setting still figures out as the most common reality of the learning practices applied on the most colleges and universities worldwide. The passive-centered and instructor-oriented learning setting implies that the learning is unidirectional, having the student as the receiving agent of information and knowledge, while the teacher stands as the information center, acting as a message transmitter. Intensive research on education highlighted that novel learning practices can be better applied to these settings, especially taking into account that the scarcity of information availability, which was a common limiting factor to previous decades and centuries, should not be taken as a significant portion of learning centers. The widespread information available on the internet with tools that were previously unthinkable urge the necessity of revising the tradition of passive and unidirectional teaching, i.e., relying upon the need of an instructor to pass information to a student. Among the approaches developed as an adaptation to the era of information and knowledge abundance available to the learners, some active-learning and student-oriented methodologies have been disclosed and applied to numerous settings under different degrees. An example of those is Project-Based Learning (PBL), which relies as an effective tool to promote the excitement and challenge-driven learning, based on the application of actual and complex problems as the main driver for the promotion of knowledge, having the students seek the information and knowledge necessary to fulfill the solutions for such problems, and the instructor as a tutor to assist on the development of solutions.

PBL aims to place the student as the main actor in their learning process. As a result, the role of the teacher must change, since he leaves the position of bearer of all knowledge to that of facilitator of the learning process (English & Kitsantas, 2013, Mitchell & Rogers, 2020). PBL, in addition to enabling students to become responsible for their own learning, also promotes the development of transversal skills, such as: teamwork, communication and leadership, among others (Lehmann, Christensen, Du & Thrane, 2008; Chimendes, Andrade, Rosa, Miranda & Silva, 2018; Murzi, Chowdhury, Karlovšek &, Ruiz Ulloa, 2020). The use of PBL in engineering courses is a way of adding value to student learning, as well as being recognized to be effective in preparing for the professional development required in engineering-related jobs (Jollands & Molyneaux, 2012; Chimendes, Rosa, Miranda & Andrade, 2017; Larsen, Kjærsgaard, Bigum & Jacobsen, 2019).

PBL has been applied to real problems such as educational strategy in various situations of partnership between universities and companies; for example, a course on Digital Lean Manufacturing and the related industrial applications, (Raweewan & Kojima, 2020), or a group of Civil Engineering and Industrial Engineering developing solutions to problems of standardization of procedures in the Netherlands (MacLeod & van der Veen, 2020), or even in rural applications, in which Finnish students evaluated the design of innovative low-cost projects using mobile internet technologies of things in Engineering courses (Mielikäinen, Angelva & Tepsa, 2019). This is also being done in the Industrial Engineering course at the Engineering School of Lorena at the University of São Paulo. This course was first implemented in 2012 and receives 40 students annually. PBL was first implemented in the coursework in 2013, after technical visits made to schools in the United States (Massachusetts Institute of Technology and Harvard University), Portugal (University of Minho) and Brazil (University of Brasília). The lessons learned from the two North American universities was the realization of the intense partnership with companies in which their students work through projects to solve real problems (Edström & Kolmos, 2014). At the Portuguese University, one of the lessons learned was about a project-based course in which students in the fourth year of the Industrial Engineering and Management career along the same lines as American universities and with the adoption of the Project-Based Learning (PBL) methodology. The University of Brasilia in its Production Engineering course also adopted PBL in specific design disciplines from the fourth to the tenth semesters of the career (Lima, Silva, Janssen, Monteiro & Souza, 2012). The Engineering School of Lorena hosts two project-based courses aimed at partnering with companies: Integrated Project of Industrial Engineering II (IPIE II) in the fourth semester and Integrated Project of Industrial Engineering III (IPIE III) in the seventh semester. The objective of IPIE II is to put the student to work on projects related to real problems that are proposed by small / medium sized companies. IPIE III has a similar objective to IPIE II, but usually with problems of greater technical complexity. This study focuses on the application of IPIE II at the Engineering School of Lorena. The case presented herein refers to a group of 39 students who took the course from August to November 2019.

2 Methodology and Application of PBL to the Study Context

The method of research utilized was case study. This research method shows inductive focus on analysis of obtained data and a descriptive one for the presentation of results. A case study is generally organized around some questions referring to "how" and "why" of such investigation, and it can be decomposed to its most relevant components. There are four essential steps for a case study. They are: (i) – delimitation of the case-unit, (ii) – data collection, (iii) – selection, analysis and data interpretation, and (iv) – report writing; the four of which are applied and can be easily visualized on the structure of this work.

The first activity of the course consisted on prospecting projects with partner companies about a month before the start of the semester. Once the partnership is closed and the project is defined, each company prepares a Project Charter with Project information. Usually, two or three meetings are held in the companies to align the project at the students' level (second year of the Engineering course) and the time they will have to carry out the project (4 months). In this class of 2019, seven projects were aligned with five companies. Table 1 presents the main characteristics of the companies and the projects carried out.

The classroom schedule during the semester had 14 meetings coordinated by the class instructor. An introductory presentation on Project Management was made in the first class, with an emphasis on six key PMBOk processes(PMI, 2017; Novaes & Andrade, 2018) Define Scope, Work Breakdown Structure, Define Activities, Sequence Activities, Estimated Activity Durations and Develop Schedule.

Table 1 – Projects developed in 2019 by the students enrolled in IPIE II

Project	Business Type	Project Goals
A	Veterinary Clinic	To improve administrative-financial and supply inventory management processes
B	ICT (Information and Communication Technology) Service Provider	To improve inventory management of ICT supplies and equipment
C	ICT Service Provider	To operate in the control of operations aiming to balance the distribution of services among the different teams working in the field.
D	Hospital	To assist in the implementation of Lean Healthcare in a sector of the Hospital
E	Steel Painting Industry	To increase the degree of use of an industrial painting line.
F	Steel Painting Industry	To develop a systematic acquisition of pallets used in the assembly of racks for the various measures of steel coils
G	Food Packaging Industry	To contribute to the improvement of the engraving process of cylinders used in rotary printers

The main phases of the project that occurred throughout the semester are presented in table 2.

Table 2 – Project Phases and Activities

Phase	Class(es)	Classroom Activity	Activity in the Business setting
1	1	Class on Project Management	None
2	2	Presentation of projects; Team formation	None
3	3 and 4	Review on theory on essential topics for the projects	First visit to the businesses
3	5 through 8	Project follow-up meetings	Business visits and meetings
4	9	Oral presentations	Project follow-up meetings
5	10 through 13	Project follow-up meetings	Business visits and meetings
6	14	Instructions on the final report, competence evaluation, and project evaluation	Business visits and meetings
7	15	None	Final oral presentation and delivery of solutions

In the second class, the teams were divided and the leader of each team was defined. In the next two classes, essential concepts for good project management were explored: PDCA, process design software and some basic quality management and productivity management tools. From the fifth to the eighth class, the instructor met with the teams on an alternating basis, i.e., a class with four teams and in the following class with the three remaining teams.

In the eighth class, the teams delivered a first project report. In the ninth class, there was a presentation of all teams to the course instructor and two guest professors. After each presentation, feedback was given by the professors. From the tenth to the thirteenth class, the instructor met again, alternately with the teams.

In the thirteenth class, the teams delivered the second partial report of the project, which was evaluated by the course instructor and returned to each team in the next class.

In the fourteenth and last face-to-face class of the course, the teams received instructions on the final presentation of the project to be made in the companies, followed by a mandatory survey with three questionnaires to assess their feedback and perception on key points.

Parallel to this schedule of activities in the classroom, between the fourth and the fourteenth week of the project, all the teams visited the companies. These visits took place at the intervals required by the project.

During the semester, the teams delivered three reports. The first was delivered in the eighth class and aimed to provide a complete description of the first phase of the project divided into four parts: problem identification, observation, analysis and action plan. The second report was delivered in the thirteenth class, about 15 days before the final report was delivered to the company. In this report, the team should present a final draft to the report to receive feedback in order to improve the report to be delivered to the company. Finally, the third report was delivered to the company.

3 Results and Discussion

3.1 Evaluation of Project-Based Learning Methodology

The assessment was made from the first questionnaire called the PBL Questionnaire which contained 4 questions based on a 5-point Likert scale: 1 (Strongly disagree), 2 (partially disagree), 3 (Neither disagree - nor agree), 4 (partially agree) and 5 (Totally agree). This questionnaire was answered individually.

Table 3 presents the results for each of the four questions (column 2). From the third to the ninth columns are the simple arithmetic averages for each of the questions for the seven teams. The codes from A to G are those that represent each of the companies shown in table 1. Finally, the last column presents the simple arithmetic mean of each of the questions for the 35 respondents.

Table 3. PBL Questionnaire.

ID	Question	A	B	C	D	E	F	G	Average
1	The use of PBL in the discipline is one of the differentials of the Industrial Engineering course	5.00	5.00	5.00	4.83	5.00	5.00	5.00	**4.97**
2	I understand that PBL concepts should be used in more subjects of the course	4.50	4.60	5.00	4.67	4.80	5.00	5.00	**4.77**
3	PBL methodology makes learning more motivating	4.17	5.00	5.00	4.50	4.75	5.00	5.00	**4.74**
4	The PBL methodology improves the development of interpersonal relationships	4.33	4.80	4.50	4.83	5.00	5.00	5.00	**4.77**

The data in table 3 show almost complete agreement that the use of PBL in this course is one of the differentials of the Industrial Engineering coursework from the students' perspective. The other three questions show that students have a very high degree of agreement that the concepts of PBL should be used in other disciplines, that the use of methodology makes learning more motivating and improves the development of interpersonal relationships. All of these results reveal that the PBL methodology is recognized and validated by students as very important in their professional training.

3.2 Competences

The assessment was made using a questionnaire called the Competence Questionnaire, which contained 10 questions based on the Likert scale in the same way as the PBL Questionnaire. This questionnaire was answered individually. It aimed to evaluate the development of 2 transversal competences (teamwork, personal development) and 1 technical competence (project management).

Table 4 presents the results for each of the ten questions and its structure of columns and numerical results is identical to that of the PBL Questionnaire. The first four questions refer to teamwork. Questions 5 and 6 refer to two aspects of personal development (creativity and critical thinking). Finally, questions 7-10 were related to the technical competence of project management.

The analysis of the first four questions related to teamwork reveals that the students more agreed than disagreed, since all answers are higher than the average 3.0. However, a point to highlight is that, in general, students knew how to manage conflicts well in all teams (question 4), which suggests a good degree of maturity taking into account that they are second year engineering students and aged average of 19 years. On the other hand, the results of questions 1 to 3 point out serious difficulties in relation to teamwork for the team that worked on project A (Veterinary Clinic) and a little difficulty for the team that worked on project C (ICT service provider).

Table 4. Competence Questionnaire

ID	Question	A	B	C	D	E	F	G	Average
1	All the members of my team contributed to the success of the work	2.67	5.00	2.50	4.00	3.60	4.80	5.00	**3.88**
2	The success of my team was due to the union between its members	2.67	5.00	4.00	4.33	3.40	5.00	5.00	**4.12**
3	All the members of my team fulfilled the tasks established	2.67	4.60	3.25	4.33	3.60	5.00	5.00	**4.03**
4	All conflicts experienced in my team were overcome in a coherent and respectful way	4.83	5.00	3.75	4.83	5.00	5.00	5.00	**4.63**
5	The project helped develop my creativity for problem solving	4.17	5.00	4.75	4.17	3.80	5.00	5.00	**4.51**
6	I realize that I developed a greater critical sense in this project that helps me to evaluate the differences in work proposals	3.83	5.00	4.75	4.17	4.40	4.40	4.75	**4.43**
7	The meetings that took place were productive and decisive for the good results of the project	3.33	4.60	4.50	4.00	2.80	4.80	5.00	**4.09**
8	My team met all deadlines	4.83	4.80	5.00	4.83	3.40	4.40	5.00	**4.31**
9	My team knew how to manage time well, fulfilling the proposed schedule	2.67	4.40	4.75	4.33	2.20	4.60	5.00	**3.91**
10	The necessary knowledge for the development of the project was sought from different sources	4.83	5.00	4.25	4.00	3.40	4.80	5.00	**4.46**

Regarding the two questions that aimed to evaluate aspects of personal development, it appears that students in general more agreed than disagreed that the project helped in the development of creativity and critical sense.

One aspect that draws attention in the analysis of the results of transversal skills is that when it comes to individual development (creativity and critical sense) the numerical results suggest their development in greater intensity, from the perspective of the respondents, when compared to the characteristics of teamwork who do not depend only on an action by the individual (student), but on the other individuals (colleagues) who interact with him in the team.

Questions 7 to 10 are related to the technical competence of project management. In the four questions, the students more agreed than disagreed in relation to aspects of the development of a project, which points out that these aspects (productive meetings, meeting deadlines and time management) were developed during the execution of the project. The question 10 stands out, which is related to a typical characteristic of PBL, which is the fact that students often need to acquire specific technical knowledge throughout the project. And the results reveal that students sought knowledge from different sources, since not all the technical information they could have only with the course instructor.

3.3 Course evaluation

The third questionnaire called the Discipline Evaluation Questionnaire aimed at evaluating the discipline and contained four open questions, which consisted in essay-like questions answered by the team after a meeting between its members in the fourteenth week.

The first question was: What are the positive aspects of the project carried out? The answers given presented a series of positive points involving technical and transversal skills, as well as aspects of professional life. Four teams stressed the importance of having carried out a project through an experience in the practice of solving a real problem. Three teams highlighted the issue of professional responsibility that this project brought to the students, because for all its members it was the first time that they were facing a medium or high complexity challenge in a company. The learnings were highlighted, which were accelerated from technical topics that came into contact for the first time, such as ERP (management software), logistics and specific Lean Manufacturing tools (Value Stream Mapping, Chronoanalysis). Some teams pointed out that the projects made it possible to experience teamwork in practice, as well as "professional" communication with managers and employees with whom they had contact.

The second question was: What are the points that need to be improved in the discipline of IPIE II? Three teams pointed out the need to improve the project contracting process before the beginning of the semester: "further study of the feasibility of the proposed problem" (Project F - Steel Painting Industry); "To establish more precisely the problem to be studied, as it turned out to be greater than that contained in the Project charter" (Project A - Veterinary Clinic); "Greater clarity in the definition of the project's focus by the company" (Project B - ICT service provider). Some other points were also pointed out so that they can be improved: a more in-depth feedback from the teacher for the reports delivered, and the availability of a technical bibliography to support projects of greater complexity.

The third question was: What previous knowledge is very important to develop the project in the discipline of IPIE II? The responses were very varied, but pointed to a series of technical knowledge that students had already acquired in the first three semesters of their course, such as: (i) - quality management tools (Ishikawa diagram, 5 whys); (ii) - productivity management tools (5w2h, Kanban, Kaizen, Key Process Indicator) and (iii) - management tools in general (SWOT, flowcharts).

The fourth question was: Would the team indicate the company in which it worked so that new projects in the discipline are carried out there? Yes or no? Why? Four of the teams replied that YES (Project B - ICT Service Provider; Project D - Hospital; Project F - Steel Painting Industry; Project G - Food Packaging Industry). And all the answers were assertive and highlighted the intense learning that the team had. Three of the teams answered NO (Project A - Veterinary Clinic; Project C - ICT Service Provider; Project E - Steel Paint Industry). Each of the teams when answering NO pointed out reasons for their answer, two of which stood out: difficulties in communicating with managers and / or employees of the company and difficulties in receiving information from the company necessary to carry out the project.

Two projects were carried out at the ICT service provider. Below, the answer given by the two teams:

> YES, because everyone we interact with in the company was very open during the execution of the project (Project B)
>
> NO, since the group's performance was limited due to technical information that the company cannot provide. However, the team emphasizes that the company is extremely receptive and provided us with great support. So, if the project was in another area of the company it could be very interesting (Project C)

This response from the team that worked on project C shows that the problem was not related to the company, but with characteristics of the project that contained technical information that the company cannot provide due to confidentiality issues with its supplier. In this case, it is clear that the answer was NO, but with a possibility that it could be YES if it were in another area of the company.

Two projects were also carried out in the steel painting industry. A similar fact to the one described above also occurred, as one of the teams signaled positively and the other negatively. The responses were:

> YES, because the company shows confidence in the students' work, and gave the group a lot of freedom of action and welcomed us in a very solicitous way. (Project F)
>
> NO, because the company unfortunately has a series of communication problems, which impacted the quality of delivery reliability. (Project E).

Reading these two responses reveals quite different scenarios in the same company. In reality, students when answering the question did not directly analyze the company, but the employees of the company with whom they had contact. This is a very complex factor to be evaluated by the instructor when defining the project before the semester begins, as the evaluation of the project is technical, and it is difficult to assess the degree of communication that company employees will have with students.

The only categorical NO was the students who carried out the project at the veterinary clinic. This seems to be related to the fact that it is a small company with high management informality and a low degree of standardization of its processes.

The Competencies Questionnaire analyzed in section 5.2 allows for another type of analysis: the arithmetic mean of the respondents of the teams for each of the three competencies. Table 5 shows these results and the last line shows the average of the answers to the 10 questions for all respondents in each of the teams. This was not the objective of this questionnaire, but the results allow a more in-depth analysis of the answers given to the fourth question of the Discipline Evaluation Questionnaire.

Table 5. Team Evaluation

Competence	A	B	C	D	E	F	G
Teamwork	2.96	4.89	3.38	4.38	3.90	4.95	5.00
Personal Development	4.00	5.00	4.75	4.17	4.10	4.70	4.88
Project Management	3.50	4.70	4.63	4.29	2.95	4.65	5.00
Average	**3.38**	**4.84**	**4.15**	**4.30**	**3.56**	**4.78**	**4.97**

A point that draws attention is the fact that the four teams that answered that they would indicate the company to carry out a new project are the ones that have the highest arithmetic mean of the answers in this competency questionnaire. And the three teams that answered that they would not indicate for the new project are those that have the lowest arithmetic mean in relation to the development of competencies. Was the students' perception about the development of skills linked to the good performance of the project? This is a thought-provoking question, to which the first answer is apparently yes, but only better research could better clarify this point.

Two facts stand out, the almost unanimous answers of total agreement of all the elements of the team that worked in the project G (Food Packaging Industry). This team, when indicating the company so that new projects could be carried out, replied: "Yes, because everyone involved in the project was very helpful and available for any doubts and problems that arose". This answer seems to reinforce that the students' perception of skills development is related to the success of the project, including the good interaction between students and employees of the partner company.

On the other hand, it is also worth noting the fact that the only categorical NO (Project A - Veterinary Clinic) was given to the team that apparently had problems with teamwork, as shown by the average 2.96 in table 5. Therefore, this categorical NO may be related to problems that go beyond the informal management of the company. This too is an assumption that would need to be further investigated.

The analysis of the teams' responses in the open questionnaire when confronted with the arithmetic averages in this table 5 point out ways for further research to be carried out. The application of evaluation questionnaires is relevant to the management of a discipline of projects carried out in companies, which are quite different from traditional and contentious disciplines. The greatest learning for the coordination of the discipline is about the importance of receiving a critical analysis from the students at the end of the project.

4 Conclusion

The development and application of alternative methods of learning in Engineering is a continuous effort to fulfil the expectations of a trained engineer to the challenges one will face outside of the Academic settings. Project-Based Learning, as an example of the possible array of new methodologies applied to Engineering courses, has been established as an adequate method to integrate theoretical core concepts of Industrial Engineering to open-ended problems faced by actual businesses through the approach taken by the Engineering School of Lorena at the University of São Paulo. The findings described herein demonstrate the development of competences throughout the application of PBL with second-year Industrial Engineering students, relying on the development and validation of solutions to projects proposed by partner industries.

The results demonstrate that, albeit a wide variance of degree of satisfaction of working with a type and size of business, positive outcomes were obtained. Using Likert-analysis, the results demonstrate accordance to the positive outcomes self-evaluated by the students regarding the methodology applied to the course, as well as to the development of core competences by themselves, and aspects of teamwork. In this sense, this work summarizes that, through proper guidance, the application of PBL can be a rather powerful tool to bring the students close to the realities they will likely face in a few years after graduation within Engineering settings.

5 References

Chimendes, V. C. G.; Andrade, H. S.; Rosa, A. C. M.; Miranda, Y. C. C. R. & Silva, M. B. (2018). Práticas pedagógicas para desenvolver o espírito crítico científico no aluno. *Espacios* (Caracas). 39 (49), 10-20.

Chimendes, V. C. G., Rosa, A. C. M.; Miranda, Y. C. C. R. & Andrade, H. S. (2017). The use of Multidisciplinarity, Interdisciplinarity and Transdisciplinarity to develop the Critical and Scientific Spirit in the student. International *Journal of Advanced Engineering Research and Science*, 4, 1-6.

Edström, K., & Kolmos, A. (2014). PBL and CDIO: Complementary Models for Engineering Education Development. *European Journal of Engineering Education, 39(5),* 539-555.

English, M. C., & Kitsantas, A. (2013). Supporting Student Self-Regulated Learning in Problem- and Project-Based Learning. *Interdisciplinary Journal of Problem-Based Learning,* 7(2). 128-150.

Jollands, M., & Molyneaux, T. (2012). Project-based learning as a contributing factor to graduates work readiness. *European Journal of Engineering Education, 37(2),* 143-154.

Larsen, S. B., Kjærsgaard, N. C., Bigum, P. V., & Jacobsen, P. (2019) Understanding how students learn in project-based courses: A review of literature. *Proceedings of SEFI 47th Annual Conference*. Budapest, Hungary. 1684-1693.

Lehmann, M.; Christensen, P.; Du, M. & Thrane, M. (2008) Problem-oriented and project-based learning (POPBL) as an innovative learning strategy for sustainable development in engineering education. *European Journal of Engineering Education,* 283-295. http://dx.doi.org/10.1080/03043790802088566

Lima, R. M., Silva, J. M., Janssen, N., Monteiro, S. B., & Souza, J. C. F. (2012). Project-based learning course design: a service design approach. *International Journal of Services and Operations Management*, *11(3),* 293-313.

MacLeod, M. &. van der Veen, J. T. (2020) Scaffolding interdisciplinary project-based learning: a case study, *European Journal of Engineering Education*, 45:3, 363-377. https://doi.org/10.1080/03043797.2019.1646210

Mielikäinen, M. T., Juhani Angelva, J. & Tepsa, T. (2019) From customer projects to ECTS. *Proceedings of SEFI 47th Annual Conference*. Budapest, Hungary. 780-786.

Mitchell, J. E. & Rogers, I. (2020) Staff perceptions of implementing project-based learning in engineering education, *European Journal of Engineering Education.* 45(3) 349-362. https://doi.org/10.1080/03043797.2019.1641471

Murzi, H. G., Chowdhury, T. M., Karlovšek, J. &, Ruiz Ulloa, B. C. (2020). Working in large teams: Measuring the impact of a teamwork model to facilitate teamwork development in engineering students working in a real project. *International Journal of Engineering Education* 36(1), 274-295

Novaes, F. A. M. & Andrade, H. S. (2018). Um ensaio sobre o direcionamento para a criação de projetos relacionados à políticas públicas. Espacios (Caracas), v. 39(11), 1-12.

Project Management Institute – PMI (2017). A guide to the project management body of knowledge: PMBOK guide, PMI, 6th ed.

Raweewan, M. & Kojima, F. (2020) Digital lean manufacturing - Collaborative university-industry education in systems design for lean transformation. *Procedia Manufacturing*. 45. 183-188. https://doi.org/10.1016/j.promfg.2020.04.092

Design of a new Workstation in a Productive Process: importance of Multidisciplinary Integration

Ana C. Pedrosa[1], Marta C. Simões[1], Miguel A. Mendes[1], Paulo J. Martins[1, 2], Rui M. Sousa[1, 2]

[1] Department of Production and Systems, School of Engineering, University of Minho, Guimarães, Portugal
[2] ALGORITMI R&D Center, School of Engineering, University of Minho, Guimarães, Portugal

Email: [a80667, a93777, a81002]@alunos.uminho.pt, [pmartins, rms]@dps.uminho.pt

Abstract

During the 7th semester of the Integrated Master Degree in Industrial Engineering and Management (IEM) at University of Minho - Portugal, teams of students develop projects in interaction with industry. The project lasts the whole semester and each team works in a different company. This type of projects is formally included in the IEM curricular structure through the course unit (CU) PIEGI2 (Integrated Project in IEM 2) and in fact involves all the remaining five CU of the semester as PSU (Project Supporting Courses). This paper is associated to the work carried out by a team of students in an electrical wiring company (supplier of the automotive industry) and, using qualitative analysis, aims to show the importance of the integration of the contents addressed by the PSUs. Thus, the main goals of this empirical paper are: (i) describe the design process of a new workstation (required due to a problem identified by a customer) and (ii) show how the multidisciplinary integration was important in this project. To design the new workstation, various concepts/tools from the several PSUs were used, namely: (i) anthropometry and illuminance (PSU - Ergonomic Workplace Analysis), (ii) Business Process and Modelling Notation – BPMN (PSU - Integrated Production Management), (iii) Generic Product Data Management – GenPDM (PSU - Production Information Systems), (iv) Value Stream Mapping – VSM and Key Performance Indicators - KPI (PSU - Production Systems Organization II) and (v) SIMIO (PSU - Simulation). By combining contents of all the PSUs of PIEGI2, the students' team was able to develop an integrated solution encompassing not only the physical installation but also managerial aspects (e.g. product data management). Although the new workstation was not yet implemented, the work developed by the students was highly appreciated by the company engineer's and by all the teachers involved.

Keywords: Industry interaction; Active learning; Project-based learning; Multidisciplinarity; workstation design

1 Introduction

Industry 4.0, otherwise known as the fourth industrial revolution, is currently attracting the industry attention, in a logic of innovation to ensure competitiveness. This revolution is driven by innovative technologies that have impact in production systems and business models. Industrial companies, namely those in the automotive and machinery sector, are part of a dynamic and highly competitive market, which requires a demand for continuous improvement in production planning, manufacturing processes and operations management. To be competitive, a company must be ahead of technological advances, to respond more efficiently to the increasingly demanding market, with shorter lead times, high quality, reduced cost and diversity.

In many sectors, including the suppliers of the automotive industry, the progressive involvement of customers in the process of developing new products is crucial to ensure the complete alignment of perspectives / requirements. Often, the specific requisites of a new product imply the development of a new production system, or the improvement of existing ones. For this, the design of new production processes may be necessary, eventually involving modified / new equipment (and the respective financial feasibility study), thus constituting a challenge for the company.

This was exactly what happens at the company where the project described in this paper was developed. A specific customer asked for a modification in the products: elimination of the printed identification label affixed to each connector of the electrical wiring and its replacement by the direct printing of the identification code on the connector body. The reason for this customer's request is simple: the label is prone to peel off. Although apparently simple, this modification has major implications, namely in terms of (i) printing process, (ii) supply of materials (connectors) to the assembly line and (iii) wiring assembly process. As for aspects (ii) and (iii), the requested change will increase human error implying thus the development of error-proof mechanisms (poka-yoke). However, as previously mentioned, this paper addresses aspect (i), i.e., the development of a new workstation with a laser engraving machine to produce connectors with printed identification. Even so, as the new workstation is part of a whole, it is necessary to analyse the entire production process. Naturally, this work (analysis and development) involves the integrated use of different methodologies/techniques/tools, to address aspects such as: ergonomics, process mapping, value stream mapping and product data management, and, at a later stage, production process simulation. In fact, the main purpose of this paper is to emphasize the importance of integration of all these aspects while developing interdisciplinary projects.

As already referred, these projects are developed by teams of students during an entire semester and are based on the Project-Based Learning (PBL) approach (Graaff & Kolmos, 2007; Powell & Weenk, 2003). This kind of projects in interaction with industry is being continuously implemented since 2005 at the Production and Systems Engineering Department of University of Minho, Portugal (Lima et al., 2017).

Thus, in terms of conceptual contribution, this paper aims to contribute to the existing literature on PBL developed in cooperation with industry, by providing evidences of the interdisciplinary integration importance.

The paper is organized as follows. After a brief introduction on chapter 1, chapter 2 presents the theoretical foundation used in the project, namely in terms of lean manufacturing, ergonomics, product data management, process modelling and simulation. The work developed is described in the third chapter and addresses the analysis of the current production process and the development of the new workstation (already mentioning some expected results). The main achievements, problems and conclusions are outlined in chapter 4.

2 Theoretical Foundation

The literature review of an empirical paper should present the underlying theories or the related existing knowledge (Nakano & Muniz, 2018). Thus, this chapter will address the concepts / techniques / tools involved in the project, namely in terms of definition, expected achievements, advantages and disadvantages.

2.1 Lean Tools

Inherent to the lean manufacturing paradigm, there is a large set of methodologies / tools / techniques than can be used both to analyse and improve production systems.

Key Performance Indicators (KPIs) are measures of system achievements during a given period and are defined accordingly to the intended goal. Organizations use KPIs at multiple levels to evaluate their success.

Value Stream Mapping (VSM) is a graphical tool to represent the material and information flows associated to a product or family of products (Rother & Shook, 2003). A VSM encompasses the entire path taken along the supply chain, from the suppliers to the customer. Like other process mapping methods, it helps in terms of introspection (better understanding of the process), but mainly regarding the analysis / diagnosis and improvement of the process under study.

More specifically, the use of VSM allows (i) the identification of wastes and other problems, which in fact represent improvement opportunities, (ii) the identification of the lean concepts/tools applicable in the analysed context, and (iii) the development of an action plan (eventually a 5W2H plan (what, where, why, who, when, how and how much)) to define and schedule improvement actions.

5S is a widely referred methodology (yet often misunderstood) for organizing spaces so work can be performed efficiently, effectively, and safely. This system focuses on putting everything where it belongs and keeping the workplace clean, which makes it easier for people to do their jobs without wasting time or risking injury. However, the main challenge is to maintain the "5S culture". 5S also facilitate visual control, flow, standard operations and other Just-In-Time (JIT) aspects. The 5S program is usually implemented as a strategic plan for some key aspects of the company to begin to show improvements towards total quality.

2.2 Ergonomic Analysis

From an ergonomic point of view, there are several aspects that may compromise the introduction of a new process/system in a factory. In fact, this is an important area to consider, since it is dealing with the welfare of the human being. It is still worth mentioning that this topic has an even higher relevance in factories that require a high human work labour, as the employee satisfaction is a key point.

First, ergonomics studies the relation between the human being and the work he executes, seeking to develop an integration between the work conditions, the physical and psychological capacities and limitations of the worker and the efficiency of the productive system. The goal is to increase the safety, health and comfort of the worker, so the workspace adapts to the worker and not the other way around. Indissociable from ergonomics, is anthropometry, which studies the dimensions of various human being parts (using different measuring tools), giving valuable information on the physical and biological conditions of an individual.

Workers performing Manual Material Handling tasks (MMH) are prone to Work-related Musculoskeletal Disorders (WMSD), which are the most frequent occupational health problem in the EU, and MMH is a major cause of vertebral lesions, more specifically in the lumbar region, especially if the materials are heavy and difficult to pick up or handle. When MMH tasks are inevitable, companies should strictly follow the existing legislation to make this task as safe as possible. One of the quantitative methods approached to try to define safe limits is the NIOSH Lifting Equation, or simply NIOSH'91.

Regarding occupational noise, one of the main aspects is the sound pressure, which is expressed in Pascal (Pa). As the human ear reacts logarithmically to stimulation, the sound pressure level scale (logarithmic measure) was created and the unit is the decibel (dB). Noise can cause problems such as loss of audition, reversible lowering of hearing acuity, and destruction of cells. In fact, one third of professional diseases is deafness, resulting from the exposure to high sound levels.

Lighting is an essential factor for a good work environment. Without adequate lighting for the workplace, negative impacts are more likely to happen, either for the health of the worker or for the efficiency of the workplace, resulting in visual damage, an increase in the number of accidents and consequently lower productivity. The lighting provided by natural light is ideal. However, it is not always possible to resort to it, so it is necessary to install artificial light, which can be general, localized or combined.

The fundamental photometric quantity to be taken into consideration is illuminance (E). Illuminance is the measure of the incident luminous flux per unit of surface, measured in lux (lx).

2.3 Product Data Management

"Information systems are interrelated components working together to collect, process, store, and disseminate information to support decision making, coordination, control, analysis, and visualization in an organization." (Laudon & Traver, 2011). There are two different ways of defining information systems: the components that put together an information system and the role that those components take part within an organization. In addition to the obvious components of data, software and hardware, the process and the people are also important components for a system (Boutgeois et al., 2007), as it could not function without them. Focusing on the role that these systems play, it is fair to say that production information systems take an engaging role within the production system of any company (Snehal, n.d.). These systems accelerate the daily pace of actions, change the structure of organizations and shape the essence of work as knowledge and information have grown into vital economic assets (Gutenberg et al., 2017). The versatility to make available different kinds of information at any given time and the ability to provide detailed data (Essays, 2018), is the key factor to an efficient information system. Most organizations depend on external firms to deliver their information services (Gutenberg et al., 2017) as it can be a complex task to achieve a suitable system.

Generic Referencing

In the age of industry 4.0, amongst other requirements for a company to be eligible as a Smart Manufacturing System, it is the capacity to address product diversity and mass customization, which in addition to working to satisfy the exact needs of customers, tries to preserve the gains of mass production (Pine, 1993).

Traditional representation models have fallen short to match up the requirements to deal with the very high diversity of products that characterizes current markets (Gomes et al., 2011; Martins & Sousa, 2013). In this context, the Product Data Management (PDM) function becomes extremely complex, demanding innovative approaches, namely the generic referencing paradigm. Generic referencing seeks to group articles by families, differentiating them by previously established parameters that facilitate referencing. To obtain a trustworthy information system and being generic referencing one of the main tools to use, it was followed the six-step method introduced in Gomes et al. (2011).

2.4 Process Modelling

Business Process Model and Notation (BPMN) allows the representation of business processes by creating a diagram using a set of standard graphical symbols (OMG, 2011). The primary goal of BPMN is to provide a notation that is readily understandable by all business users, from the business analysts that create the initial drafts of the processes, to the technical developers responsible for implementing the technology that will perform those processes, and finally, to the business people who will manage and monitor those processes. With BPMN it is possible to fill the information gap between the conceptual and process implementation.

As for existing processes, BPMN is used to diagnose problems and identify improvement opportunities. However, communication failures are an obstacle to its adoption: it is essential to inform organization employees about the inherent purpose and benefits. Also, the lack of support from management, as well as the lack of knowledge about the model (leading to "fear of change"), always weigh in accepting BPMN use. Financial issues also represent resistance to BPMN utilization. The difficulty in expressing the monetary results obtained with this model, contributes to the scepticism of the managers regarding the return on investment.

2.5 Simulation

In general terms, simulation can be interpreted as the imitation of the operation of a real-world process or system over time (Banks, 1999). According to this author, it is an experimental method with detailed modelling of a real system, where, through visual models' and/or graphical animation, it is possible to predict how the system will behave in each period of time. In the context of learning environments, Guneri & Seker refer that an abstract computer simulation can be used to represent the essential features of the intended system, so that learners can test their analytical and design skills in a convenient and safe environment.

Among many simulation programs, SIMIO was adopted for this project. It is based on intelligent objects, and unlike other simulation systems, there is no need to write any programming code, as the process is completely graphic (Pegden, 2007; Sturrock & Pegden, 2010). In SIMIO, a vehicle, a customer or any other agent of a system are examples of possible objects and, combining several of these, one can represent the components of the system in analysis. Thus, a SIMIO model may look like the real system.

To create a simulation process, it is needed to identify the problem and formulate it, draw the model, collect data. After that it is crucial to verify and validate the model. If the model is approved then the test plan is next, model execution and results analyses.

SIMIO allows the simulation of various situations that may occur and directly influence the production process. The observation of the material, people or information flows provides a better insight of the process behaviour.

3 Developed Work

In this chapter will be presented the practical application of the techniques referred above.

3.1 Value Stream Mapping and Workplace Organization

The application of some Lean tools in the company where this project was carried out, was extremely useful, as they allowed to understand the current problems and conditions of the production process.

In the assembly lines, various KPI have been measured, such as cycle time, takt time, work in process, setup time or line efficiency. These values allowed to evaluate the current performance of the assembly line and to compare it with the performance of the assembly line after the implementation of the new workstation with the laser engraving machine. This machine will allow four employees to work simultaneously.

VSM was applied in order to identify problems and respective causes (current state VSM). Next, the intention was to develop a future VSM to illustrate what was expected to be achieved with the changes, such as the creation of the new workstation that would in turn change the way the assembly line was supplied. However, due to time constraints, the future state VSM was not developed. Nevertheless, the current state VSM provided valuable input for the design of the new workstation, namely regarding the previously mentioned KPI.

To create a better working environment in the company, and consistency for high quality processes, the 5S methodology was applied. It was mainly used in areas adjacent to the assembly lines, where there were too many boxes and other components, completely messy and stacked on top of each other. As for the new workstation, an "ideal" layout was developed, however, it was not implemented.

3.2 Noise, Illuminance and Anthropometric Analysis

NIOSH'91 equation will not be implemented in this company, as the tasks performed by the workers do not require the movement of objects.

Companies where lower exposure action values $L\ (Ex,\ 8h))$ exceed 80 $dB\ (A)$ or $(c,\ peak)$ exceed 135 $dB\ (C)$, must provide employees with Personal Protective Equipment (PPE) to prevent hearing damage. As the new workstation will be located close to a noise producing source (sectioning area), additional constructive measures to reduce the propagation of noise, such as noise-proof panels, will be necessary.

The analysis of the values provided by the company, revealed that the illuminance in the assembly line was between 300 and 500 lux. ISO 8995:2002 states that illuminance values shall be calculated according to the visual requirements of the task to ensure its proper performance. In addition to this, the costs associated with the lighting system should also been taken into consideration, without affecting optimal energy use. Depending on the tasks, visual requirements range from low to high, ranging from 200 lux to 1000 lux. At the station considered, which was one the assembly lines, the visual demands are high, so a lighting system with a range between 500 and 1000 lux is recommended.

The integration of contents/tools of the PSU Ergonomic Workplace Analysis, made it easier to design an ergonomic workstation, e.g. by defining some important dimensions. Naturally, the worker's satisfaction and welfare at his workstation are quite important in terms of productivity.

3.3 Generic Referencing

The company works with more than 600 electrical wiring references. In order to deal with diversity, the use of the generic referencing concept was proposed. To demonstrate the usefulness of this approach, it was developed the generic PDM model of a cable, a major component of any electrical wiring (Figure).

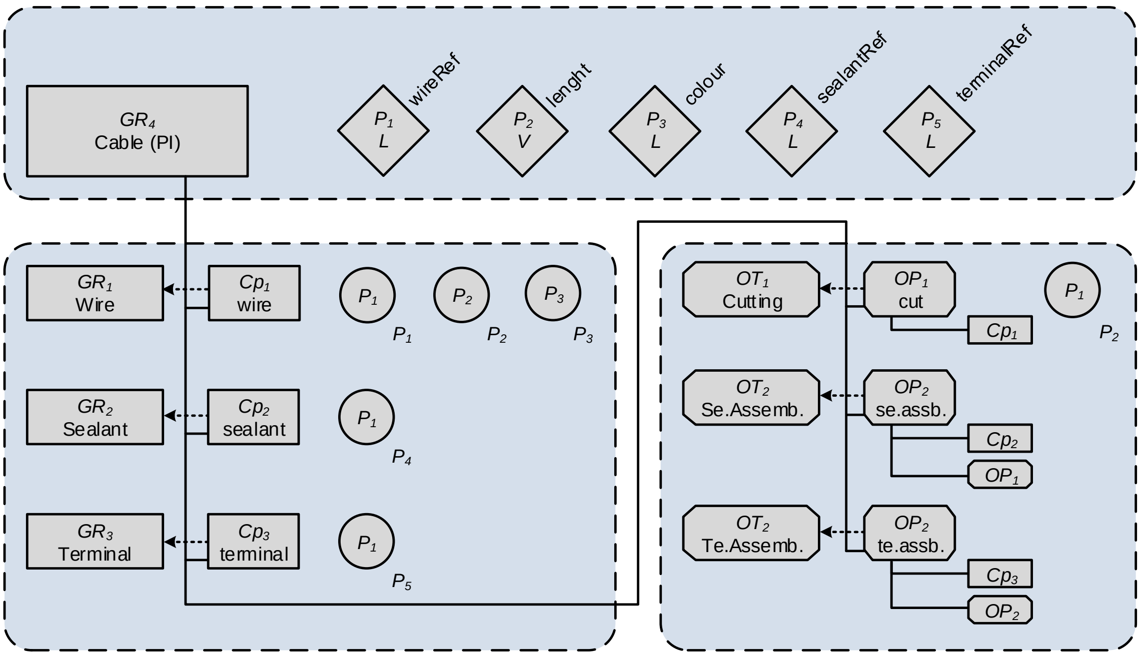


Figure 1. Generic PDM model of a family of cables.

This model includes the family characterization (upper area), the generic bill-of-materials (lower left area) and the generic bill-of-operations (lower right area). With this approach, instead of being stored in the system, the bill-of-materials and the bill-of-operations of any specific cable are automatically generated only when they are necessary. This is just one of the aspects that shows that the effort associated to PDM is much lower when generic referencing is adopted.

3.4 Failure Recovery Procedure Modelling

When the customized connectors (with the engraved identification code), produced in the new workstation, start to be used in the assembly lines, there will have to be a new procedure to face a specific problem: the need to replace a defective connector. In this scenario, both the employees and the segment leaders need to know how to act. The process was designed and represented with BPMN (Figure 2).

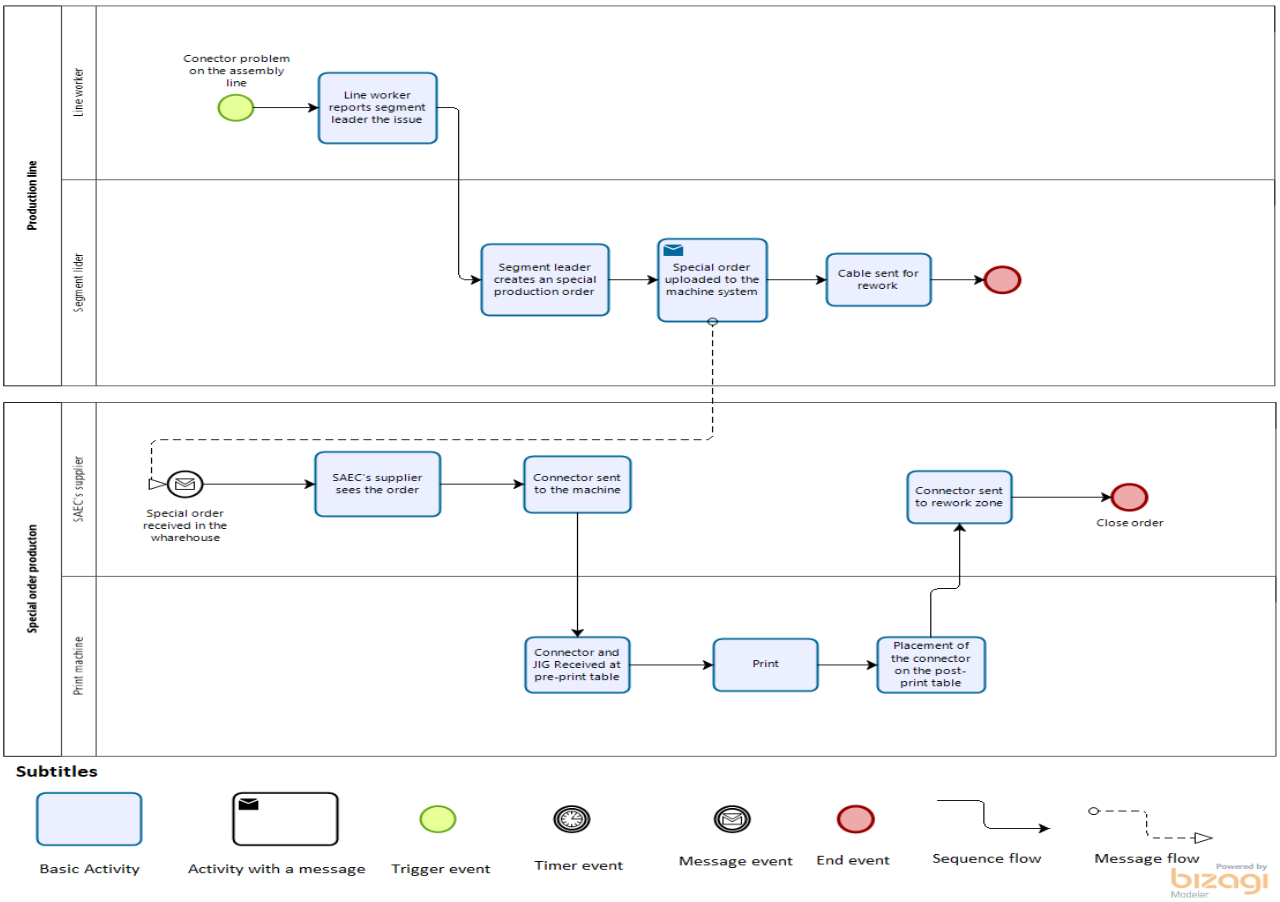


Figure 2. Process for substitution of a defective connector.

This BPMN diagram determines the tasks that each person involved must execute to deal with the referred problem, and, thus, can be interpreted as an alternative way of defining a standard work procedure.

3.5 Material Flow and Production Rate Simulation

To study the material flow from the warehouse to the assembly line, passing through the laser engraving machine, a simulation was created. Thus, in a controlled environment it was possible to understand the impacts of certain variables in the process, e.g. the absence of a worker of the new workstation. The SIMIO technique allows to verify how this absence will influence the production of the laser engraving machine and if this will compromise the supply of the assembly line (by estimating the supply delay time).

After running the simulation and doing some tests, it was concluded that one worker could engrave 8000 connectors in 8 hours, so the new workstation will be able to produce 32000 printed connectors. To supply the four workers of the workstation, it is needed one supplier working for 8 hours too.

4 Conclusion

The design of a new workstation to produce customized electrical connectors, composed by a laser engraving machine and operated by (at most) four workers, was achieved. The development of this workstation implied first the analysis of the entire production process of electrical wiring, which has led to the development of improvement proposals. In the entire project, different aspects were addressed, namely value stream mapping and workplace organization (section 3.1), ergonomic workplace analysis (section 3.2), product data management (section 3.3), process mapping (section 3.4) and simulation (section 3.5). These areas were integrated, to a greater or lesser extent, making it possible to design a workstation with an estimated output of 4000 connectors per hour. One example of such integration occurred between process modelling (PSU - Integrated Production Management) and standard work (PSU - Production Systems Organization II), materialized in the BPMN diagram of Figure 2. Also, the ergonomic design and the 5S methodology worked closely for the workstation development. The layout proposal, for the assembly lines adjacent areas, was developed taking into consideration results coming from simulation. Finally, the work developed in terms of PDM (excerpt represented in Figure), encompassed contents from two PSU: Production Information Systems and Integrated Production Management.

With regard to less successful aspects, it is worth mentioning the case of illuminance and occupational noise, as the students' team had not access to the necessary measuring instruments and, thus, they had to rely on the data provided by the company. Proposals involving noise reduction panels and new lighting systems were developed. However, as the company will be relocated in 2020/2021, the necessary investment is not pertinent.

Unfortunately, it was not possible to implement the new workstation in the period of time allotted for the project. In fact, the only implementation in the shop-floor achieved by the team, was the application of the 5S methodology. However, two important aspects should be mentioned: (i) the feedback from the company regarding the work developed by the students' team was very positive, and (ii) the effective implementation of solutions in the industry, although desirable, is not the primary goal of the PIEGI2 project.

Despite the referred problems, it is clear from above, that the integration of contents from the several PSU was determinant for the project success.

Acknowledgments

This work has been supported by FCT – Fundação para a Ciência e Tecnologia within the R&D Units Project Scope: UIDB/00319/2020.

5 References

Banks, J. (1999). Handbook of Simulation:Principles, Methodology, Advances, Applications and Practice. *Engineering & Management Press*, *2*, 3–5.

Boutgeois, D. T., Smith, J. L., Wang, S., & Mortati, J. (2007). Information Systems for Business and Beyond. *Bioinformatics: Tools and Applications*, 381–401. https://doi.org/10.1007/978-0-387-92738-1_18

Essays, U. (2018). The Information Systems In Manufacturing Industry Information Technology Essay. *UKEssays*.

Gomes, João P, Martins, P. P., & Lima, R. M. (2011). Referenciação genérica: metodologia de caracterização de artigos. *Encontro Nacional de Engenharia e Gestão Industrial 2011 (ENEGI 2011)*, *January 2015*, 27–29.

Gomes, João Paulo, Martins, P., & Lima, R. M. (2011). Generic Referencing: Methodology of parts characterization. *XVIII International Conference in Industrial Engineering and Operations Management (ICIEOM2011)*, 1-12(TI.ST.135.856.18611).

Graaff, Erik de; Kolmos, A. (2007). Management of Change Implementation of Problem-Based and Project-Based Learning in Engineering Edited. In *University Science and Mathematics Education in Transition*. https://doi.org/10.1007/978-0-387-09829-6

Gutenberg, J., Pascal, B., & Hollerith, H. (2017). Information system. *Encyclopaedia Britannica, Inc.*

Laudon, K., & Traver, C. G. (2011). Management Information Systems. *Prentice Hall*, *12*.

Lima, R. M., Carvalho, D., Sousa, R. M., & Mesquita, D. (2017). Implementation of industrial engineering and management projects in interaction with companies,{Implementa}?ão de projetos de engenharia e gestão industrial em intera?ão com empresas. *International Symposium on Project Approaches in Engineering Education*, *9*, 52–61.

Martins, P. J., & Sousa, R. M. (2013). An overview of the generic product data model GenPDM. *22nd International Conference*

on Production Research, ICPR 2013.
Nakano, D., & Muniz, J. (2018). Writing the literature review for empirical papers. *Producao*, *28*. https://doi.org/10.1590/0103-6513.20170086
OMG. (2011). *Business Process Model and Notation (BPMN), V2.0*. *2*(1), 1–4. https://doi.org/10.1016/s0020-1693(97)05933-1
Pegden, C. D. (2007). Simio: A new simulation system based on intelligent objects. *Simulation Conference*.
Pine, B. J. (1993). Mass Customization: The New Frontier in Business Competition. *Harvard Business School Press*.
Powell, P. C., & Weenk, W. (2003). *Project-led engineering education*. Lemma.
Rother, M., & Shook, J. (2003). Learning to See Value Stream Mapping to Create Value and Eliminate Muda. *Lean Enterprise Institute Brookline*. https://doi.org/10.1109/6.490058
Snehal, R. (n.d.). Essay on Production Information System | Production Management. *Business Management Ideas*.
Sturrock, D. T., & Pegden, C. D. (2010). Recent innovations in Simio. *Winter Simulation Conference*.

Bringing PBL to Philippines's higher education: How much are teachers geared for the transition from traditional to PBL approach?

Mia Eleazar[1], Armin Aragoncillo[2], Minh Xuan Nguyen[3], Anna Lyza Felipe[4]

[1] University of Santo Tomas, Manila, Philippines
[2] The Future University, Khartoum, Sudan
[3] Ho Chi Minh City Open University, Ho Chi Minh City, Vietnam
[4] RMIT University, Ho Chi Minh City, Vietnam

Email: mveleazar@ust.edu.ph, arminaragoncillo@gmail.com, minhnx.158t@ou.edu.vn, anna.felipe@rmit.edu.vn

Abstract

A teacher's teaching philosophy is the Northern star for directing their practices. Different teachers have their own views of effective routes for their students' academic achievement and thus follow different teaching approaches in delivering courses. Project-based learning (PBL) is constantly gaining popularity in computing and engineering education, especially in Western education systems. However, this approach is still preliminary in the Philippines, and the transition from the traditional to PBL is still challenging for educators of this region, where most of the teaching is still very much teacher-centered and lecture-based. This study explores the compatibility and mismatches between Computing and Engineering teachers' teaching philosophies and principles of PBL approach. The teaching philosophies are investigated through the two lenses of Behaviorism and Constructivism. The participants are non-PBL practitioners from different universities and colleges in the Philippines who have the desire to deliver PBL in Computing and Engineering courses for the first time. The study is conducted with mixed methods utilizing a survey followed by an in-depth interview, which cover the participants' (1) belief of learners, (2) curriculum flexibility, (3) teaching-learning activities, (4) teachers' roles and (5) assessment in comparison with the commonalities of PBL approach. The survey's data analyzed in SPSS showed that the participants leaned more on the side of constructivism in their belief of teaching and learning; however, the analysis of interviews in NVivo revealed different degrees the teachers sticked to Behaviorism or Constructivism as regards teacher's role, learning style, and assessment in different parts of their teaching.

Keywords: project-based learning, teaching philosophy, constructivism, behaviorism.

1 Introduction

Teaching practice is guided by beliefs in effective teaching and learning. Such beliefs are formed from teachers' learning experiences, teaching experiences, observation of good teaching practice, as well as exposure to academic workshops, conferences and trainings. Also, different disciplines may have discrepant effective teaching practices. In computing and engineering education programs, course content and teaching methods are required to be constantly updated to keep up with the shifting sands of the word of technology. Among various teaching methods, PBL is widely recognized as effective for education in this field; however, whether this drastic approach is challenging to cultures appreciating rote learning is questionable. PBL is a teaching-learning approach, stemming from constructivism (Jumaat, Tasir, Halim, & Ashari, 2017), which assists independent and autonomous learners to resolve real-life problems in authentic projects (Krajcik, Czermiak, & Berger, 1999). If fosters active, collaborative learning, individualization of learning, and intrinsic motivation of learning to satisfy self-inquisitiveness with the assistance or facilitation of teachers (Chua, 2014; Orevi & Dannon, 1999). The emphasis put on self-discovery of knowledge by self-learning and learning in groups corresponds to the core principles of constructivist learning theory.

On the contrary, for Eastern context, (Subramaniam, 2008) favored the idea that most Asian students try to keep a harmonious atmosphere, avoid raising individual voices, consider teachers as distributors of knowledge, and evaluators of their learning. In such learning environments, the constructivist approach would find a slim chance to fit in (Bekerman, 2001).

Generally, it is expected that education in the region will be characterized by teacher-centered classrooms (Campbell & Yong, 1993), an emphasis on extrinsic motivation (Young-Ihm, 2002), and a focus on "drill-like approaches" (Agarkar & Brock, 2017). However, there has been a shift to encourage more student-centered classrooms in Asia (Hallinger & Lu, 2013), even in places with a long tradition of teacher-centeredness, product-based teaching, and students' passiveness (Braine, 2003). The movement away from Behaviorism in Asian education has been clearly proved with the rarity of research publications mentioning teacher-centered instructions in this region in the recent literature. However, the comparison between the present level of teachers' remaining application of this teaching method and the scope of their implementation of constructivist approach has not drawn much attention. Obviously, these two teaching approaches are quite contradicting and can hardly tolerate each other in the same delivery. Thus, this creates a paradox-like situation in the Philippines where the Behaviorism is deeply rooted in the educational system while that very system is in the mandate to transform to a Constructivist era, especially for the application of PBL in computing and engineering education. As part of the research project to introduce PBL approach into Colleges and Universities in the Philippines, this study investigates the compatibility between teachers' teaching philosophies according to Behaviorism and Constructivism in accordance with the principles of PBL approach. The findings of this study will answer the following research questions: (1) To what extent are the teaching philosophies of Philippines university lecturers compatible with Constructivism? (2) To what extent are the teaching philosophies of Philippines university lecturers compatible with PBL principles?

The result then serves as an orientation for intervention in the action research that manages to conduct PBL courses for computing and engineering courses in selected colleges and universities in the Philippines.

2 Background Theories

2.1 Teaching Philosophy

Teaching philosophy is defined as "a systematic and critical rationale that focuses on the important components defining effective teaching and learning in a particular discipline and/or institutional context" (Schönwetter, Sokal, Friesen, & Taylor, 2002). There goes a proverb: 'The teacher has not taught until the student has learned'. Therefore, before developing a teaching philosophy statement normally come discussions of teachers' belief in how learning actually takes place. However, there are slight differences in the components of a teaching philosophy statement following the teacher's belief of teaching and learning. A teaching philosophy statement as considered to be composed of learning models, teaching models, and assessment (Eierman, 2008), but learning goals, teaching methods, learning assessment, and teaching assessment (Kearns & Sullivan, 2011), or conceptualization of learning, conceptualization of teaching, goals for students' learning, the implementation of the philosophy and personal growth plan (Chism, 1998), and conceptualization of learning, conceptualization of an effective teaching and learning environment, expectations of the student–teacher relationship, student assessment, and assessment of learning goals (Owens, Miller, & Grise-Owens, 2014).

As can be seen, common concerns can be found in teachers' belief of learning serving as a foundation for the teaching and learning activities, the organization of curriculum, the roles of teachers, and the design of assessment to favor learning. However, in this study, the teaching philosophy is used as reference checklist for comparison of Behaviorism against Constructivism and PBL approach, which embrace quite contrasting views of learners. Therefore, the teachers' beliefs of learners should also be included in the following review of the two learning theories.

2.2 Behaviorism vs Constructivism as foundation for teaching practices

The Table 1 compares and contrasts the two learning theories following the aforementioned components of teaching philosophy statements to lay the foundation for more insight into the status quo of PBL education in the Philippines' Universities.

Table 1. Behaviorism vs constructivism as the foundation of teaching practices.

	Behaviorism	Constructivism
Teachers' belief of learning	Teachers consider learning as a change in behaviour in response to stimuli, and this happens in students' observation, exposure to teachers' explanation, and practice with teachers' feedback and motivation (Fosnot, 2013). Learning is achieved when a desired response is given to a target stimulus (Ertmer & Newby, 1993).	Teachers conceptualize learning as the active interaction of learners to the surrounding physical and social environment to interpret and reinterpret their understanding of the world (Fosnot, 2013). Learning occurs when one constructs both mechanisms for learning and his or her own unique version of the knowledge, colored by background, experiences, and aptitudes (Roblyer & Doering, 2012).
Teachers' belief of learners (Ertmer & Newby, 1993).	Students take a passive role in receiving knowledge by reacting to the stimuli	Students are expected to actively search for knowledge and validate their understanding through collaboration and communication with relevant people.
Teaching activities	Teaching is to (1) select the cue to gain target responses from students; (2) develop the proper practice to elicit desired responses; and (3) set up situations with stimuli to get students' response and then give them feedback for reinforcement (Gropper, 1987).	Teaching is to guide students in their meaning making, and in self-monitoring, evaluating and updating meaning construction. Also, teachers need to create real-life situations for students to experience (Ertmer & Newby, 1993).
Teachers' roles	Teachers are knowledge transmitters (Scheurman, 1998).	Teachers are facilitators or collaborators (Scheurman, 1998).
The organization of curriculum	The curriculum is predetermined, divided into small tasks and arranged in an increasingly complex order (Fosnot, 2013).	Curriculum comprises tasks that are complex and authentic (Applefield, Huber, & Moallem, 2000).
The design of assessment	Criterion-referenced assessment (Ertmer & Newby, 1993) which is the assessment comparing learners' performance with a set of criteria to decide whether they pass or fail the test (Clifford, 2016).	Assessment tests students' knowledge and their application of knowledge in solving problems (Ertmer & Newby, 1993).

2.3 PBL Principles

Project-based learning approach is an instructional approach encouraging students to be autonomous learners to carry out their authentic projects (Krajcik et al., 1999). However, according to (Heitmann, 1996) PBL approaches can be divided into two versions: "project-organized curriculum" and "project-oriented studies". The former is described as a mixture between other methods of instructions and PBL approach with small projects for each course, which are built up to the final project before university graduation; whereas, the latter is probably unconnected project work in each course. In the condition of the Philippines higher education, where PBL courses are still not common, it is expected that the project-oriented studies are reasonable for universities that apply PBL for the first time. However, regardless of whatever version of PBL is used, in many cases, the PBL approach is laid on the foundation of constructivism (Chu, Tse, Loh, & Chow, 2011; Seet & Quek, 2010) with the following principles.

As regards the mechanism of learning, PBL looks at learning as a process of students' responding to the task to construct knowledge through social interaction based on their previous knowledge and experience (Seet & Quek, 2010). Learning occurs when students can use their schema – their individual accumulated understanding of the world - to interpret and comprehend the relevant knowledge taught to them. The bridge between what is already known and what is new and reasonably challenging should be done in the zone of proximal development where, according to (Vygotsky, 1978), students can reach their potential levels of development after exceeding their actual levels thanks to the scaffolding of more capable peers or the teacher. In practice, project-based learning is fulfilled through individual research and group work to complete the project (Perrenet, Bouhuijs, & Smits, 2000). Indeed, after the project has been given to a team, students have to divide workload to each team member and work on the given tasks individually. However, because of the complex nature of the project, the collaboration among different students, and between students with teachers and local experts is essential for the investigation and realization of the artefact as claimed by Marx, Blumenfeld, Krajcik and Soloway (1997).

As for teachers' roles, teaching in PBL courses, teachers rarely give pure lectures, but predominantly act as facilitators (Blumenfeld et al., 1991; Chua, 2014). The final goal of teaching is to help individual students to construct their own knowledge through meaning making which is aided by exchanges and guidance of friends and teachers. As regards in-class activities, inquiries will unveil some certain areas of knowledge that need addressing for further learning in the course. As for presentations, teachers play a crucial role in discovering challenges of student groups to either guide them through to the solutions or match groups for cross assistance. Also, sometimes students construct incorrect understanding of the issue and show problems that need troubleshooting. These difficulties prove the necessity of tutorials for student groups (Perrenet et al., 2000) where evaluation of the project progress and solution to technical or group management problems are figured out. The most striking teaching activities in PBL approach, therefore, can be concentrating on lectures for introducing new concepts, presentations moderation for assessing students' work and providing feedback, and group tutorials for troubleshooting students' challenges, especially technical problems.

For learning styles, PBL is largely learner-centered, so it upholds the "considerable individualization of curriculum" (Moursund, 1998). The content of a PBL course is therefore developed from the learning needs of students to complete their assigned projects and is also guided by the learning outcomes of the course and the program as a whole. The teachers' project selection is, therefore, of utmost importance for the success of the course because either too challenging or too easy projects will render students bored with learning. Also, the intricacy of projects sometimes requires the combination of expertise of two or more disciplines (Mills & Treagust, 2003), which improves students' experience of how different knowledge should be integrated in real-life work.

When it comes to assessment, PBL approach assesses not only academic but also non-academic skills (Chua, 2014) to gear students towards working in authentic projects currently demanded by the industry. Assessment, therefore, is designed to evaluate the academic performance of students together with their manipulation of soft skills in group work and communication with related agents for their projects. To do so, a multi-component assessment scheme is required to include students' presentations, peer evaluation, learning journals, quizzes, and the final artefact itself. In that manner, PBL courses are mainly equipped with formative assessment (Bell, 2010; Montequín, Fernández, Balsera, & Nieto, 2013). Additionally, the use of rubrics is recommended since they provide students with clear expectations of outcomes and clarifies criteria for assessment as emphasized by (Grant, 2011).

3 Methodology

The researcher performed a structured survey and interview to obtain the quantitative and qualitative understanding of the compatibility and mismatches between Computing and Engineering teachers' teaching philosophies and principles of PBL approach.

24 non-PBL practitioners in selected colleges and universities in the Philippines were identified by the researchers. All non-PBL practitioners are teaching in computing and engineering. Cronbach alpha will be applied to validate the reliability of the questionnaire.

The survey is adapted from (Zinn, 1990) investigating teachers' beliefs about learners (items 11 and 12), beliefs about the purpose of education (item 3), belief about content (items 1 and 5), and beliefs about the learning process (items 2, 4, 9, and 15). Items about the instructional process and the role of educators (items 6, 7, 8, 10, 13, and 14). The questions about Constructivism are based on literature review of that learning theory as presented above. The data from the survey will be analyzed using paired t-test for each category.

A follow-up interview was conducted upon 5 participants whose belief, according to the survey result, fell into the category of behaviorism. The in-depth interview showed the participants' rationale as to why and how they are practicing behaviorism. The interview will focus on five (5) points: belief of learners, teaching activities, teachers' roles, curriculum flexibility, and focus of assessment (on academic skill only in tests or also include soft skills in presentations, and students' portfolio). The data will be analyzed in NVIVO to bring forward the highlights of the teachers' beliefs and current practice in comparison with the fundamentals of PBL approach.

Finally, recommendations were presented to future researchers to introduce PBL methodologies to the participants.

4 Research Findings

4.1. Survey Results

Table 2 shows the reliability of the questionnaire exploring the conformity of teaching philosophies of non-PBL practitioners in the Philippines and the principles of behaviorism and constructivism. The differences are evaluated using the two-tailed test statistical method.

Table 2. Comparison between behaviorism and constructivism.

Teachers' Belief Criterion	Cronbach Alpha α	t-value	p-value
Beliefs about the learning process	.969	-.10057	.780655
Beliefs about the content	.965	.15695	.7818965
Belief about the purpose of education	.929	.2262	.822045
The instructional process and the role of educators	.984	-.00198	.848725
Teachers' belief about learners	.786	-.79912	.45545

Table 3. Cronbach alpha interpretation.

Cronbach's alpha	Internal consistency
$\alpha >= 0.9$	Excellent

$0.9 > \alpha >= 0.8$	Good
$0.8 > \alpha >= 0.7$	Acceptable
$0.7 > \alpha >= 0.6$	Questionable
$0.6 > \alpha >= 0.5$	Poor
$0.5 > \alpha$	Unacceptable

Cronbach alpha was used to check the reliability of the questionnaire. The result shows that all items per criterion received an excellent reliability, except item "Teachers' Belief About Learner" (α = 0.786). The result of Teachers' Belief About Learner has an acceptable internal consistency based on Table 3. This identifies the question's reliability as "acceptable" or "fair" and can be interpreted as to how the respondents understood the learner's role while in a student-centered environment.

The foundations of the practices for teaching were identified as either behaviourism or constructivism, which can be seen in Table 1. Six factors were used as the criteria, namely: teachers' belief of learning, teachers' belief of learners, teaching activities, teachers' roles, organization of curriculum and design of assessment. Using t-test with a critical value of $p<0.05$, the p-value obtained was based on the probability of a null hypothesis, which identifies the teacher as a behaviorist, versus that of an alternative hypothesis, where a teacher leans more towards a constructivist. The results were taken from the survey conducted using the adapted questions from Zinn (1990), identifying two varying degrees of the participants' inclination toward each of the two teaching methodologies. Based on p-value result in Table 2, the participants had identified the following criteria as mostly the same with their personal teaching practice: (1) learning process, (2) content, (3) purpose of education, (4) instructional process and role of educators. This result was used to determine the correlation of each criterion to one another. It should be pointed out, however, that the t-value is smaller than the value on the degree of freedom chart; this means Behaviorism and Constructivism is understood to be significantly different.

The teaching philosophies of the participants were identified mostly under constructivism, which were also aligned with their understanding of the PBL principle's use of a project-oriented studies approach. Likewise, it can be said that few were familiar with project-organized curriculum and would only partially apply to professional courses which are specifically intended for capstone project's preparation but not for the entire curriculum. Because of this, with the mechanisms of learning, students are constrained to working within their own course. Collaboration and social interaction are limited to specific groups which would oftenly change per course. As evidently shown on Table 2 results where belief on the learning process, content, and purpose of education are identified as somehow correlated in defining how projects are developed.

4.2 Interview Results

Based on the interviews, the teacher's role, learning style and modes of assessment are still considered mixed between the two teaching methods. Participants still deliver pure lectures, mixed with facilitator roles during hands-on activities. Because of this, the learning style is also mixed as either teacher-centered during pure lecture days, to student-centred during classroom activities. Indicative of the results as shown in Figure 1, the Teacher's Role and Teaching Activities come out as Very Positive and Very Negative, indicating extreme identified beliefs showing a big difference on how the participants understand and practice PBL. The correlation between the teacher's role and activities signify how it affects the participants' decision in designing and delivering teaching and learning activities. Assessments are based on a fixed syllabus given for each course. The modes of assessment given are mostly summative in the form of quizzes and exams, with projects and activities identified to be formative, measuring technical skills, as well as soft skills, such as communication. However, participants still identify that knowledge comes from the teacher, making the classroom setup as teacher-centered, with activities given to students after a lecture. The interviewees also agreed that a student's role (belief of learners) and how and what they learn (belief of learning) is related to the design of the curriculum and the assessment given to them. This is again indicative of how the Philippine education system is based on a set curriculum.

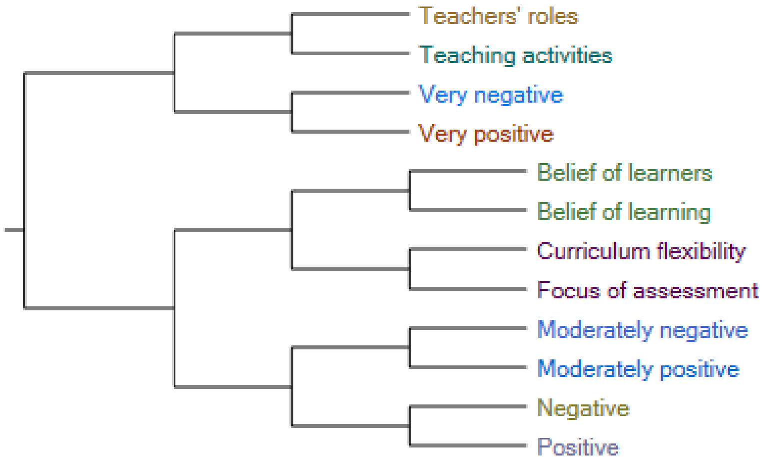


Figure 1. Nvivo interview result

5 Discussion and Conclusion

The Philippines educators' vision to uplift the current state of economy is very clear and orientation of PBL in the educational system can take up this vision (Tiangco, 2005). And in this study, 19 out of 24 participants from different Philippine universities were identified to be focusing more on constructivism. Though the approaches in teaching computing and engineering discipline for the participants signify that they are transitioning from teacher-based approach to a learner-based system. This is due to the fact that in every Philippine University setting, it starts with the curriculum where program outcomes are identified, to the course syllabi where learning outcomes are then derived. This then translates to the teaching activities and design of assessments to validate if said outcomes have been met. However, a teacher's role and how their students are supposed to learn is identified still on the behaviorist point-of-view where students are expected to be passive listeners to teachers who deliver lectures.

The philosophies in teaching computing and engineering of teachers leaning more on constructivism and those sticking more to behaviorism are similar in terms of the beliefs about the learning process, content and purpose of education as shown in Table 2. Though teachers still believe that they are knowledge providers rather than facilitators that lead students to the solution to the problem. The teacher expects the learners to acquire knowledge through the education process. Improving the aptitude of learners to sustain, nurture and cultivate the students to harness their potentials through their maturation process (de Leon-Carillo, 2007). Learning occurs through the process of constructing the artefacts, so the end product is critical to the learning goals (Grant, 2011; Prince & Felder, 2006). Teachers have a clear intention to meet students' needs by means of class activities and motivate students' learning.

While teachers' role is still that of being a knowledge provider rather than a facilitator, teachers have clear intention to guide students' learning by providing class activities that motivate students' learning in the process. This is shown in Figure 1 from the Teachers' role and Teaching Activities results, which has very negative and very positive results respectively. The result identifies how the Constructivist participant and the Behaviorist participant have very different beliefs when it comes to PBL.

In conclusion, although the Computing and Engineering programs at most Phillipine universities still quite strongly adhere to behaviorism with fixed curricula, quizzes and tests, teacher roles and student roles. But it can be noted that the approach is shifting from teacher-based to learner-centered based on the outcome of the study, that: (1) while behaviorist and constructivist differ in opinion on how learning is delivered, based from the six factors, there is no significant difference with regards to desired knowledge gained by its learners;

(2) while teachers are considered the prime source of knowledge in Philippine setting (de Leon-Carillo, 2007), the teaching philosophies of the participants were identified mostly as under constructivism; and (3) Philippine universities are seen to be transitioning from being teacher-based to embracing PBL beliefs, such as defining student learning outcomes, identifying the roles of teachers as facilitators, use of rubrics and small project collaborations.

With this, it can be said that the openness in using PBL in Computing and Engineering programs can prove to be vital in the readiness of the students to enter the real-work life experience as mentored by their teachers.

6 References

Agarkar, S., & Brock, R. (2017). Learning theories in science education. In *Science education* (pp. 91-103): Brill Sense.

Applefield, J. M., Huber, R., & Moallem, M. (2000). Constructivism in theory and practice: Toward a better understanding. *The High School Journal, 84*(2), 35-53.

Bekerman, Z. (2001). Cultural resources and the gap between educational theory and practice. *Teachers College Record, 103*(3), 471-484.

Bell, S. (2010). Project-based learning for the 21st century: Skills for the future. *The clearing house, 83*(2), 39-43.

Blumenfeld, P. C., Soloway, E., Marx, R. W., Krajcik, J. S., Guzdial, M., & Palincsar, A. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational psychologist, 26*(3-4), 369-398.

Braine, G. (2003). From a teacher-centered to a student-centered approach: A study of peer feedback in Hong Kong writing classes. *Journal of Asian Pacific Communication, 13*(2), 269-288.

Campbell, K. P., & Yong, Z. (1993). The Dilemma of English Language Instruction in the People's Republic of China. *Tesol Journal, 2*(4), 4-6.

Chism, N. V. N. (1998). Developing a philosophy of teaching statement. *Essays on Teaching Excellence, 9*(3), 1-2.

Chu, S. K. W., Tse, S. K., Loh, E. K. Y., & Chow, K. (2011). Collaborative inquiry project-based learning: Effects on reading ability and interests. *Library & Information Science Research, 33*(3), 236-243.

Chua, K. (2014). A comparative study on first-time and experienced project-based learning students in an engineering design module. *European Journal of Engineering Education, 39*(5), 556-572.

Clifford, R. (2016). A rationale for criterion-referenced proficiency testing. *Foreign Language Annals, 49*(2), 224-234.

de Leon-Carillo, C. (2007). Filipino Pre-service Education Students' Preconceptions of Teacher Roles Viewed through a Metaphorical Lens. *Asia-Pacific Journal of Teacher Education, 35*(2), 197-217.

Eierman, R. J. (2008). The teaching philosophy statement: Purposes and organizational structure. *Journal of Chemical Education, 85*(3), 336.

Ertmer, P. A., & Newby, T. J. (1993). Behaviorism, cognitivism, constructivism: Comparing critical features from an instructional design perspective. *Performance improvement quarterly, 6*(4), 50-72.

Fosnot, C. T. (2013). *Constructivism: Theory, perspectives, and practice*: Teachers College Press.

Grant, M. M. (2011). Learning, beliefs, and products: Students' perspectives with project-based learning. *Interdisciplinary Journal of Problem-Based Learning, 5*(2), 6.

Gropper, M. (1987). Family medicine and psychosocial knowledge: how many hats can the family doctor wear? *Soc Sci Med, 25*(11), 1249-1255.

Hallinger, P., & Lu, J. (2013). Learner centered higher education in East Asia: assessing the effects on student engagement. *International Journal of Educational Management*.

Heitmann, G. (1996). Project-oriented study and project-organized curricula: A brief review of intentions and solutions. *European Journal of Engineering Education, 21*(2), 121-131.

Jumaat, N. F., Tasir, Z., Halim, N. D. A., & Ashari, Z. M. (2017). Project-Based Learning from Constructivism.

Kearns, K. D., & Sullivan, C. S. (2011). Resources and practices to help graduate students and postdoctoral fellows write statements of teaching philosophy. *Adv Physiol Educ, 35*(2), 136-145.

Krajcik, J. S., Czerniak, C., & Berger, C. (1999). *Teaching children science: A project-based approach*: McGraw-Hill College.

Marx, R. W., Blumenfeld, P. C., Krajcik, J. S., & Soloway, E. (1997). Enacting project-based science. *The elementary school journal, 97*(4), 341-358.

Mills, J. E., & Treagust, D. F. (2003). Engineering education—Is problem-based or project-based learning the answer. *Australasian journal of engineering education, 3*(2), 2-16.

Montequín, V. R., Fernández, J. M., Balsera, J. V., & Nieto, A. G. (2013). Using MBTI for the success assessment of engineering teams in project-based learning. *International journal of technology and design education, 23*(4), 1127-1146.

Moursund, D. (1998). Project-based learning in an information-technology environment. *Learning and Leading with Technology, 25*, 4-5.

Orevi, N., & Dannon, R. (1999). *Learning ecology with educational technologies*. Paper presented at the International Workshop on Science Teachers Education Toward the New Millennium, Haifa, Israel.
Owens, L. W., Miller, J. J., & Grise-Owens, E. (2014). Activating a teaching philosophy in social work education: Articulation, implementation, and evaluation. *Journal of Teaching in Social Work, 34*(3), 332-345.
Perrenet, J., Bouhuijs, P., & Smits, J. (2000). The suitability of problem-based learning for engineering education: theory and practice. *Teaching in higher education, 5*(3), 345-358.
Roblyer, M. D., & Doering, A. H. (2012). Integrating educational technology into teaching.
Scheurman, G. (1998). From behaviorist to constructivist teaching. *Social education, 62*(1), 6-9.
Schönwetter, D. J., Sokal, L., Friesen, M., & Taylor, K. L. (2002). Teaching philosophies reconsidered: A conceptual model for the development and evaluation of teaching philosophy statements. *International Journal for Academic Development, 7*(1), 83-97.
Seet, L. Y. B., & Quek, C. L. (2010). Evaluating students' perceptions and attitudes toward computer-mediated project-based learning environment: A case study. *Learning Environments Research, 13*(2), 173-185.
Subramaniam, G. (2008). Confronting Asian Concerns in Engaging Learners to Online Education. *International Education Studies, 1*(4), 10-18.
Vygotsky, L. S. (1978). Mind in society: The development of higher mental processes (E. Rice, Ed. & Trans.). In: Cambridge, MA: Harvard University Press.(Original work published 1930, 1933 ….
Zinn, L. M. (1990). Identifying your philosophical orientation. *Adult learning methods, 2*, 37-56.

Building a Needs-based Curriculum in Data Science and Artificial Intelligence: Case Studies in Indonesia, Sri Lanka, and Thailand

Chutiporn Anutariya[1], Marcello Bonsangue[2], Taufik F. Abidin[3], Matthew Dailey[1], Katerina Fraidaki[4], Tiago Gomes[6], Felienne Hermans[2], Suratsavadee Korkua[5], João L. Monteiro[6], Nugraha P. Utama[7], Sofia Pereira[6], Amalka Pinidiyaarachchi[8], Sandro Pinto[6], Jan N. van Rijn[2], Opim Salim Sitompul[9], Wararat Songpan[10], Chitsutha Soomlek[10], Frank Takes[2], Suzan Verberne[2], and Chitraka Wickramarachchi[11]

[1] Asian Institute of Technology, Thailand
[2] Leiden University, the Netherlands
[3] Universitas Syiah Kuala, Indonesia
[4] Athens University of Economics and Business, Greece
[5] Walailak University, Thailand
[6] University of Minho, Portugal
[7] Institut Teknologi Bandung, Indonesia
[8] University of Peradeniya, Sri Lanka
[9] Universitas Sumatera Utara, Indonesia
[10] Khon Kaen University, Thailand
[11] University of Sri Jayewardenepura, Sri Lanka

Email corresponding authors: chutiporn@ait.ac.th, m.m.bonsangue@liacs.leidenuniv.nl

Abstract

Indonesia and Thailand are middle-income countries within the South-East Asia region. They have well-established and growing higher education systems, increasingly focused on quality improvement. However, they fall behind regional leaders in educating people who design, develop, deploy and train data science and artificial intelligence (DS&AI) based technology, as evident from the technological market, regionally dominated by Singapore and Malaysia, while the region as a whole is far behind China. A similar situation holds also for Sri Lanka, in the South Asia region technologically dominated by India. In this paper, we describe the design of a master's level curriculum in data science and artificial intelligence using European experience on building such curricula. The design of such a curriculum is a nontrivial exercise because there is a constant trade-off between having a sufficiently broad academic curriculum and adequately meeting regional needs, including those of industrial stakeholders. In fact, findings from a gap analysis and assessment of needs from three case studies in Indonesia, Sri Lanka, and Thailand comprise the most significant component of our curriculum development process.

Keywords: Curriculum Design; Higher Education; Data Science; Artificial Intelligence.

1 Introduction

The use of data science and artificial intelligence (DS&AI) techniques is rapidly growing in several sectors around the world, e.g., in the health care (Jiang, Jiang, Zhi, et al., 2017), transport (Abduljabbar, Dia, et al., 2019) and financial sectors (Gomber, Koch, and Siering, 2017). This revolution is accelerated by advances in data collection, storage and analysis, efficient algorithms, and an increasing computer processing power. Although the United States, China, and Europe (Carriço 2018) are the frontrunners in developing such DS&AI methods, these world-wide scientific advances also have a major impact on other countries, such as Thailand, Indonesia, and Sri Lanka. As the fields of DS&AI have the potential to contribute positively to the economic and social climate of those countries, there seems to be a great need for training professionals in this area (McKinsey Global Institute, 2017b).

Thailand, Indonesia, and Sri Lanka are middle-income countries within the South-East and South Asia region. While DS&AI based technologies are gaining traction and becoming strategic priorities, these countries are still falling behind regional leaders in the technological market, such as Singapore and Malaysia, while the region as a whole is far behind China (McKinsey Global Institute, 2017a). Thailand, Indonesia, and Sri Lanka have well-established and growing higher education systems, increasingly focused on quality improvement. However, they fail in educating people who design, develop, deploy, and train DS&AI based technology, as evident from the acute shortage of data analysts in public and private companies (McKinsey Global Institute, 2017c, Mathur, Aneja, et al., 2019).

These trends make clear that development of talent and capabilities is needed if DS&AI are to reach their full potential throughout the region. The success of political and economic initiatives by governments in these countries to transform the current export-based economy into an innovation- and knowledge-based economy will critically depend on the readiness of the labour force for ICT in general and data-driven technologies in particular. Economic and social development increasingly depend on innovation (Bundy, 2017). Universities have an important role in driving innovation and development. They can do so both through their role in carrying out research and development and by training workers for the knowledge economy. Higher education is not only playing an important role in human resource development, but also in bringing students to companies through internships and in the regional workforce education via professional training.

In this paper, we investigate the great demand of employees in the field of DS&AI in Thailand, Indonesia, and Sri Lanka. In particular, we look at the requirements that small-, medium-, and large-sized companies, both public and private, have on their next generation of workers. These requirements impose new challenges for higher education in computer science across these countries: maintaining and improving education quality (Wittayasin, 2017); and improving the relevance of curriculum and instruction at a time of rapid change in labour market needs. Extraordinary effort is demanded to diversify curricula and to develop, for example, a needs-based curriculum for a master's degree in the fields of DS&AI. These needs are vital for companies to grow larger and keep pace with the advancement in the rest of the world, more importantly in USA, China, and Europe. The design of a novel curriculum in DS&AI is a nontrivial exercise because we have to take into account a constant trade-off between having a sufficiently broad academic curriculum and adequately meeting regional needs, including those of industrial stakeholders.

This paper reports the work compiled using the input from three different activities in the context of the *Erasmus+* project on *Curriculum Development in Data Science and Artificial Intelligence*, registered under the reference number *599600-EPP-1-2018-1-TH-EPPKA2-CBHE-JP*. We proceed as follows. In Section 2 we identify the existing academic curricula, in Section 3 the labour needs from industry, and in Section 4 the gaps that need to be fulfilled by a new curriculum in DS&AI. The curriculum development is described in Section 5. Finally, we draw some conclusions in Section 6.

2 Identifying existing academic curricula

Through desktop research and using a common template, we have collected data from 35 master's degree programmes in DS&AI in Thailand, Sri Lanka, and Indonesia. Many of the programmes we collected data from are generic master's in computer science and contain only few courses related to data science or artificial intelligence. Only 13 out of 35 programmes are directly related to data science or artificial intelligence. Of these, only two are full-fledged programmes on artificial intelligence. The main reason is because in Asia computer science education programmes are often developed in a generic way, e.g., based on ACM curricula recommendations. Most common programmes are therefore named Computer Science, Information Technology, Information System, and Computer Engineering. These programmes often include several elective tracks, such as hardware and computer architecture, communication and networking, computer systems or software. However, there are almost no programmes specific to DS&AI. As a result, students are only allowed to follow a limited number of elective courses within their track, limiting their dedicated knowledge on data science or artificial intelligence.

In Thailand, the fields of DS&AI are currently part of the national strategic plan, called Thailand 4.0, which is a 20-year strategy to accelerate the country's development from upper-middle-income country to high-income country status through digital transformation of manufacturing. Therefore, the development of study programmes in DS&AI are encouraged by the government, although only four dedicated master's degree programmes in Data Science (and none in Artificial Intelligence) are currently available. A related major challenge comes from the northern and north-eastern regions of Thailand, because of the limited number of experts who are eligible to teach and supervise research in master's and doctoral programmes.

In Indonesia, the name of the study programmes in the computing field must be as specified in the ACM Computing Curricula: Computer Science, Information Technology, Information Systems, or Computer Engineering. Due to the above naming regulations, we were able to identify only three specific master's programmes in DS&AI, while several courses are typically available under existing computer science, information technology, and Information systems curricula.

The situation in Sri Lanka is very similar to the one in Thailand, with a government pushing towards a new digital revolution in industry, but with a not well developed higher education programmes specialised in DS&AI to absorb the increasing request from the labour market in these areas.

To summarize the curricula of the existing programmes in areas related to DS&AI, we divided the course types into three groups: core, elective, and supportive course. The core courses are the mandatory courses in the curricula. The elective courses are additional ones that can be selected by students among several alternatives. The supportive courses are related to the basic knowledge which may be the pre-requirement for admission or a preparatory course for the programme. Skills such as communication and presentation, and DS&AI ethics are not always present as full-fledged courses, but incorporated into the programme of other core, elective or supportive courses. The most popular topics among the core courses in all programmes we analysed are data management, data mining, data warehousing, machine learning and research methodology. There are various elective topics which are hard to categorize because of a non-uniform naming. There is only one topic which is taught in all programmes: data and text analytics. Finally, all programmes make available three groups of supporting knowledge: programming, algorithmics, and mathematics/statistics.

3 Identifying labour needs from industry

Across South-East and South Asia regions, talent shortages in DS&AI—caused by gaps and mismatches between labour market needs and the available supply of educated and trained professionals—constrain economic growth (Skinner, Saunders and Beresford, 2004). These shortages prevent companies from scaling up, meeting demand in new locations, and launching new products and services. The talent shortage will have a direct impact on their competitiveness and productivity. We explored the current needs that companies in Thailand, Indonesia, and Sri Lanka have for DS&AI experts. We gathered information systematically through a questionnaire sent to several companies in the above countries, asking to quantify their needs in DS&AI job positions and internship, and which knowledge/skills they require or would ask for professional trainings. We differentiated between the needs of the companies by their size in terms of employees (small: < 50, medium: 50-249, and large: ≥ 250 employees), and we covered several sectors including both public and private companies. We received a response from 59 companies: 23 from Thailand (no medium company responded), 26 from Indonesia, and 10 from Sri Lanka. Here, we consider labour needs not only concerning knowledge, but also those that can occur in skills (programming) or practice (tools).

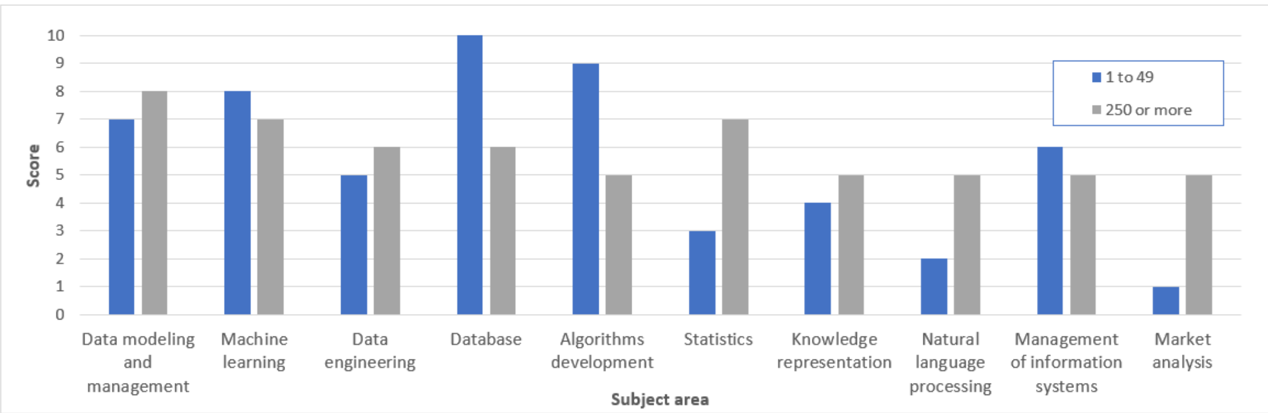


Figure 1. Subject areas with high demand in Thailand for internship placement of companies with different sizes.

In Thailand, an analysis reveals the highest demand for jobs as data scientist, AI/data analyst, software engineer, and business analyst, respectively. The demands of job positions follow a similar trend for small- as well as large-sized companies. Companies require interns to have a strong background in programming (Python, R, SQL, Anaconda, Tensorflow, Genetic Algorithm, and NoSQL), to be fast learners, to have basic skill to complete the end-to-end workflow (public cloud computing platform, SAP, Microsoft Office 365, Power BI, Microservice (Docker for deployment project)), and to have knowledge on several subject areas as illustrated by Figure . The priority on the knowledge required lies on data modelling and management, databases, machine learning, data engineering, and algorithms development, and statistics. The most important subject areas for professional trainings are data modelling and management, machine learning, data engineering, and knowledge representation.

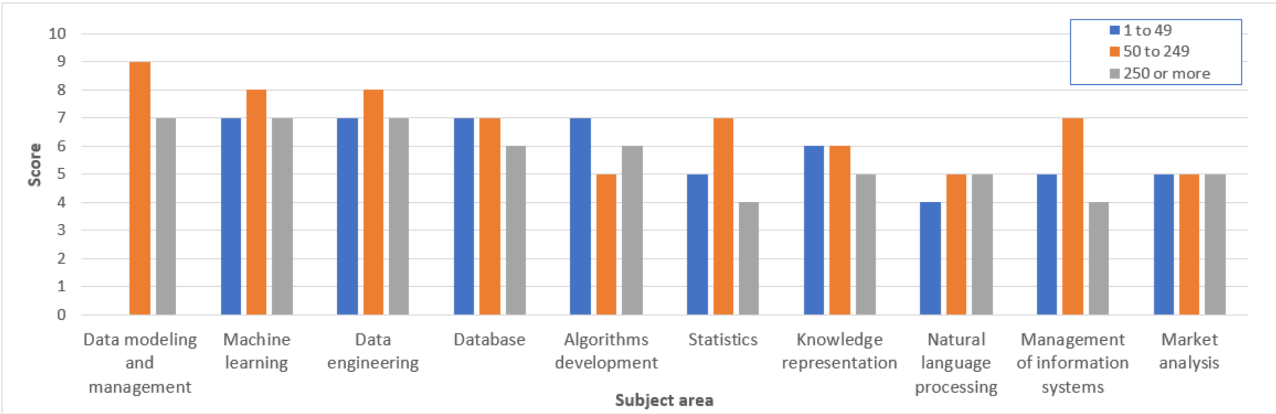


Figure 2. Subject areas with high demand in Indonesia for internship placement of companies with different sizes.

In Indonesia, the highest demand for DS&AI job positions includes data scientist, software engineer, and artificial intelligence/data analyst, respectively. The latter are especially demanded in large-sized companies. All companies we surveyed require interns to have knowledge on data modelling, machine learning and data engineering. In addition, small-sized companies require knowledge on databases and algorithms. Natural language processing is felt in general as not necessary. This is surprising since text analytics is the only course that is taught in all existing programmes (see section 2). Maybe companies do not realize that text analytics is an important subfield of natural language processing. Interestingly, also statistics is one of the knowledge areas that is not really required from interns by large companies. Figure 2 summarizes the average score given by the companies on the required knowledge. Concerning programming languages, required knowledge covers Python, Tensorflow, R, SQL, Java, or any web-based languages, while that for statistical and data visualization tools includes Hadoop, D3.js, Microsoft Power BI, SAP and similar. The needs for training courses cover topics on data modelling and management, machine learning and data engineering. However, the needs for professional courses on statistics, natural language processing and management of information systems are considered, on the average, less interesting.

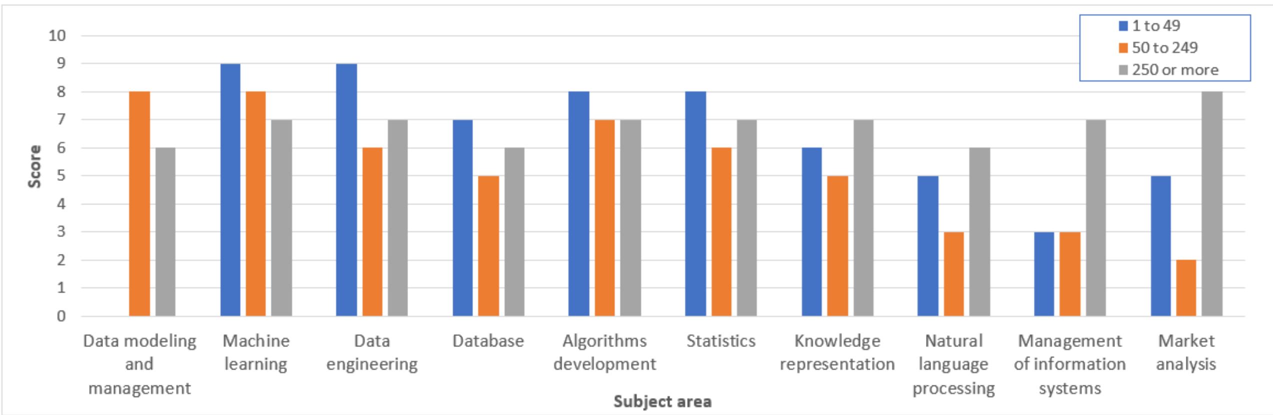


Figure 3. Subject areas with high demand in Sri Lanka for internship placement of companies with different sizes.

In Sri Lanka, we received a response from only 10 companies, 4 small-sized, 4 mid-sized, and 2 large ones. They were all private companies, and all positioned in an ICT related area. Overall, the highest demands for DS&AI job positions are machine learning engineer, data scientist, and artificial intelligence/data analyst, respectively. Students are required to have knowledge of programming language such as Python, TensorFlow, R, SQL, and to be able to use Matlab, Hadoop, and Git. There are large differences between what is considered important as knowledge of the interns, depending on the size of the company. Large companies prefer interns with knowledge of market analysis, whereas small- and medium-sized ones prefer knowledge of machine learning and algorithms, and consider market analysis as the least important subject. Other topics that are considered important are data modelling and management and data engineering. Figure 3 summarizes the findings. The most important subject areas for professional trainings are data modelling and management, machine learning, and data engineering. Large companies find algorithms also very important. The least important subject areas are databases, statistics and market analysis, probably because the employees already have knowledge on these subjects and do not need extra training.

4 Identifying the gaps

In this section, we explicitly identify the gaps to be addressed in the development of master's degree programmes in DS&AI in Thailand, Indonesia and Sri Lanka. With this goal, we organized in each country a focus group composed of at least 4 academics, 3 students and 3 representatives from ICT companies. This composition guaranteed that all relevant stakeholders provided their input in understanding what is needed by a new education programme in DS&AI. We investigated the following issues:

1. Identification of subject areas related to DS&AI that are most in need in the country (and wider region).
2. Identification of a set of skills that the curriculum should develop and promote.
3. Teaching and learning processes that are appropriate for the curriculum (project-based learning, professional certifications, trainings, practical and industrial projects, workshops, internships, research, theses, etc.).
4. Required resources, facilities, tools, as well as support that the universities should provide (what we lack or need).
5. Any concerns and opinions regarding internships and job opportunities that the curriculum should provide.

Next, we briefly summarize the results of the discussion fora in Thailand, Indonesia, and Sri Lanka. The teaching and learning of the DS&AI curriculum must be able to meet both the needs of the industry and the interest of students. Teaching and learning should lay down the foundation of core knowledge that is sufficient for learning DS&AI, including (1) mathematics, logic, and statistics, (2) programming and computational thinking, and (3) data management. The need for knowledge of business analytics and machine learning depends on the student group characteristics and the objectives of the students. Therefore, it is preferred to have different tracks in the curriculum ranging from (1) applying data analytics techniques to solve problems, analysing data for the industry, and (2) developing deep knowledge in DS&AI, which can enhance the higher performance for the particular industry.

The laboratory equipment should be prepared and ready to use for the most effective learning. The tools used in teaching and learning should be in line with those commonly used in the industry, including Google cloud, Hadoop, Python, and Tensorflow. Students should have the skills to use those tools that can lead to the product development, not just a tool that running or testing as experiments. The courses must be built in collaboration with the industry in applying the real case study for teaching or for students to experiment. Students should practice an internship in a company, or work on industrial projects.

Finally, students should not only gain hard skills through courses and internship training, but also soft skills. The soft skills that are suggested to be developed include: (1) communication skills, (2) analytical skills/ empirical skill, and (3) presentation skills, both in terms of how to present and how to use visual tools to effectively communicate the results of data analysis to the users.

5 Developing the curriculum

In agreement with the international views on higher education, the objective of a master's degree programme in DS&AI is to provide students with a suitable basis for a further career, both in research as well as in industry and society in general. As such, it provides the student with the specific knowledge and abilities, exemplified in the form of a master's degree that allows graduates access to a PhD programme in DS&AI and related disciplines. Also, it prepares graduates for a position in which they can earn their own subsistence, for example by working in knowledge-intensive companies. Our starting point in the development of the curriculum was to take into account the needs and gaps described in the previous sections as well as to provide graduates with a basic understanding of all the key areas of DS&AI, and an advanced understanding in some of these key areas.

The programme has a duration of two years, and includes core courses, electives, an internship, and a thesis work. The core courses define the key areas of the curriculum in DS&AI, and are therefore present as a dedicated mandatory course in the programme. From the data we collected, we arrived at the conclusion that there is a general, and largely worldwide (Quality Assurance Netherlands Universities, 2015), consensus that our proposed five core courses below define the key areas of DS&AI:

- Artificial intelligence: This course introduces the students to fundamentals of Artificial Intelligence, in particular to several techniques on planning and decision procedures ranging from precise to uncertain and temporal reasoning with applications to intelligent agents.
- Business Intelligence and Analytics: Business intelligence is a process of analysing business data to obtain business insights and actionable intelligence and knowledge, to support better business decision making and capture new business opportunities. This course gives the students an understanding of the principles and practices of business intelligence and data analytics to support organizations in conducting their business in a competitive environment.
- Computer Programming for DS&AI: This course is a laboratory course that provides students with the computer programming background necessary for preparing, manipulating, analysing, processing, and visualizing data sets as well as for building-data-driven predictive models
- Data Modelling and Management: The course emphasizes on emerging data models and technologies suitable for managing different types and characteristics of data. In particular, the focus is on developing skills for analysing, evaluating, modelling, and developing database applications with concerns on both technical and business requirements.
- Machine Learning: This course introduces the fundamentals and applications of machine learning. Students learn to design, implement, and evaluate intelligent systems incorporating models learned from data.

The above set of core courses is not intended to constitute the complete master's programme. Programme flexibility and adaptability to the regional needs is obtained through additional elective courses. Within the *Erasmus+* project on *Curriculum Development in Data Science and Artificial Intelligence*, we have developed the following 11 elective courses:

- Natural Language Processing
- Computer Vision
- Distributed Systems
- Human Computer Interaction and Information Visualization
- Knowledge Representation
- Multicriteria Optimization and Decision Analysis
- Nature Inspired Computing
- Recent Trends in Machine Learning
- Social Network Analysis
- Software Development and Project Management
- Spatial-Temporal Data Analysis

Core and elective courses cover all aspects of data science intended as the extraction of useful domain knowledge from large, complex data sets. Core courses like *Machine Learning* or *Data Modelling and Management* provides the critical knowledge needed for decision makers based on statistically significant patterns in data. Business applications are treated in courses like *Business Intelligence and Analytics*, while the detection of anomalies in patterns of behaviour is developed in the electives *Social Network Analysis* and *Spatial-Temporal Data Analysis*. Finally, the course *Distributed System*s treats, for example, the analysis of services in cloud computing.

The curriculum we developed covers the broad field of artificial intelligence as the theory and development of computational systems able to perform tasks inspired by human intelligence. We basically develop on three main views of the field of Artificial Intelligence:

1. *Symbolic AI* – consisting of knowledge representation, logic reasoning, inductive logic programming, precise planning, and decision procedures;
2. *Statistical AI* – consisting of decision networks, probabilistic programming (including Bayesian program synthesis), computer vision (activities and image recognition as well as machine vision), natural language processing, and machine learning; and
3. *Subsymbolic AI* – consisting of distributed artificial intelligence (including agent-based modelling, swarm intelligence and multi-agent systems), distributed computing, natural computing, multi-objectives optimization, and autonomous systems.

It is not a surprise that machine learning plays a pivotal role in the curriculum, as, today, it can be considered the most widely applied discipline within Artificial Intelligence. Machine learning comes in the curriculum in at least three “flavours”: supervised learning, unsupervised learning, and reinforcement learning. Supervised learning refers to methods for learning a model from a set of training data containing both input and output results. Regression and classification are typical examples of supervised learning techniques. Unsupervised learning consists of building a model from a data set, via for example visualization or clustering. Reinforcement learning is about taking actions in an environment to maximize some notion of cumulative reward, as for example used in robot navigation and games (including chess, Go, and business games).

As part of the programme, students are required to get few months placement with a company before graduating. As students participate in internships, they gain real work experience, which not only benefits employers, but also provides a valuable complement to university education and an input to job counselling (Vairis, Loulakakis, and Petousis, 2014). All knowledge required by the companies as described in Section 3, is covered within the core or elective courses before the internship takes place.

6 Conclusion

In this paper we described the design of a master’s level curriculum in data science and artificial intelligence based on a gap analysis and assessment of needs from three case studies in Indonesia, Sri Lanka, and Thailand. On the one hand, we realize that in these countries many of the master’s programmes we collected data from are generic master’s in computer science and contain only few courses related to data science or artificial intelligence. On the other hand, we proceeded via a systematic process by gathering information from several companies in Indonesia, Sri Lanka, and Thailand to understand the needs and the gaps. Based on all information, we developed a novel curriculum for a master’s programme in DS&AI that covers the main areas of the fields, it allows flexibility of study depending on the regional needs, and it comprises an internship for students to gain work experience. The approval and accreditation of the developed curriculum to be delivered by eight participating institutes in three countries are underway; hence, the programmes are expected to be launched in fall 2020 or spring 2021.

Acknowledgements

The authors would like to thank the European Union *Erasmus+* programme which provided funding through the *Capacity Building Higher Education* project on *Curriculum Development in Data Science and Artificial Intelligence*, registered under the reference number *599600-EPP-1-2018-1-TH-EPPKA2-CBHE-JP*.

7 References

Abduljabbar, Dia, Liyanage, and Bagloee (2019). Applications of Artificial Intelligence in Transport: An Overview. *Sustainability*, Vol. *11, No. 1,* pp. 189—212.

Bundy (2017). Preparing for the future of Artificial Intelligence. *AI & Society,* Vol 32, pp. 285—287.

Carriço. (2018). The EU and artificial intelligence: A human-centred perspective. *European View*, Vol. 17, No. 1, pp. 29–36.

Gomber, Koch, and Siering (2017). Digital Finance and FinTech: current research and future research directions. *Journal of Business Economics,* Vol 87, pp. 537–580.

Mathur, Aneja, Anwar, Shridhar, and Sanchez (2019). *Future of Work in Sri Lanka: Shaping technology transitions for a brighter future*, TANDEM research report, International Labour Organization, pp. 1—98.

Jiang, Jiang, Zhi, Dong, Li, Ma, Wang, Yilong, Dong, Shen, Haipeng and Wang (2017). Artificial intelligence in healthcare: past, present and future. *Stroke and Vascular Neurology,* Vol. 2, No. 4, pp. 230—243.

McKinsey Global Institute (2017a). *Artificial intelligence: Implications for China*.

McKinsey Global Institute (2017b). *Artificial intelligence: The Next Digital Frontiers?*

McKinsey Global Institute, (2017c). *Artificial intelligence and South-East Asia's Future.*

Quality Assurance Netherlands Universities (2015). *Artificial Intelligence Academic Programmes in the Netherlands: A State-of-the-Art Report.*

Skinner, Saunders, and Beresford (2004). Towards a shared understanding of skill shortages: differing perceptions of training and development needs. *Education + Training*, Vol. 46, No. 4, pp. 182—193.

Vairis, Loulakakis, and Petousis (2014). The role of internships in a higher education institute. In QScience Proceedings of the World Congress on Engineering Education 2013, pp. 27—34.

Wittayasin (2017). Education Challenges to Thailand 4.0. *International Journal of Integrated Education Development*, Vol.2, No.2, pp 29—35

360º Educational Robotics Project Management for High Abilities and Gifted Students

Marlete M. da Silva[1], Carla Maria Chagas Cavalcante Koike[2], Liliane Bernardes Carneiro [3]

[1] Graduate Program in Mechatronic Systems, University of Brasília, Brazil
[2] Computer Science Department, University of Brasília, Brazil
[3] Institute of Psychology, University of Brasília, Brasília, Brazil

Email: marlete_eng@outlook.com, koike@unb.br, liliane.bernardes@gmail.com

Abstract

This paper presents the results of a project that analysed Specialized Educational Assistance (AEE) for High Abilities and Gifted Students (AH/SD) aged 7 to 15 in two public schools in the Federal District over a period of 24 months. The work was developed through a partnership between University of Brasília (UnB) and the State Department of Education of the Federal District (SEEDF). This project enabled the implementation of two educational robotics laboratories, acquisition of electronic devices (five educational robotic kits and two kits for assembling 3D printers), among other materials. The project also provided scholarships for Mechatronics and Computer Engineering students at the university as well as opportunities for teacher training, including support for the monitors and students in class throughout the project period. It was also possible to develop a system to control the attendance to AH/SD students. The objective of this study consisted of inserting Educational Robotics (RE) in attendance to AH/SD students and evaluating scientific knowledge in the field of robotics and cognitive development through workshops aimed at stimulating skills, creative thinking, cooperation, interpersonal relationships, and problem solving. It also aimed at sharing a successful experience that combined the contents conveyed to students of graduate, undergraduate and technical level courses in the execution of the lesson planning. Thus, this paper presents an ER project management model with a multidisciplinary team that contributed to the technological learning process in basic education and obtained a successful result.

Keywords: Educational Robotics; High Abilities and Gifted Students; ER laboratory.

1 Introduction

Educational Robotics (ER), also called Pedagogical Robotics, provides opportunities for students to learn and practice abilities and skills in several areas of knowledge, such as physics, algebra, geometry, design, electronics, mechanics and computer programming. In addition to providing interdisciplinary learning, ER consists of a significant tool for student development when it comes to the desirable aspects of the theoretical and methodological model adopted in the Specialized Educational Service to High-Ability and Gifted Students (AEE-AH/SD) in the Federal District (DF), Brazil. The work described in this paper had the main goal of evaluating the impact of ER in the cognitive development of students with high abilities as well as to implement ER laboratories for High Abilities and Gifted Students (AH/SD) attended by the specialized service.

1.1 Robotics and Educational Robotics Concept

Robotics is a multidisciplinary area in engineering that not only comprises abundant research studies in the development and application of robots but also provides opportunities for the study of computational thinking and experimentation methods in the classroom.

Therefore, the term "robotics" does not only refer to a set of automated machines that accelerate the production system but it has also been as an instrument for multidisciplinary teaching in schools (Chang, 2010). It is believed that the use of ER in classrooms has a positive impact on student learning and that it can be seen as a new learning strategy (Liying & Baichang, 2018).

ER is a very promising area of knowledge that shows the potential of learning methods such as observation, knowledge of basic concepts electronics, programming, appropriate teaching pedagogy obtained through teacher training, and monitoring of classes through periodic evaluations (Ya-Wen, 2018).

ER has been shown to promote students' creative attitude, communication skills, systemic vision, cooperation and teamwork, as well as to favor increased interest and motivation to learn traditional disciplines in the regular teaching curriculum (Chang, 2010).

1.2 Resources needed in ER

The learning environment of ER usually includes resources such as computers, softwares, as well as electronic and electromechanical components. Through the integration of these elements, students build and program automated devices with the objective of exploring concepts from different areas of knowledge (Peleg & Baram-Tsabari, 2017).

The development of robotic devices for educational purposes is a multidisciplinary activity that not only involves theoretical studies related to STEM (Science, Technology, Engineering and Mathematics) but can also indirectly address other areas such as biology, chemistry, and languages (Benitti, 2012).

The inclusion of ER contents favors students as for improving visualization of abstract concepts such as vectors, forces, gravity, geometry, electromagnetism, among others (Karim, Lemaignan & Mondada, 2015). Therefore, ER can benefit the learning process of mathematics and physics in elementary, middle, and high school.

Regarding the development of activities of non-specifically technical learning, studies (Kopcha, 2017) indicate that conventional education still needs to evolve. Most studies report that robots play a positive role in the development of creative thinking as well as improve social skills and logical reasoning for problem solving. In addition, interaction with robots increases motivation, engagement and creates a positive attitude towards ER education among children (Blikstein, 2013).

ER is not included in the regular basic education curriculum of public schools in Brazil. However, private schools have shown growing interest in this area, often investing in after-school programs or independent projects such as robotics laboratories, and organization and participation in events such as olympiads and exhibitions.

Blikstein (2013) advocates for linking intellectual work in the classroom with students' ability to build things, either with their parents or friends in garages, or in companies and schools (Blikstein, 2013).

The approach of robotics in schools, which can involve technological methodology, presents a significant potential for pedagogical changes, especially due to students' interest in building robots and developing projects using electronic and mechanical components.

In order to increase student's awareness about sustainable development, this paper proposes building robots with reusable material and the use of free programming platforms of educational robots. By doing so, it is possible to experience the advent of a new era for educational technology learning (Eguchi, 2010; Gershenfeld, 2007).

1.3 Development of cognitive skills

Over the last years, ER attracted the interest of education professionals as a powerful resource for developing skills, especially cognitive ones, in students of Basic Education, strengthening science learning, mathematics, technology, informatics, and other interdisciplinary subjects.

In the literature, ER covers knowledge and transversal skills in STEM areas, such as subject-oriented knowledge (e.g., knowledge of physics, mathematics etc.) and cognitive skills (e.g., analysis, classification, and prediction). Consideration of the practice domain, troubleshooting process, engineering design process and scientific research skills characterize ER (Toulmin, 2007).

Other important abilities to personal development include cognitive, meta-cognitive and social skills, such as research skills, creative thinking, decision making, problem solving, communication skills and team work. All of which are necessary in ER laboratories.

Eck et al. (2013) reported that infants improved their resistance and ability to concentrate for a certain period as well as developed planning and cognitive flexibility apply to learning abstract rules. Most studies about ER emphasize cognitive domains and skills more than the attitude domain (Keren & Fridin, 2014).

According Mataric (2000), robots assist in children's cognitive and intellectual development (Mataric, 2000). Hmelo-Silver & Pfeffer, (2004) explain the importance of cognitive processes for restrict complex problems, logics, algorithms, application of rules, decision-making, strategic performance, and more detailed descriptive analyses of complexity and problem typology (Hmelo-Silver & Pfeffer, 2004).

Kandhofer (2012) argues that research needs to prove if the learning objectives have been achieved in each project, that is, if more children are interested in science and technology and have developed cognitive/social skills significantly better. In addition, proponents need to observe whether the robotic design for young children has an impact on their educational career, which requires longitudinal evaluation of projects (Kandlhofer et al., 2012).

2 Methodology

This work consisted of applying ER activities to students with high skills/Giftedness. The activities were presented by groups in two schools. Students were aged between 7 and 15.

The two schools have an average of 40 students each, thus divided from regular education: elementary school (2nd, 3rd, 4th, and 5th grades), middle school (6th, 7th, and 8th grades), and high school (9th and 10th grades). The attendance hours took place once a week in the morning (from 8a.m. to 12a.m.) and in the afternoon (from 2pm. to 6p.m.). Students were aggregated by affinity, not necessarily by age groups but by interests in specific subjects. This work was performed in five steps:

- Teacher training.
- Acquisition of materials and construction of the ER laboratories.
- Selection of monitors at University of Brasília.
- Planning classes with teachers that attend to highly-Skilled/gifted students.
- System development on high skills and giftedness.

The work team was formed by five undergraduate students in Mechatronics Engineering, one undergraduate student in Computer Engineering, two high school students (one in Computer Technician course and one in Electronic Technician course), two professors at the university, two teachers at the State Department of Education of the Federal District (SEEDF), one doctoral student and one master's student in Mechanical Engineering, along with the project coordinator.

2.1 Teacher training

Teacher preparation to start ER classes require the proposition of a robotics teaching model that mixes the tangibility of the robots with the possibility of development of various contents. Teachers are essential resources in the educational structure. They need to feel confident about using the tools and methods used to build robots (Kradolfer, Dubois, Riedo, Mondada, & Fassa, 2014).

Such confidence can only be achieved through appropriate training and active/proactive involvement. Many of the teachers feel hesitant in dealing with robotics in the classroom. Such behavior reflects their reluctance in learning new concepts, which can sometimes be associated with the absence of robotics in the standard curriculum as well as with the fact that the learning outcome is achieved in the long term (Shuttleworth, 2018).

The content of the ER course was designed and ministered over a period of 6 months, and the project trained 30 teachers from the Federal District. This training was prioritized for teachers that provide assistance to AH/SD students. The training contents consisted of basic notions of electronics, free software programming, scratch, and usage of microcontrollers (Arduino), and various electronic devices.

The programme diversity, in terms of interaction approaches and addressed themes, transforms PAEE/ALE in a platform for those who wish to share and learn more about active learning and project oriented approaches to teaching/learning of engineering.

2.2 Materials Acquired and Construction of Laboratories

In the course of the teacher training, during the initial 6 months of the project, each school involved in the study provided a classroom for mounting the laboratories (Figure 1). Both had approximately 25m^2. They were equipped with chairs and tables covered with rubber blankets, and cabinets for accommodating support materials. In addition, several electronic devices were purchased: microcontrollers, mounting kits for 3D printers, five educational robotics kits, and 10 laptops.

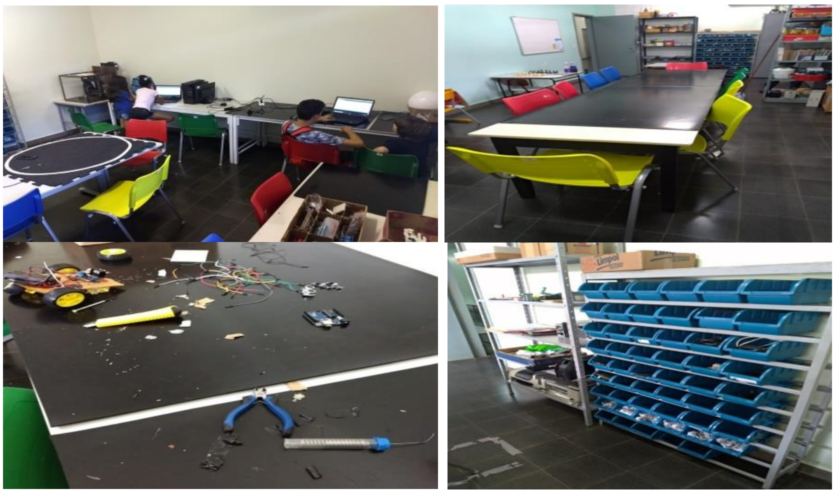


Figure 1. Educational Robotics Laboratory.

2.3 Selection of Scholarship Students

Professors/researchers of University of Brasília performed the selection of monitors for supporting school teachers that attend to AH/SD students. The selected tutors were five undergraduate students in Mechatronics Engineering and one in Computer Engineering, all of whom mastered ER content. All fellows were guided by the team of teachers.

2.4 Lesson Planning

The planning involved the collective documentation of the content taught in the resource room (laboratory), by separating materials for building prototypes, installing programs, setting machines, searching content with references, and accessing research through the Internet. For instance, if creating a robot is an activity to be performed, then a problem is generated, and one should use creativity to come up with a robot proposal. Several questions must be answered: How should the robot move? By using wheels or legs, or by crawling? What will be the energy source to be used? What materials ought to be used? What will be its shape? Will it look like a cart, a human or a spider? How will it be controlled? The answer to these and other questions should be based on discussions and search for solutions in magazines, books, films or on the Internet. After conception, one should move on to the construction phase, which will contribute to the development or improvement of manual skills, for it will be necessary to design, cut, fit, glue, screw, paint, and weld components, among other actions.

2.5 System development for High Abilities and Gifted Students

A system was created to register the students to be attended, teachers, and schools of the Federal District with resource rooms for AH/SD students as well as to generate specific reports about the activities to be developed. This system was intended to decrease the number of reports and the filling out of paper forms, speeding the issuance of records and response to service inquiries. The system is currently in the testing phase, holding a database fed with more than 700 registered students.

3 Results

The results obtained from the project developed were significant. It was possible to assemble two ER laboratories, provide professional training for teachers, participate in annual events inherent to ER, and acquire materials for student use (educational robotics kits, electronic devices, and one 3D printer) as well as support for handling them.

Therefore, it was possible to develop individual projects with students of the prototype building service using the materials acquired in the laboratory.

Social skills were acquired through participation and research to solve problems related to the ER proposed activities.

The monitors, students, and guiding researchers obtained experience in the content approached. The former group received participation grants, and support in class was provided to them as well as to teachers and students.

4 Discussion and Conclusion

Despite the scientific progress in this project, one identified the potential limitations of the education system as a whole when it comes to implementing emerging Educational Robotics in its schools (Renzulli, 2012), mainly in terms of infrastructure and acquisition of materials for the opening of the laboratories (ranging from electronic devices to 3D printers).

The greatest challenge of this work was not only convincing the teachers regarding the relevance of Robotics but also training them and developing the content modules of ER based on the regular curriculum of basic education.

The challenges were minimized by the teacher training course, development of class tutorials, and monitor support, which in fact brought confidence to the development of classes along with the school teachers responsible for their respective ER research laboratories.

ER should be interpreted as a discipline to promote essential life skills (cognitive and personal development, and team work). Therefore, it is possible for students to develop their potential imagination, expressing themselves, making original choices, and generating value to their lives. The benefits of ER can be perceived in all children engaged in robotics projects. Therefore, topics related to awakening interest in science and technology should be included in the basic regular curriculum of every school in the Federal District.

Acknowledgments

The authors of this paper thank the Federal District Research Foundation (FAPDF) for funding this project.

5 References

Benitti, F. B. V. (2012). Exploring the educational potential of robotics in schools: A systematic review. Computers & Education, 58(3), 978-988.

Blikstein, P. (2013). Digital fabrication and "making" in education: The democratization of invention. In J. Walter- Herrmann & C. Bóching (eds.), FabLabs: Of Machines, Makers and Inventors (pp. 1-21). Bielefeld: Transcript Publishers.

Chang, C. W., Lee, J.-H., Po-Yao, C., Chin-Yeh, W., & Gwo-Dong, C. (2010). Exploring the possibility of using humanoid robots as instructional tools for teaching a second language in primary school. Journal of Educational Technology & Society, 13(2).

Eguchi, A., (2010). What is educational robotics? Theories behind it and practical implementation. In D. Gibson & B. Dodge (eds.), Proceedings of Society for Information Technology & Teacher Education International Conference 2010 (pp. 4006-4014). Chesapeake, VA: AACE.

Eck, H., Hirschmugl-Gaisch, S.; Hofmann, A.; Kandlhofer, M.; Rubenzer, S.; Steinbauer, G. (2013). Innovative concepts in educational robotics: Robotics projects for kindergartens in Austria. In Proceedings. Austrian Robotics Workshop, Vienna, Austria, 23–24 May; pp. 10–12.

Gershenfeld, N., (2007). Fab: the coming revolution on your desktop - From personal Computers to personal fabrication. NY: Basic Books.

Hmelo-Silver, C. E., & M. G. Pfeffer. 2004. Comparing expert and novice understanding of a complex system from the perspective of structures, behaviors, and functions. Cognitive Science 28 (1): 127–38.

Karim, M. E., S. Lemaignan & F. Mondada, (2015). "A review: Can robots reshape K-12 STEM education?" IEEE International Workshop on Advanced Robotics and its Social Impacts (ARSO), Lyon, pages. 1-8.doi: 10.1109/ARSO.2015.7428217.

Kandlhofer, M., Steinbauer, G., Sundström, P., & Weiss, A. (2012). Evaluating the long-term impact of RoboCupJunior: A first investigation. In D. Obdrzalek (ed.), Proceedings of the 3rd International Conference on Robotics in Education, RiE2012 (pp. 87-94). Prague: MatfyzPress.

Keren, G., Fridin, M. (2014). Kindergarten Social Assistive Robot (KindSAR) for children's geometric thinking and metacognitive development in preschool education: A pilot study Computation Human Behavior, pp. 400–412.

Kopcha, T.J., McGregor, J., Shin, S,; Qian, Y., Choi, J., Hill, R., Mativo, J., Choi, I. (2017). Developing an Integrative STEM Curriculum for Robotics Education Through Educational Design Research. J. Form. Des. Learn. 2017, 1, 31–44.

Kradolfer, S., Dubois, S., Riedo, F., Mondada, F. & Fassa, F., (2014). A sociological contribution to understanding the use of robots in schools: the thymio robot. In Social Robotics, pages 217–228. Springer.

Liying, X. & Baichang, Z. (2018). A systematic review on teaching and learning robotics content knowledge in K-12, Computers & Education, volume 127, pages 267-282, ISSN 0360-1315, doi:10.1016/j.compedu.2018.09.007.

Mataric, M. J. Socially Assistive Robotics. Science, 3(6):233–242, 2000.

Peleg, R., & Baram-Tsabari, A. (2017). Learning Robotics in a Science Museum Theatre Play: Investigation of Learning Outcomes, Contexts and Experiences. Journal of Science Education and Technology, 26(6), 561-581.

Renzulli, J. S., (2012). Reexamining the role of gifted education and talent development for the 21st century: A four-part theoretical approach. Gifted Child Quarterly, 56, 150-159.

Toulmin, C.N., Groome (2007). M. Building a Science, Technology, Engineering and Math Agenda; National Governors Association: Washington, DC, USA.

Shuttleworth M., (2018). True experimental design. Retrieved [date of retrieval] from experiment resources http:/www. experiment-resources.com/true-experimental-design.

An Overview of Assessment of Competences based on publications in journals

Mariane C. Souza[1,2], Rui M. Lima[1]

[1] Department of Production and Systems, Algoritmi Centre, School of Engineering, University of Minho, Guimarães, Portugal
[2] Federal University of Rio Grande – Campi Carreiros, Brazil

Email: marianecasseres@gmail.com, rml@dps.uminho.pt

Abstract

Competences assessment transcends disciplinary areas and its research has increased worldwide. However, research in competence assessment in the engineering universe is something relatively new, concerning other disciplinary areas such as medicine and education. Understanding the state of art in areas where studies on competence assessment are more developed is an important step for transferring that knowledge to Engineering. This article aims to analyze the competences assessment state of art and to understand the actors involved in assessment methods (who is the assessor and who is being assessed), when and how the assessment process occurs, in medicine context, education, and engineering areas. The chosen approach was to carry out a literature review study based on a search using the Elsevier Scopus indexing service, in the timeframe 2000 to 2019. Using the search-terms "competences evaluation", "competencies evaluation", "competencies assessment" or "competences assessment", applied to title, abstract and keywords, was possible to identify 1,984 periodical documents, which 1,563 documents were of interest to the study, and related to Medicine, Education or Engineering areas. As a selection factor, the ten (10) most cited articles in each area were analyzed. Based on the study, the authors concluded the methods of assessing competences in medicine and education field may be used to support the Engineering area to develop reliable and valid methods for assessing competences. Besides, it was possible to identify that engineering competence assessment methods presented a focused computers simulators use. However, for medicine and education, the methods focus was evidenced in Objective Structured Clinical Examinations (OSCEs), based on scenarios.

Keywords: Competences Assessment; Competences Assessment Methods; Assessment of Engineering Competences.

1 Introduction

The culture of competence assessment arose from growing criticism of traditional testing; methods related to the unrealistic nature of tests. As a consequence, there was a “loss of faith” as valid learning measures (McDowell, 1995). The culture of competence assessment started to arise when US schools were held responsible for their educational outcomes. As a consequence, they began to realize most educational outcomes could not be assessed by paper and pencil tests (Stiggins, 1991).

This way, competence assessment can offer too much to education and training, promoting learning, evaluating progress, helping to determine curriculum effectiveness and training program (Kaslow et al., 2009). Besides, it makes possible to use assessment to guide and assess students development improving the instruction quality. In the state of art, competence definition is varied term, do not present a single definition. This study, define competence as characteristics, knowledge, skills, experience, and values that an individual needs to perform successfully in an academic or professional context (Achcaoucaou et al., 2014).

As learning and instruction are increasingly based on competences, there is a growing demand for assessment methods to determine competence (Baartman, Bastiaens, Kirschner, & van der Vleuten, 2007). However, methods for assessing professional/students competences can vary significantly. Research into assessment methods based on real or problem-oriented scenarios grows each year and demands logic/reasoning/argument competences, rather than simply remembering the facts (M. Govaerts, Van der Vleuten, Schuwirth, & Muijtjens, 2007; Kennedy, Regehr, Baker, & Lingard, 2008; Ornellas, Falkner, & Stålbrandt, 2019; Redfern, Norman, Caiman, Watson, & Murrells, 2002; Sharpless & Barber, 2009; Van Der Vleuten & Schuwirth, 2005). As well, technological advances have allowed the creation of a diverse range of simulators that can facilitate learning and assessment in different areas (Morgan & Cleave-Hogg, 2002; Scalese, Obeso, & Issenberg, 2008; Vedula, Ishii, & Hager, 2017; Ziv, Small, & Wolpe, 2000).

Although efforts to define and measure competences have been grown over the time. It is happening in recent years where a higher number of notable initiatives are being developed. Medicine and education have become reference areas in competences assessment. In this sense, this study aims to analyze the competences assessment state of art and to understand the actors involved in assessment methods (who is the assessor and who is being assessed), when and how the assessment process occurs in medicine, education, and engineering areas context.

2 Methodology

Considering the objective defined for this study and the lack of similar studies in engineering, an exploratory bibliographic research approach was chosen. This approach is intended to provide a first-hand information for competence assessment analysis in engineering, which allows to create conditions for future in-depth studies. The collection and treatment of data research were based on the following steps performed in the Scopus database, on March 07, 2020:

i) Browse for database with the search term (using double quotes) "competences evaluation", "competencies evaluation", "competencies assessment" or "competences assessment": 2,832 results.

ii) Select articles published in journals: 2,247 results.

iii) Select articles between the years 2000 to 2019: 1,984 results.

iv) Limit the results of interest areas (Medicine, Education, and Engineering): 1,563 results, 79% of the total.

v) Extract and analyze the ten (10) most cited papers in each subject area: 30 results.

vi) Exclude articles that did not fall within the research scope: 29 articles for analysis.

Table 1 shows the ten (10) most cited articles in each subject area, as well as the number of citations, according to the Scopus database.

Table 1. Analyzed papers

Medicine			Education			Enginnering		
Num	Author	Citations	Num	Author	Citations	Num	Author	Citations
1	Van der Vleuten & Schuwirth, 2005	581	**11**	Van der Vleuten & Schuwirth, 2005	581	**21**	Succar, Sher & Williams, 2013	93
2	Yule, Flin, Paterson-Brown & Maran, 2006	419	**12**	Kaslow et al., 2009	172	**22**	Amiri, Zandieh, Soltani & Vahdani, 2009	46
3	Dunn et al., 2006	280	**13**	Govaerts et al., 2007	156	**23**	Plebankiewicz, 2010	46
4	Scalese, Obeso & Issenberg, 2008	239	**14**	Ziv, Small & Wolpe, 2000	154	**24**	Rouse, 2011	31
5	Landon et al., 2009	218	**15**	Baartman, Bastiaens, Kirschner, & Van Der Vleuten, 2007	114	**25**	Berio & Harzallah, 2007	31
6	Norman et al., 2002	106	**16**	Redfern, Norman, Caiman, Watson, & Murrells, 2002	107	**26**	Vedula, Ishii & Hager, 2017	29
7	Sturman, 2005	99	**17**	Norman et al., 2002	103	**27**	Augustin, Hockemeyer, Kickmeier-Rust, & Albert, 2011	25
8	Govaerts et al., 2011	96	**18**	Govaerts et al., 2011	101	**28**	Bohlouli et al., 2017	24
9	Sharpless & Barber, 2009	81	**19**	Yanhua & Watson, 2011	99	**29**	Arditi & Balci, 2009	18
10	Morgan & Cleave-Hogg, 2002	78	**20**	Kennedy, Regehr, Baker & Lingard, 2008	89	**30**	Achcaoucaou et al., 2014	15

The search resulted in 1,563 publications. Table 2 shows the publications of the last 20 years (2000 to 2019) in the disciplinary areas. Besides, to understand the origin of studies on assessment of competences, the first research in medicine area, took place in 1967 in the United States. The assessment of competences for education appeared in 1974, also in the United States. Then, after 19 years, in England, Engineering began to invest and concern about studies on the subject.

the analysis presented in table 2 shows a variation in medicine and education publications. In education it is possible to see that 59 publications were developed (2015). However, on previous years this number decreased, increasing again just in 2019. In 2017, a 64% of growth in competence assessment in medicine could be observed. It is important to notice that in 2019 researches related to engineering area were developed with a significant increase related to 2018.

Table 2. Number of publications by subject area

#	Medicine	Education	Engineering	#	Medicine	Education	Engineering
2019	97	77	**20**	**2009**	47	27	4
2018	98	53	7	**2008**	42	18	1
2017	**100**	47	9	**2007**	50	32	2
2016	64	49	3	**2006**	39	17	0
2015	57	**59**	5	**2005**	25	15	3
2014	70	44	5	**2004**	33	9	0
2013	52	46	7	**2003**	29	11	1
2012	57	32	5	**2002**	22	13	0
2011	48	37	6	**2001**	12	9	1
2010	32	24	4	**2000**	16	9	0

3 Bibliometric analysis

Initially, a general analysis on this study subject is considered and then the increasing publications number is presented, as well as countries, higher education institutions, authors, and journals with greater attention to the theme.

3.1 Top authors on competences assessment

The research results were analyzed considering the number of publications by the authors. In medicine, Appelbaum, P. S. is the author with the largest number of publications, resulting in twenty-three (23) appearances. Appelbaum has an affiliation at Columbia University Irving Medical Center, Department of Psychiatry (United States). In education, Baartman, L. K. J. developed eight (8) articles linked to the Open University of the Netherlands, Welten Institute, Heerlen, (Netherlands). Finally, in engineering, Jennings, M. is the author with the largest number of publications, all from the University of Aberdeen (United Kingdom) with three (3) studies.

3.2 Top 5 higher education institutions that publish on Competences Assessment

The research results in Scopus database for the whole world presented more than 200 higher education institutions which has publications on the topic. The University of Toronto is a reference in publications numbers for medicine area, as well as the Maastricht University for Education. In Engineering, the numbers in Educational Institutions show similarities, however, the University of Aberdeen has developed 3 papers. Due to the reduced number of publications per institution in engineering, it was decided to summarize only the areas of medicine and education, see Table 3.

Table 3. Educational Institutions with the highest number of publications

#	Medicine	Num	Education	Num
1	University of Toronto	32	Maastricht University	14
2	University of California	24	Universitat Autònoma de Barcelona	11
3	Harvard Medical School	24	Universitat de Barcelona	8
4	University of Pennsylvania	22	University of Massachusetts Medical School	7
5	University of Washington	22	Utrecht University, Universidad Complutense de Madrid	7

3.3 Journals with the higher number of papers published between 2000 and 2019

The research presents the main journals that publish about the topics described in Table 4. An in-depth view of these sources allowed the studies identification in medicine regarding competences assessment directed to journals focusing on Surgical Education, Psychiatry, Endoscopic Surgery, Emergency and geriatric psychiatry.

In education, the mainly results include journals related to studies on assessment of competences for nursing, which may, in fact, overlap education and medicine studies. Regarding it, they can be simultaneously found on

Scopus database, both in medical and education journals. In engineering, the publications sources are diverse, however, two (2) of the identified sources are related to Engineering Education. They are: International Journal of Engineering Education and European Journal of Engineering Education.

Table 4. Journals with the higher number of papers

#	Journals	Num
1	Nurse Education Today	25
2	Academic Medicine	24
3	Training and Education in Professional Psychology	19
4	Journal of Continuing Education in Nursing	15
5	Journal of Dental Education, Nurse Education in Practice	14

3.4 Top 10 Countries that published on Competences Assessment

The research resulted in 1,563 publications and presented the 15 countries that most published on competences assessment. In table 5 is possible to see the top 15 countries for each area. The United States is the country with the largest number of publications for medicine and education. Nevertheless, China is the country with the highest number of publications in Engineering.

Table 5. Top 10 countries with the highest number of publications

#	Medicine	Num	#	Education	Num	#	Engineering	Num
1	**United States**	**547**	**1**	**United States**	**264**	**1**	**China**	**14**
2	United Kingdom	129	2	Espanha	68	2	United States	12
3	Canada	93	3	United Kingdom	48	3	Spain	8
4	Australia	64	4	Germany	40	4	United Kingdom	5
5	Netherlands	41	5	Canada	38	5	Australia	3
6	Germany	37	6	Netherlands	35	6	Malaysia	3
7	Italy	32	7	Australia	34	7	Philippines	3
8	Spain	32	8	Russia	12	8	Chile, Germany, India, Indonesia, Iran, Italy, Lithuania, Poland, Saudi Arabia, South Korea, Switzerland, Thailand	2
9	India	20	9	China	8			
10	France	19	10	Ireland, Malaysia, New Zealand, Norway, Thailand	7			

4 Competences assessment methods

The literature on competences assessment can be analyzed from different perspectives. The assessment of competences in the engineering universe is something relatively new compared to other disciplinary areas such as medicine and education. Understanding the state of the art in areas where studies in competences assessment are deeply developed, this research becomes a relevant tool in order to help to develop methods for assessing competences in Engineering context.

Considering this context, 28 (twenty-eight) competences assessment methods were analyzed, using guiding questions as parameters for analysis. Thus, questions were selected as: Who is the competences assessor? Who is being assessed? At what time the competences assessment is performed? How is the competences assessment performed? Such questions were analyzed from the perspective of competence assessment methods, as Figure 1 presents. Initially, the definition of the term “competences” is presented from different perspectives.

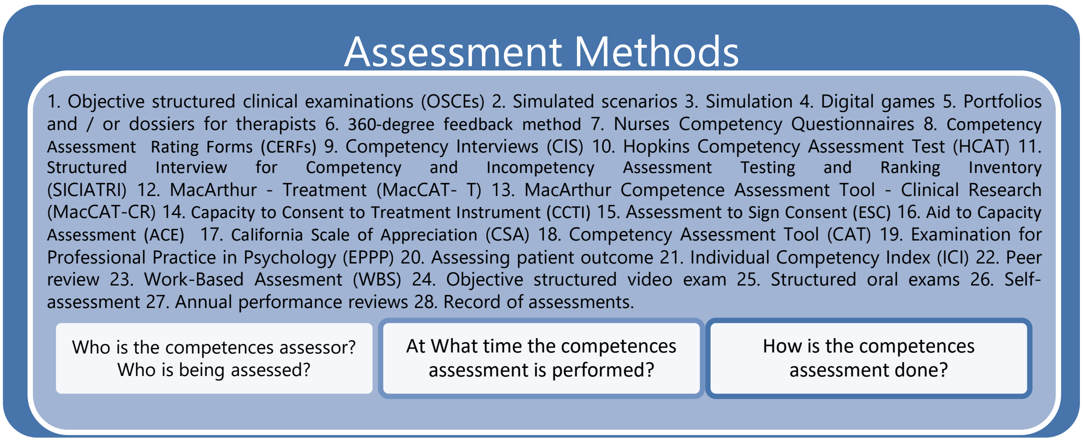


Figure 1. Analysis of Competences Assessment Methods

Neither all assessment methods were analyzed in the 3 (three) guiding questions. As an example, in MacArthur Competence Assessment Tool, the patient is assessed according to his competences to consent with the treatment defined by the professionals. In this study, the method analysis will not be performed related to the actors involved in the process. On the other hand, its of evaluation model was considered for analysis.

4.1 Different definitions of competence

In the analysis of the assessment methods, it was possible to identify that the evaluation process developed for students, doctors, psychologists and professionals are exclusively to analyze their skills, and not experiences or ability. Table 6 presents different definitions for the term competence, according to authors under analysis.

Table 6. Definition of the term Competences

Author(s)	Definition of Competences	
Van Der Vleuten and Schuwirth (2005)	It is the ability to deal with a complex professional task, integrating relevant cognitive, psychomotor and affective skills.	MEDICINE
Sturman (2005)	It refers to a judgment about whether a person is able to provide informed consent.	
Sharpless and Barber (2009)	The status or quality of being adequate or well qualified, demonstrates ability or may have a legal definition (that is, being legally qualified to take some action).	
Redfern et al. (2002)	Ability to operate in the real world, whatever the conditions.	EDUCATION
Baartman et al. (2007)	It consists of connected knowledge, skills and attitudes that can be used to properly solve a problem.	
Succar, Sher, and Williams (2013)	It refers to an individual's ability to perform a specific task or deliver a measurable result.	ENGINEERING
Rouse (2011)	Sufficient knowledge, capacity and experience to allow the successful completion of a task / initiative.	
Augustin, Hockemeyer, Kickmeier-Rust, and Albert (2011)	Method as the student develops the digital game solutions.	
Bohlouli et al. (2017)	Knowledge, experience and skills that people need to perform their duties.	
Achcaoucaou et al. (2014)	Characteristics, knowledge, skills, experience and values that an individual needs to perform successfully in an academic or professional context.	

4.2 Who is the competences assessor? Who is being assessed?

The Objective Structured Clinical Examinations (OSCEs), consist of several clinical meetings (called stations), typically with trained actors, playing the role of a client/patient presenting one or more symptoms. Thus, the assessment method is carried out by specialists, doctors, psychologists or teachers to assess students and/or health professionals (Kaslow et al., 2009; Redfern et al., 2002; Van Der Vleuten & Schuwirth, 2005; Yanhua & Watson, 2011).

Perception Questionnaires are the standard competence assessment methods for nurses and psychologists. A popular assessment method in psychology is the so-called Competency Assessment Rating Forms (CERF) or perception questionnaire, and in the research by Kaslow et al. (2009) the assessor actors are characterized by specialists in the field. In this sense, the competence assessment method, entitled Nursing Competences Questionnaire, provides a basis to develop a national method for assessing clinical competences (minimum standards). The method could be used by nurses (assessed), nurse professors and professionals (as assessors) (Norman, Watson, Murrells, Calman, & Redfern, 2002).

In addition, the requirement for all psychologists seeking licensure in the USA, is the Examination for Professional Practice in Psychology (EPPP). Though, in psychology area, another popular assessment method is the pre and post-therapy assessment, being patients in treatment (assessed) and psychologists (the assessors) (Sharpless & Barber, 2009). The person assessing competences is called "assessor" and the person being assessed is the "assessed".

The studies by Kennedy et al. (2008), Redfern et al. (2002), Sharpless and Barber (2009) and Van Der Vleuten and Schuwirth (2005), involve the construction of situations that resemble real practice scenarios. The assessment modes, such practical scenarios, can occur from the perspective of specialists, doctors, psychologists, teachers, students or health professionals.

Students and/or health professionals are assessed by the field specialists through certain performance assessment methods such as: objective structured video exam assessment methods, structured oral exams, self-assessment, annual performance reviews and assessment records (Kaslow et al., 2009).

Simulation-based education allows trainees to improve their competences in a risk-free environment. In this type of assessment method, the simulation takes place through specialists performing the assessment process (as assessors), and students and/professionals being assessed (Berio & Harzallah, 2007; Morgan & Cleave-Hogg, 2002; Scalese et al., 2008; Vedula et al., 2017; Ziv et al., 2000).

In digital games assessment method, the mathematical structure relates the problem solution of student's behavior. In digital games, the student's behavior (in game context) is evaluated related to their identified and absent competences (Augustin et al., 2011). The portfolios assessment methods and/or dossiers of therapists allow the information collection and compilation on the evidence of the patient performance (assessed) and psychologists, doctors or specialists as assessors (Kaslow et al., 2009; Sharpless & Barber, 2009; Van Der Vleuten & Schuwirth, 2005). The 360-degree feedback method contributes to the development of competences. This method allows supervisor, co-worker, teacher, specialist, doctors or psychologists be responsible for the assessment process, which can be developed for students and/or health professionals (assessed) (Bohlouli et al., 2017; Kaslow et al., 2009; Sharpless & Barber, 2009; Van Der Vleuten & Schuwirth, 2005).

In the Peer Review method, proposed by Van Der Vleuten and Schuwirth (2005) students and professionals from any area are assessed by specialists. The Work-Based Assessment (WBS) method, aims to build impressions and perform judgments about student's performance (assessed), for this method, teachers and specialists can be characterized as assessors (M. Govaerts, Schuwirth, van der Vleuten, & Muijtjens, 2011). The authors Succar et al. (2013) developed a method for assessing the competences of students and professionals (assessed), entitled as the Individual Skills Index (ICI), which can be assessor by specialists. In order to assessment Polish civil construction contractors (assessed), the assessment method in an interview format was sent to clients (assessors) providing a contractors prequalification (Plebankiewicz, 2010).

4.3 At What time the competences assessment is performed?

The research results were also analyzed related to the moment where the assessment process takes place. The results present the assessment of competences being applied in different times as a qualification exam, interview, or even without any specific context, which can occur at any time.

Assessment methods such as Objective Structured Clinical Examinations (OSCEs), simulation, digital games, nurses' competence questionnaires, Examination for Professional Practice in Psychology (EPPP), Work-Based Assessment (WBS), objective structured video exam, exams structured oral and annual performance reviews, are methods that typically occur in an exam process . Furthermore, competence assessment methods that consist in scenarios can occur in an interview process, as a qualification exam.

On the other hand, examples of methods which the assessment process can occurs at any time are 360-degree feedback method, Competency Assessment Rating Forms (CERFs), MacArthur Competence Assessment Tool, Peer review, Self-assessment, and Assessment record (Bohlouli et al., 2017; Dunn, Nowrangi, Palmer, Jeste, & Saks, 2006; Kaslow et al., 2009; Sharpless & Barber, 2009; Succar et al., 2013; Van Der Vleuten & Schuwirth, 2005). In the method of assessment through Portfolios and/or dossiers of therapists, patients undergoing treatment are assessed by psychologists or specialists as well.

4.4 How is the competences assessment done?

The results present different forms in assessment process, which are analyze how the assessment process is carried out. It can be done from questionnaires, forms, interviews, use of simulation, documents, protocols, self-report to simulated scenarios with real practice.

Perception questionnaires and forms are methods identified as support and in some cases other are used to complete the assessment (Arditi & Balci, 2009; Norman et al., 2002; Sturman, 2005; Yule, Flin, Paterson-Brown, & Maran, 2006). In the Competency Assessment Rating Forms (CERFs), the the assessment is done using semi-structured form, through a list of indicators with personal and practical competences (Kaslow et al., 2009; Yule et al., 2006). Similarly, Nurses' Competence Questionnaires method are organized into 78 (seventy-eight) items divided into eight constructs, namely: leadership, professional development, assessment, planning, intervention, cognitive ability, social participation and ego strength. The evaluated subjects classify their own competence in each item using a performance frequency scale of 4 (four) points (never forever) (Norman et al., 2002).

The assessment using the Hopkins Competency Assessment Test (HCAT) method is performes through questions of true / false format and sentence completion, with scores ranging from 0 to 10 (higher scores indicating greater competence). In addition, there are methods that use the form of structured and semi-structured interviews to assess competences (Berio & Harzallah, 2007; Sturman, 2005). Therefore, the interviews are structured in items, and each item is classified on a Likert scale. Still, to complement the assessment, self-report is another very common possibility for assessing competences (Sturman, 2005).

The method structure possibilities can be identified in exam format. In the Examination for Professional Practice in Psychology (EPPP), a test with multiple choices for the assessment process is used. Oral tests are used for structured oral exams and the structured video exam competences assessment method uses real practice in video format for assessment (Kaslow et al., 2009; Sharpless & Barber, 2009). In the Objective Structured Clinical Examinations (OSCEs), Work-Based Assessment (WBS) and the simulated scenario assessment method, are simulated, and use rubrics as tools to assess performance (Bohlouli et al., 2017; Kaslow et al., 2009; Sharpless & Barber, 2009; Van Der Vleuten & Schuwirth, 2005).

Nevertheless, the simulation can be used as a way to assess competences (Augustin et al. 2011) and also an online software (Berio & Harzallah, 2007; Succar et al., 2013). Furthermore, in some of the competences assessment methods, documents and/or multiple choice and/or videos are used as an assessing form (Kaslow et al., 2009; Sharpless & Barber, 2009; Van Der Vleuten & Schuwirth, 2005). Finally, real scenarios and practices are found as a assessing competences mode (Kaslow et al., 2009).

Assessment of people's competences are often found in literature, on the other hand, studies that evaluate the most important competences for organizations are less viewed. The Amiri, Zandieh, Soltani, and Vahdani (2009) study used a quantitative analysis to identify aspects and attributes of competence, using the AHP Adaptive approach as an assessment framework. In the peer review method, a check sheet is used to support the assessment process; to assess the performance and compare it with a certain level of competence (pre-established by the assessors) (Kaslow et al., 2009; Van Der Vleuten & Schuwirth, 2005).

Finally, a check sheet that includes five (5) levels, is described as the method of assessment used in the Individual Competency Index (ICI) specific area or topic; level 1 (basic) denotes an understanding of the fundamentals and some initial practical application; level 2 (intermediate) denotes a solid conceptual understanding and some practical application; level 3 (advanced) denotes significant conceptual knowledge and practical experience in executing a competence according to a high and consistent standard; and level 4 (specialist) indicates extensive knowledge (Succar et al., 2013).

5 Conclusion

This study aims to analyze the competences assessment state of art and to understand the actors involved in assessment methods (who is the assessor and who is being assessed), when and how the assessment process occurs in medicine, education, and engineering areas context.

The importance of assessing competences in higher education institutions is undeniable. This fact reflects the growing number of studies in different subject areas, taking medicine and education as reference. Engineering seeks through seminal studies, the design and development of methods for assessing competences that are reliable and valid for the engineering context. Thus, the understanding of the state of the art has become an important result, even if initially, to develop methods for assessing competences for engineering.

Some of the main results of the presented study can be summarized using the 3 (three) guiding questions. The assessors actors involved in the competence assessment processes were doctors, psychologists, teachers and professionals; the actors assessed are defined as students and professionals. For the assessment moment , the application takes place at different times, which may be in a qualification exam, interview or even, without any specific context, occurring any time. As the assessment is done, there are perception questionnaires, forms, interviews (structured and semi-structured), simulation use, documents, protocols, self-report and simulated scenarios with real practice. In addition, methods such as a check sheet, rubrics, grids, are used as a guide and, in some cases, scales are used to determine the competence level as well.

Finally, the authors conclude that the methods of evaluating competences medicine and education field can serve as support tools and assist Engineering to develop reliable and valid methods for assessing competences. Moreover, it was possible to identify that the engineering competence assessment methods presented that there is a strong focus on the use of simulators, through computers, in their assessments. However, for medicine and education, was evident the importance of the use of scenarios methods for assessment of competences.

Acknowledgments

This work has been supported by FCT – Fundação para a Ciência e Tecnologia within the R&D Units Project Scope: UIDB/00319/2020.

6 References

Achcaoucaou, F., Guitart-Tarrés, L., Miravitlles-Matamoros, P., Núñez-Carballosa, A., Bernardo, M., & Bikfalvi, A. (2014). Competence assessment in higher education: A dynamic approach. *Human Factors and Ergonomics In Manufacturing, 24*(4), 454-467. doi:10.1002/hfm.20394

Amiri, M., Zandieh, M., Soltani, R., & Vahdani, B. (2009). A hybrid multi-criteria decision-making model for firms competence evaluation. *Expert Systems with Applications, 36*(10), 12314-12322. doi:10.1016/j.eswa.2009.04.045

Arditi, D., & Balci, G. (2009). Managerial competencies of female and male construction managers. *Journal of Construction Engineering and Management, 135*(11), 1275-1278. doi:10.1061/(ASCE)CO.1943-7862.0000100

Augustin, T., Hockemeyer, C., Kickmeier-Rust, M., & Albert, D. (2011). Individualized skill assessment in digital learning games: Basic definitions and mathematical formalism. *IEEE Transactions on Learning Technologies, 4*(2), 138-148. doi:10.1109/TLT.2010.21

Baartman, L. K. J., Bastiaens, T. J., Kirschner, P. A., & van der Vleuten, C. P. M. (2007). Evaluating assessment quality in competence-based education: A qualitative comparison of two frameworks. *Educational Research Review, 2*(2), 114-129. doi:10.1016/j.edurev.2007.06.001

Berio, G., & Harzallah, M. (2007). Towards an integrating architecture for competence management. *Computers in Industry, 58*(2), 199-209. doi:10.1016/j.compind.2006.09.007

Bohlouli, M., Mittas, N., Kakarontzas, G., Theodosiou, T., Angelis, L., & Fathi, M. (2017). Competence assessment as an expert system for human resource management: A mathematical approach. *Expert Systems with Applications, 70*, 83-102. doi:10.1016/j.eswa.2016.10.046

Dunn, L. B., Nowrangi, M. A., Palmer, B. W., Jeste, D. V., & Saks, E. R. (2006). Assessing decisional capacity for clinical research or treatment: a review of instruments. *The American journal of psychiatry, 163*(8), 1323-1334. doi:10.1176/appi.ajp.163.8.1323

Govaerts, M., Schuwirth, L., van der Vleuten, C., & Muijtjens, A. (2011). Workplace-based assessment: Effects of rater expertise. *Advances in Health Sciences Education, 16*(2), 151-165. doi:10.1007/s10459-010-9250-7

Govaerts, M., Van der Vleuten, C., Schuwirth, L., & Muijtjens, A. (2007). Broadening perspectives on clinical performance assessment: rethinking the nature of in-training assessment. *Advances in Health Sciences Education, 12*(2), 239-260.

Kaslow, N. J., Grus, C. L., Campbell, L. F., Fouad, N. A., Hatcher, R. L., & Rodolfa, E. R. (2009). Competency Assessment Toolkit for Professional Psychology. *Training and Education in Professional Psychology, 3*(4 SUPPL. 1), S27-S45. doi:10.1037/a0015833

Kennedy, T. J., Regehr, G., Baker, G. R., & Lingard, L. (2008). Point-of-care assessment of medical trainee competence for independent clinical work. *Academic Medicine, 83*(10), S89-S92.
McDowell, L. (1995). The impact of innovative assessment on student learning. *Innovations in Education and Training International, 32*(4), 302-313.
Morgan, P. J., & Cleave-Hogg, D. (2002). A worldwide survey of the use of simulation in anesthesia. *Canadian Journal of Anaesthesia, 49*(7), 659-662.
Norman, I. J., Watson, R., Murrells, T., Calman, L., & Redfern, S. (2002). The validity and reliability of methods to assess the competence to practise of pre-registration nursing and midwifery students. *International Journal of Nursing Studies, 39*(2), 133-145. doi:10.1016/S0020-7489(01)00028-1
Ornellas, A., Falkner, K., & Stålbrandt, E. E. (2019). Enhancing graduates' employability skills through authentic learning approaches. *Higher education, skills and work-based learning*.
Plebankiewicz, E. (2010). Construction contractor prequalification from polish clients' perspective. *Journal of Civil Engineering and Management, 16*(1), 57-64. doi:10.3846/jcem.2010.05
Redfern, S., Norman, I., Caiman, L., Watson, R., & Murrells, T. (2002). Assessing competence to practise in nursing: A review of the literature. *Research Papers in Education, 17*(1), 51-77. doi:10.1080/02671520110058714
Rouse, W. B. (2011). Necessary competencies for transforming an enterprise. *Journal of Enterprise Transformation, 1*(1), 71-92. doi:10.1080/19488289.2010.548905
Scalese, R. J., Obeso, V. T., & Issenberg, S. B. (2008). Simulation technology for skills training and competency assessment in medical education. *Journal of General Internal Medicine, 23*(1 SUPPL.), 46-49. doi:10.1007/s11606-007-0283-4
Sharpless, B. A., & Barber, J. P. (2009). A conceptual and empirical review of the meaning, measurement, development, and teaching of intervention competence in clinical psychology. *Clinical psychology review, 29*(1), 47-56.
Stiggins, R. J. (1991). Relevant classroom assessment training for teachers. *Educational Measurement: Issues and Practice, 10*(1), 7-12.
Sturman, E. D. (2005). The capacity to consent to treatment and research: a review of standardized assessment tools. *Clinical psychology review, 25*(7), 954-974.
Succar, B., Sher, W., & Williams, A. (2013). An integrated approach to BIM competency assessment, acquisition and application. *Automation in Construction, 35*, 174-189. doi:10.1016/j.autcon.2013.05.016
Van Der Vleuten, C. P. M., & Schuwirth, L. W. T. (2005). Assessing professional competence: From methods to programmes. *Medical Education, 39*(3), 309-317. doi:10.1111/j.1365-2929.2005.02094.x
Vedula, S. S., Ishii, M., & Hager, G. D. (2017) Objective Assessment of Surgical Technical Skill and Competency in the Operating Room. In*: Vol. 19. Annual Review of Biomedical Engineering* (pp. 301-325).
Yanhua, C., & Watson, R. (2011). A review of clinical competence assessment in nursing. *Nurse Education Today, 31*(8), 832-836. doi:10.1016/j.nedt.2011.05.003
Yule, S., Flin, R., Paterson-Brown, S., & Maran, N. (2006). Non-technical skills for surgeons in the operating room: A review of the literature. *Surgery, 139*(2), 140-149. doi:10.1016/j.surg.2005.06.017
Ziv, A., Small, S. D., & Wolpe, P. R. (2000). Patient safety and simulation-based medical education. *Medical Teacher, 22*(5), 489-495.

Design and Development of Automated Guided Vehicles for Active Learning in Material Handling Management for Smart Manufacturing Operation

Yasiru Shikshitha Malshan Benaragama, Pisut Koomsap

Department of Industrial Systems Engineering, Asian Institute of Technology, Pathumthani, Thailand

Email: fluxes94@gmail.com, pisut@ait.asia

Abstract

Automated guided vehicles (AGVs) have become a preferred material handling system commonly seen for logistics in a manufacturing facility in the modern days when flexibility is critical in smart manufacturing for offering a variety of low volume products to serve individual demands. Accessibility to AGVs, however, is very limited in school due to their commercially high costs, complexity, and restrictions imposed by the manufacturers in alterations. This paper presents the design and development of a fleet of in-house AGVs to support the active learning of students with hands-on experience in the material handling management in smart manufacturing. The AGVs were designed and built in a modular manner with open-source, off the shelf parts that can be swapped, altered, and changed as necessary to allow access to almost all aspects of the AGV, such as access to inertial measurements of bearing, velocity and acceleration, motor readings of speed and power consumption, live camera feed for image processing, various proximity readings, magnetic line following output and many more features in order to give sufficient resources for the students to experiment on. They also allow students to execute their algorithms on the AGVs to get hands-on experience in AGV fleet management and navigation.

Keywords: AGVs, Material Handling Management, smart manufacturing, hands-on experience

1 Introduction

As the industries move towards the Industry 4.0 era, syllabi related to outdated technology that is being taught to engineering students becomes irrelevant (R.Toto & Nguyen, 2009). The contents taught for the next generation of engineers should be up to date so that they will be ready with the knowledge they ought to have when they enter industries. To do this, educational institutes should have syllabi and infrastructure to meet these demands. Educational institutes have experimented on integrating industrial engineering courses with real-world scenarios to improve students' IT skills and improve their problem-solving abilities (Frank et al, 2003). The relationship between active learning and creation of innovative minds are explored and proven in recent studies in Japanese universities (Ito and Kawazoe, 2015). The forward thinkers in Industrial Systems Engineering at Asian Institute of Technology, always strive towards the development of technologies to satisfy the requirements for industries of tomorrow. The importance of having such support systems which gives students a chance of learning autonomously (Gonzalez et al, 2016) are quite obvious. The lecturers at AIT are teaching the knowledge of the future so that the students are one step ahead once they enter industries. To help in this endeavour, Industrial Systems Engineering (ISE) has developed a Smart Future Learning Factory to support the student learning in an Erasmus+ Curriculum development of Masters Degree program in Industrial Engineering for Thailand Sustainable Smart Industry (MSIE 4.0), which was funded by the European Commission.

The Smart Learning Future Factory upon completion will have many resources which can be used to educate students on subjects related to the industry. Such a Smart Learning Future Factory has the capacity to train engineering students by giving them a practical understanding about Industry 4.0 (Learning factory modules). The impact of these Smart Factories has on students and the positive outcomes they show can be seen from Smart Factories already established in universities (Neser, Simonsa and Abéa, 2017). When considering the Smart Factory at AIT, among the many resources the Smart Factory will posses, one asset that is already operational and implemented in the Smart Factory is the Material Handling System built specifically for the Smart Factory.

This Material Handling System consists of 5 prototype Automated Guided Vehicles (AGVs). Among the many services expected out of these assets, the AGVs will act as the material handling units between the workstations established in the Smart Factory, and these AGVs will also be a platform from which students can gather knowledge related to industrial engineering, further proving the use of robots in teaching students on developing problem solving skills among many other advantages (Flowers & Gossett, 2002). The AGVs also acts as an important asset in the Smart Factory by representing a physical system integrated with emerging technologies such as IOT (Internet of Things) and cloud computing, all key components of a Smart Factory (Chen et al, 2018).

From the information provided above, the importance of active learning for students in a classroom environment is clear. This paper provides an answer on approaching an effective active learning environment; by having AGV mobile units as a platform from which the students gain hands-on experience in engineering-related subjects. Section 2 will discuss initial design and development phase of the AGVs followed by secondary aspects such as communication architecture and electronics assembly. Section 3 discuss how these AGVs are used in an active learning environment followed by concluding in section 5.

2 AGV development

The AGVs, all software and hardware including the PCBs were designed and developed by the first author for his Master Thesis dissertation. The AGVs were designed keeping in mind the primary goal, a platform from which the students get hands-on experience of technology. Research carried out had proven that active learning where the students learn by interacting with their environment as opposed to education received by lectures, is more effective in knowledge gathering (Linder et al, 2001). This influenced the design choices of the prototype AGVs. Also, the requirements an AGV must have for an Industry 4.0 factory was researched upon (L. Cavanini et al, 2018). Figure 1 shows the CAD design of the AGVs with all the major components pointed out. The AGVs were to be lightweight for the students to easily handle, but strong enough to carry the specified weight of the payload effortlessly. The structural framework should be able to be altered, upgraded and external devices should be able to be mounted to the framework without much hassle. Hence, the entire structural framework was built from standard aluminium profile bars, which meets all of the above demands. The outer body was made by acrylic plastic and offered easy access to internal components.

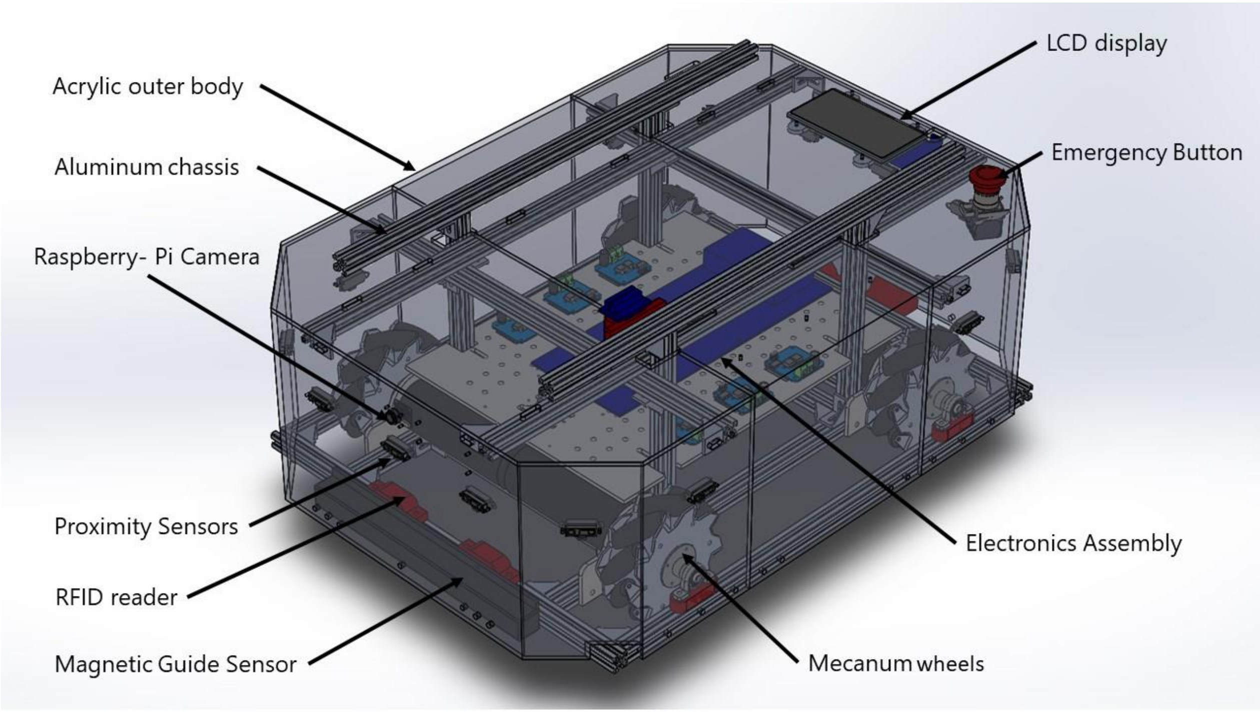


Figure 1: The CAD design of the AGV. The primary components are marked in the figure.

Adhering to the requirements of the AGV to be used as a learning platform and considering the required payload capacity, the required dimensions and other relevant data, the CAD drawing was done. The AGV was built in a

modular fashion so that further improvements can be done by future student who will work on it. The two rails on top offers the capability of mounting accessories such as the material handling unit built for the AGV, or a robotic arm, or any other equipment. Special characteristics of the design is given below.

- Lightweight aluminium frame.
- Mecanum wheels which offer more flexibility in navigation.
- Industrial magnetic line following sensor.
- Raspberry-Pi computer with onboard camera and Wi-Fi connectivity.
- 14 proximity sensors which are used in collision avoidance.
- 22 Ah 24-volt LiPo battery for long lasting operation from a single charge.
- 5.5 -inch LED touchscreen
- Digital gyroscope to keep track of the bearing of the AGV during free navigation.

The aluminium framework was chosen for its excellent rigidity while being light weight. The outer body was made using acrylic for aesthetics.

The next step in the development phase was to design the electronics of the AGVs. A printed circuit board was designed specially for the AGVs. By doing this, all the electronics of the AGV was securely fastened to one circuit board which will avoid unnecessary wiring being done on AGVs.

Beside connecting different peripherals together, the PCB offered many functions to the AGV operation. Among its many roles, the board acted as the power distribution panel for the motors and the peripherals. The control panel provided the user the possibility of interacting with the AGV. the lifter assembly provided power and control over the peripherals that will be connecter to the material handling unit. The front panel distributed power and received information from the proximity sensors connected in front.

3 Communication protocols used

The AGV can be connected via Wi-Fi to an existing Local Area Network (LAN) for a successful data transfer to and from the AGV. No specially built communication devices are needed in order to establish a stable connection. The students use the inbuild Wi-Fi of the Raspberry-Pi computer to form a stable TCP connection with the computer. Since Raspberry-Pi is, after all, a computer, students have the freedom to choose the mode of communication, even if they opt to switch to Bluetooth. Once everything is in order, the AGVs will be deployed from its docking station (figure 2) and carry out the orders sent to it.

Figure 2: The AGVs at their docking station, ready to execute commands.

4 Active learning based on the developed AGVs

The exposure of active learning in a Smart Learning Future Factory received by Industrial Engineering students will not be limited to knowledge gathered in studies specific to industrial engineering. The many different fields of engineering the students will be exposed to includes mechanical engineering, electrical engineering, electronic engineering, computer science, etc. The students will have experience in taking critical decisions, take responsibilities, meet demands and deadlines, and many more life-essential skills.

To help students in achieving these skills, the AGVs will act as a learning platform, that can be used to experiment on managing a Smart Factory equipped with flexible manufacturing and material handling systems. Students can learn to control AGVs to support the collaborative manufacturing processes happening in the factory. The AGVs with modular architecture offer flexibility in modifications and improvements using plug in components. Students can also learn about programming, experiment on coding and try new ideas.

3.1 Active Learning in Industrial Engineering

IE students require real world experience in managing resources in a factory. The AGVs are developed for students to control in a factory environment and to learn about production management. The primary function of the AGV are to act as material handling units. Students who wish to learn on task scheduling, inventory management, supply chain management and other related studies now has the chance of experimenting these aspects in real life. In-process items in the Smart Factory will be carried between the modular workstations, and the warehouse in which the items are stored. Task scheduling in between workstations, the AGVs and all other assets can be done so that the students gather knowledge on maintaining a Smart Factory.

The existing system in the Smart Factory which controls the AGVs has the capability of commanding AGVs to navigate in between workstations according to the user input. Students may use this knowledge, and take the status of the workstations into consideration and experiment on scheduling pick up and delivery and all related events.

3.2 Active learning of Electronics by IE students

Dealing with electronic components will be an essential skill for the students in the near future, due to the multi-disciplinary requirements in an Industry 4.0 era. The electronics of the AGV used up off the shelf components, easily accessible for repairs and upgrades. The reason to use these common electronics components is because of the familiarity most engineering students already have with them. Open source microcontrollers such as Arduino and ESP32 was used in the electronics assembly. A printed circuit board (PCB) was specially designed for the AGVs in order to effortlessly mount these accessories. Overall, the important components connected to the PCB was the Arduino Microcontrollers, the digital Gyroscope sensor, the industrial grade magnetic line following sensor and the Raspberry-Pi computer.

Due to this modular nature of the electronics in the AGV, repairs and upgrades can easily be carried out on the units. Students may experiment on different microcontrollers, different development boards and more powerful microprocessors if they choose to. This will increase the capabilities of the AGVs much more than what it is now. One of the most important electronic components in the AGV is the digital gyroscope. It constantly measures the current bearing of the AGV in order to precisely navigate when it is in free ranging mode. Students may experiment on different gyroscope modules available in the market and modify the AGV thanks to the modular nature of the electronics.

By involving in work related to electronics, industrial engineering students gets an idea on the basics of the electronics that they may encounter in industries. The AGVs provide a platform from which the students can get an experience of dealing with problems related to electronics, how to solve these problems, and how to improve existing electronics. These skills will be vital to the students as industrial engineers.

3.3 Active Learning in Computer Science by IE students

Industrial engineering students who are keen on developing their skills on programming languages will have the opportunity to access all of the source codes in the AGV. Low level programming languages such as C++ are used in the microcontrollers, which are responsible in the localized control of the AGV, its motor speed, the degree of rotation, the proximity sensor readings, the data from the magnetic sensor, etc. The students will have a chance of experimenting with the internal functionality of the AGV by studying how the localized operations occur. They will get an understanding on how the information received from the Raspberry-Pi computer is decrypted, analysed and acted upon. They will have a chance to gather all the data from the AGV's many sensors (magnetic guide sensor, proximity sensors, the digital Gyroscope, Magnetometer and Accelerometer, the current sensors of all the motors, etc.) and make rational decisions on how to act upon all the gathered data. Students may use this vital information to make the AGVs more intelligent. For instance, the algorithm that runs in the AGVs (at the time of writing this report) detects collisions it encounters by the sudden spikes in accelerometer data (given that the proximity sensors missed the obstacle), and then take precautionary measures to mitigate the issue. But students can use the readings of yaw, pitch and roll to make assessments of sudden changes in orientation, read the current consumption of the motors to detect abnormal current drawn from the motors during a collision as methods of detecting collisions. They may even use a combination of these sensory reading to come to a more validated decision. This is just one example which shows how students may develop the AGV units further.

The communication links was established using JavaScript coding language, which is a high-level programming language, in order to have a stable, robust and a reliable Wi-Fi connection, that will regain a broken link automatically, if such a thing was to occur. In default, the algorithms that runs in both the Raspberry-Pi and the main control computer will link the AGV to the main control computer automatically. The students will have the opportunity to study the source code, and do alterations in the hope of increasing the performance of the functionality.

One other aspect of the AGV open for students to develop is related to machine vision. The AGV comes with an onboard camera attached to the Raspberry-Pi onboard computer which has the potential to perform machine vision and act as a method for localization. By doing this, the AGVs can be made as fully free ranging robots, with the ability to locate and navigate themselves and even to detect and avoid obstacles in its path, all done with the power of machine vision.

As the industry move towards Industry 4.0 era, it will be a basic requirement for industrial engineers to have computer programming skills, and knowledge on how computer networking is done, among many other requirements. Knowledge on these studies are seldom taught in a classroom environment since these are the knowledge and experiences gained from an active learning environment.

3.4 Active learning in AGV Fleet management and problem solving by IE students

The Master Thesis research of the first author was to design and develop a fleet management system that was developed specially for the 5 prototype AGVs. By using the built hardware and the built stable communication links, the decentralized AGV fleet management system is operational and implemented (at the time of writing this report) to the Smart Factory. The algorithm developed for the fleet management algorithm enabled the AGVs to navigate autonomously according to the requests made by the modular workstations located within the Smart Factory. For a typical operation where a workstation (source workstation) has an in-process item to be delivered to destination workstation, the most suitable AGV will travel to the source workstation, pick up the item, and then travel to the destination workstation to deliver the item.

Industrial engineering students who are keen on developing the existing fleet management algorithm, or students who wish to implement their own fleet management algorithm can access the source code related to the existing system, learn from it, and improve it. Since the source codes are not protected by proprietary laws, like the ones seen on commercial machinery, the students have total accessibility to the raw codes. Users however should be mindful about the operation of the AGVs and take necessary precautions not to harm themselves, others or the AGV units, when testing new source codes.

The infrastructure built to the Smart Factory for AGV navigation (figure 3) consists of areas of free ranging navigation and specific areas (special in the vicinity of the workstations) of fixed path navigation. Even though the AGVs switches between fixed path and free ranging navigation automatically, students may experiment on different approaches to navigational routines, whether fixed path or free ranging navigation, and come up with much better and more efficient navigational protocols.

Figure 3: The layout of the Smart Learning Future Factory. The fixed path navigation routes for the AGVs are shown in yellow lines. The open space in the middle allows flexible AGV navigation.

The students have the ability to use a single AGV or multiple AGVs at a time for them to learn on how material handling units function in a factory. They can reserch on effective path planning and time scheduling in pick up and delivery, do continuous improvement in AGV fleet management and all related algorithms in order to get the maximum efficiency in material handling in the smart factory. The students may work as teams or individually and lecturers can assess the results and outcomes of the students in an active learning environment.

5 Conclusion

The Masters Degree program in Industrial Engineering for Thailand Sustainable Smart Industry (MSIE 4.0), at the Asian Institute of Technology, is oriented towards a hands-on student learning experience, along with the standard teaching methods. This is the reason for the development of the Smart Future Learning Factory, which was funded by the Erasmus+ curriculum development program by the European Union. One key aspect of the Smart Factory is the material handling system specially developed for the Factory. This material handling system consists of five prototype AGVs and the infrastructure built for its navigation. This paper discussed the potential applications of these robots not merely as a material handling unit, but also as a student learning platform with the capability of providing knowledge to industrial engineering students in so many different fields of engineering, including industrial engineering, mechanical engineering, computer science and information and communication studies.

One important aspect of the AGVs when compared with the works available in the literature is the wide range of use these robotic platforms offer when viewed from an academic point of view. The AGVs offer enormous flexibility in improving almost every aspect of it; electronics, mechanical, communication etc. The students get to interact and experiment their research and development on a real physical system. These units offer no limitations seen by industrial robots, where the accessibility to the core operations are severely limited thanks to the company policies. The prototype AGVs offer the same functionality as industrial grade AGVs at a much lower price with much more room for further development.

These AGVs developed for the Smart Factory will help students learn needed knowledge for the Industry 4.0 era by the hands-on experience gained through research and experimentation, and by doing so, produce talented industrial engineers who are experienced in many different fields of engineering, for the future of industry.

Acknowledgements

This work is the outcome of project "Curriculum Development of Master's Degree Program in Industrial Engineering for Thailand Sustainable Smart Industry (MSIE 4.0)" that has been funded with support from the European Commission (Project Number: 586137-EPP-1-2017-1-TH-EPPKA2-CBHE-JP). This publication reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

6 References

Cavanini, L et al., "A Preliminary Study of a Cyber Physical System for Industry 4.0: Modelling and Co-Simulation of an AGV for Smart Factories," 2018 Workshop on Metrology for Industry 4.0 and IoT, Brescia, 2018, pp. 169-174, doi: 10.1109/METROI4.2018.8428334.

Chen ,B., Wan ,J., Shu, L., Li, P., Mukherjee, M. and Yin, B., "Smart Factory of Industry 4.0: Key Technologies, Application Case, and Challenges," in IEEE Access, vol. 6, pp. 6505-6519, 2018, doi: 10.1109/ACCESS.2017.2783682.

Flowers, T. R., and Gossett, K. A., 2002. Teaching problem solving, computing, and information technology with robots. J. Comput. Sci. Coll. 17, 6 (May 2002), 45–55.

González-González, C. S., Moreno, L., Popescu, B., Lotero, Y. and Vargas, R., "Intelligent systems to support the active self-learning in industrial automation," 2016 IEEE Global Engineering Education Conference (EDUCON), Abu Dhabi, 2016, pp. 1149-1154, doi: 10.1109/EDUCON.2016.7474700.

Ito, H. and Kawazoe, N., 2015. Active Learning for Creating Innovators: Employability Skills beyond Industrial Needs. International Journal of Higher Education, 4(2).

Linder, S. P., Nestrick, B. E., Mulders, S., and Lavelle, C. L., 2001. Facilitating active learning with inexpensive mobile robots. J. Comput. Sci. Coll. 16, 4 (2001), 21–33.

Neser, S., Simonsa, S. and Abéa, P., 2017. Learning in the AutFab – the fully automated Industrie 4.0 learning factory of the University of Applied Sciences Darmstadt. Procedia Manufacturing, 9, pp.81-88.

Peters, Frank; Jackman, John K.; Ryan, Sarah M.; and Olafsson, Sigurdur, "An Active Learning Environment in an Integrated IndustrialEngineering Curriculum" (2003). Industrial and Manufacturing Systems Engineering Conference Proceedings and Posters. 77

Toto, R. and Nguyen, H., "Flipping the Work Design in an industrial engineering course," 2009 39th IEEE Frontiers in Education Conference, San Antonio, TX, 2009, pp. 1-4, doi: 10.1109/FIE.2009.5350529.

Design, Implementation, and Improvement of the Course for Master's Degree Program in Industry 4.0: A Case Study in Digital Factory Subject

Athakorn Kengpol[1], Nitidetch Koohathongsumrit[2], Warapoj Meethom[1]

[1] Department of Industrial Engineering, Faculty of Engineering, King Mongkut's University of Technology North Bangkok, Bangkok, Thailand
[2] Department of Statistics, Faculty of Science, Ramkhamhaeng University, Bangkok, Thailand

Email: Athakorn@kmutnb.ac.th, Nitidetch.k@rumail.ru.ac.th, Warapoj.m@eng.kmutnb.ac.th

Abstract

The objective of this study is to propose the procedures of design, implementation, and improvement for the specific course developed of project named Curriculum Development of Master's Degree Program in Industrial Engineering for Thailand Sustainable Smart Industry (MSIE 4.0), which is funded by the Erasmus and program of the European Union. The digital factory subject, which is one of 16 courses in MSIE 4.0 provides effective elements: program learning outcomes (PLOs), course learning outcomes (CLOs), assessment methods, course syllabus, and teaching guidelines. Moreover, the steps proposed in this study demonstrate the acquisition of knowledges, skills, and competencies based on the perspectives of stakeholders via its course description. There are five important CLOs: understanding the different between traditional factory and digital manufactory, applying digital manufacturing technologies e.g. cyber physical system, additive manufacturing, virtual reality augmented reality, additive manufacturing, sensor device technologies, and robotics/automated guided vehicle in a manufacturing complex requirement, analyzing works in both information-managed and file-based environments for the development of robotic and automated production systems. and implementing digital inventory to manage incoming and outgoing goods. Furthermore, the well-designed scoring rubrics of each CLO are established to measure students' learning experiences and are used to find the area of improvement at the end of every modules. For the implementation, 12 students register for the subject in the second term of 2019 between June to October at King Mongkut's University of Technology North Bangkok (KMUTNB). The students are observed by many assessment methods after they finished the modules. The students' learning experiences are summarized and improved based on the levels of CLOs. The scrupulous steps of this study can be used to guide instructors for designing other course and related issues. Moreover, the students, who accomplish this course can work in a rapid fusion of technologies for the articulation of stakeholder needs.

Keywords: Digital Factory; Rubric; Course Learning Outcome (CLO); Assessment of Learning.

1 Introduction

A curriculum is a plan for learning (Taba, 1962), it refers to the lessons and contents taught in universities or in specific programs (Vanderlinde, van Braak, & Hermans, 2009). In the past centuries, the curriculum has been designed by teacher with interested educational purposes. However, presently curriculum must be to meet the needs of stakeholders since the teachers' perspectives are inadequate to create an effective curriculum. The design of curriculum is a challenging task because it involves many elements: contents, teaching strategies, learning experiences, assessments, evaluations, and pedagogic requirements necessary. The fundamental goal of curriculum design is to improve student learning, which demonstrates when student completed or participated in a course or program. In a globalizing of technological advancement and economic growth in the era of Industry 4.0 (Sackey & Bester, 2016), the curriculum design has become the difficult task since automation and robotization have been adopted to increase their productivity, especially manufacturing enterprises (Guberman & Leikin, 2013). Therefore, the development of student based on curriculum is a critical task, the design of curriculum can be employed to overcome this problem. The new curriculum must be designed to meet the needs of all stakeholders.

The Curriculum Development of Master's Degree Program in Industrial Engineering for Thailand Sustainable Smart Industry (MSIE 4.0) project funded by the European Commission aims to develop a magister scientiae degree (MSc) for industrial engineering (IE) aligned with needs of Industry 4.0. In order to achieve the goals, 16 modern courses of Master's degree in IE are designed for learning experience and equipped with new teaching and learning materials. These courses are constructed based on structure and academic program learning outcomes (Nitkiewicz, Ayutthaya, Koomsap, Lima, & Chattinnawat, 2019). Then, a course assessment is employed to evaluate a feasibility of the modern curricula at the partner universities. The digital factory subject, which is one of 16 courses has been created to serve many purposes within the smart factory. This course, which has lectured in key subject areas requires an implementing the various digital technologies with minimal human assistance: additive manufacturing, intelligent robotics, industrial internet of things, cyber-physical system, global cloud manufacturing (Kang et al., 2016; Koohathongsumrit & Luangpaiboon, 2020). Therefore, the digital factory is discussed.

2 Course Design

Designing an academic course is not easy. It is an intricate process that needs to be carefully thought through and involves much strategic decision-making. To date, the course design can be defined as the step-by-step process used to improve modern and deliberate overall outline, mapping content to learning objectives in the course. This section describes a procedure to design the course outline of the digital factory subject by considering four dimensions of course design: stakeholders, objectives, data, and techniques (Gottipati & Shankararaman, 2017). In this study, there are six phases for designing the digital factory's course outline.

2.1 Program Learning Outcomes Design

Program learning outcomes (PLOs) refer to domain expertise and knowledges that students should be able to articulate after the completion of courses (Hammami, Saeed, Mathkour, & Arafah, 2019). In this study, PLOs of the subject are designed to conform with the Industry 4.0 data, they include selection of content, development of teaching strategies, and teaching materials or resources. Graduates should be able to complete the following PLOs: (1) apply knowledge and methods from the advanced science of industrial engineering to design, model and manage Industry 4.0 related complex industrial systems; (2) implement smart production and co-created product design and development concepts; (3) utilize big data and real time data analytics for supporting smart production, product design, and advanced manufacturing process; (4) exploit online connectivity for strengthening business capability; (5) improve sustainability by applying IE related knowledge and competences; (6) conduct research in the field of IE; (7) manage Industry 4.0 related projects; (8) manage smart production systems and supply chains; (9) lead, manage, work and communicate effectively in interdisciplinary, intercultural, and distributed teams; (10) perform with high degree of autonomy and responsibility; (11) demonstrate entrepreneurial attitude towards Industry 4.0 related businesses and its problems; and (12) demonstrate continuous self-development by effectively improving competences for professional career.

2.2 Course Objectives Design

The objectives of the subject were backward design based on the PLOs due to considering students' viewpoints (Reynolds & Kearns, 2016). As information and communication technologies connect the world into one, today's companies are challenged by increasingly aggressive competition to satisfy dynamic customer demands. Digital transformation will be indispensable, and having an ability to mimic a physical world into a virtual world will become necessary to companies for assessing scenarios before they even occur, resulting in effective operations, better failure prevention, and attractive offerings. This course aims to build student competence in digital transformation, digital factory modeling, and digital factory analysis. The students will also practice the knowledge gained in a case study factory.

2.3 Course Learning Outcomes Design

Course Learning Outcomes (CLOs) are alignments the course objectives (Okutsu, DeLaurentis, Brophy, & Lambert, 2013). The students on the completion of this course would be able to achieve the digital factory's CLOs, as shown in Table 1.

According to a syllabus, every academic course has a syllabus, which is a subject to be studied in a particular course designed by instructors and students (Chung, Lee, & Kim, 2015). The syllabus consists of rules, responsibilities, contents, activities, assessment technique, and expectations associated with the course as well as student's guide through the course. Moreover, the syllabus provides an extension of homework and subject oriented assignments. In this study, the course syllabus of the digital factory subject is proposed to complete its modules.

The subject is a required course of the new Master's degree program. This course describes important features of Industry 4.0 and attributes of digital technology for modelling and simulating industrial control systems. A new generation of workers is created based on the digital factory subject's syllabus. Thus, existing skills of workers are replaced by required competences of key technologies: autonomous robots, simulation, horizontal and vertical system integration, the industrial sensorization, cybersecurity, additive manufacturing, and augmented reality. The course syllabus of this course contains three modules, as shown in Table 2.

Table 1. CLOs of the digital factory subject.

CLO	Description
1	The students on the completion of this course would be able to understand the strategic differences between traditional factory and digital factory.
2	The students on the completion of this course would be able to understand the capacities and limitations of digital technologies available nowadays.
3	The students on the completion of this course would be able to formulate a data model representing data streamlining in a production line of an existing traditional factory using a data flow diagram (DFD).
4	The students on the completion of this course would be able to simulate the dynamic behavior of a production line and identify locations which must be closely monitored to keep productivity in control, as well as to prevent work defects and machine breakdowns.
5	The students on the completion of this course would be able to propose a digital factory platform of a case study factory in a virtual environment upon what have been learned.

Table 2. Details of course syllabus.

Module	Topic
Introduction to digital factory: road to digital transformation	Lean product lifecycle management towards digital factory, technologies for digital transformation, and integration of technologies for digital factory
Digital factory modeling: how to formulate a virtual world	Cyber-physical systems and data security, data flow model concept and construction, and simulation of a production line
Digital factory analysis: from analysis to factory solutions	Factory digitalization, factory critical points identification and suggestions for improvement, future trends of digital factory

2.4 Course Assessment Design

A course assessment is a significant task of course design, it is always used at the end for every course. Moreover, the course assessment, which can serve reinforced learning objectives provides feedback from students to improve tailored instruction and targeted feedback (Arts, Jaspers, & Joosten-ten Brinke, 2016). Students are motivated to pay attention in the courses by the assessment. The information can be employed to make changes during the current course. There are two existing assessment in education: formative and summative approaches. The formative approach can be defined as a variety of methods that instructors use to assess the learning outcomes and ongoing feedbacks. On the contrary, the summative approach is to assess learning experiences at the completion of a learning sequence by comparing it against CLOs (Dixson & Worrell, 2016). This approach allows the students and instructors to gather information about how well the course is meeting the needs of the students (Heitink, Van der Kleij, Veldkamp, Schildkamp, & Kippers, 2016). However, using a single approach is inadequate for the course assessment. Hence, an integrating of formative and summative approach is employed to assess the learning outcomes at the ends of each module (Buchholtz, Krosanke, Orschulik, & Vorhölter, 2018).

This section aims to measure the knowledge and learning experiences based on CLOs, which are specific and measurable statements for the completion of learning's units. CLOs are written with verb phrases to declare demonstrable actions by the achievement of learning activities (Jian, 2019; Kent, Laslo, & Rafaeli, 2016). The goal of course assessment is to evoke information about learning experiences and modify teaching approaches (Davis, 2016; Reinholz, 2015). To assess the CLOs, a rubric as a standard criterion is a scoring guide with criteria and is developed to evaluate students' learning outcomes (Stoller, 2015). There are five rubrics to assess each accomplishment of the digital factory's CLOs. Each rubric is divided into five scales reflecting the students' experiences precisely, as illustrated in Table 3. The five rating scales are commonly used to measure in various areas because of well interpretation (Meethom & Koohathongsumrit, 2018). Where level 1 to level 5 stand for scores of 20, 40, 60, 80, and 100, respectively.

Table 3. Assessment rubric for each CLO.

CLO	Level	Description
1	1	Students can describe the strategic differences between traditional factory and digital factory in the classroom.
	2	Students can describe the strategic differences between traditional factory and digital factory either in the classroom or examination.
	3	Students can describe the difference between traditional and digital factory both in the classroom and examination.
	4	Students can describe the difference between traditional and digital factory including the examples for improving traditional factory into digital factory either in the classroom or examination.
	5	Students can describe the difference between traditional and digital factory including the examples for improving traditional factory into digital factory both in the classroom and examination.
2	1	Students can describe the capacities and limitations of digital technologies available nowadays in the classroom.
	2	Students can describe the capacities and limitations of digital technologies available nowadays either in the classroom or examination.
	3	Students can describe the capacities and limitations of digital technologies available nowadays both in the classroom and examination.
	4	Students can describe the capacities and limitations of digital technologies available nowadays including the examples for improving traditional factory into digital factory either in the classroom or examination.
	5	Students can describe the capacities and limitations of digital technologies available nowadays including the examples for improving traditional factory into digital factory both in the classroom and examination.
3	1	Students can propose the data streamlining in a production line of an existing traditional factory.
	2	Students can formulate the data model representing data streamlining in a production line of an existing traditional factory using DFD for improvement and advantage.
	3	Students can formulate the data model representing data streamlining in a production line of an existing traditional factory using DFD for improvement in investment, rate of return, feasibility, new process work, and new opportunity.
	4	The data model is accepted by a case study.
	5	The data model is installed in a case study.
4	1	Students can describe the dynamic behavior and monitoring locations of a production line.
	2	Student can describe the dynamic behavior and monitoring locations of a production line either in the classroom or examination.
	3	Students can describe the dynamic behavior and monitoring locations of a production line both in the classroom and examination.
	4	Students can describe the dynamic behavior and monitoring locations of a production line including the examples for improving traditional factory into digital factory either in the classroom or examination.
	5	Students can describe the dynamic behavior and monitoring locations of a production line including the examples for improving traditional factory into digital factory both in the classroom and examination.
5	1	Students can describe a digital factory platform of a case study factory in a virtual environment.
	2	Student can describe a digital factory platform of a case study factory in a virtual environment either in the classroom or examination.
	3	Students can describe a digital factory platform of a case study factory in a virtual environment both in the classroom and examination.
	4	Students can describe a digital factory platform of a case study factory in a virtual environment including the examples for improving traditional factory into digital factory either in the classroom or examination.
	5	Students can describe a digital factory platform of a case study factory in a virtual environment including the examples for improving traditional factory into digital factory both in the classroom and examination.

2.5 Teaching Guidelines Design

For the first module, an instructor shows videos playing on traditional factories and digital factories. Students are encouraged to express their opinions of what they just have seen. Then, the students investigate the internet to find information regarding factory digitalization, the discussion of digital technologies in factories are performed. Next, advanced technologies common digital manufacturing, especially sensorized platforms are carried out by specific diagrams. Finally, the students are assigned to construct DFD diagrams of a visited factory. These diagrams are presented at the end of this course.

For the second module, the new technologies for product development are presented. The instructor shows videos playing movies on cyber-physical systems. Afterwards, the contribution and establishment of the cyber-physical systems are discussed. Then, the DFD diagrams are constructed to promote deeper understanding the cyber-physical systems. The students are allowed to find the real cases of interested cyber security. Next, the prevention of catastrophes regarding the cyber system's under-maintenance is proposed. The cyber security and contribution are taught (Ounsri, Tabkosai, Kengpol, & Tuammee, 2020).

The traditional production is explained to specify its weaknesses. Next, the additive manufacturing is provided. Then, the students search and present the applications of additive manufacturing, which occur in aerospace and automotive, art industry, medical and even architectural industry. The lab of such manufacturing is installed. Finally, the limitations and advantages of the technology are summarized.

The introduction of virtual reality/augmented reality is clarified. The students are able to explore and discuss the applications of such technologies. The instructor identifies the principles of virtual reality/augmented reality. Then, a brief lab demonstration on virtual reality/augmented reality is set. Finally, the learning experiences of these issues are criticized. Finally, groups of the students present its idea of a real case study.

Finally, for the third module, the concept in both information-managed and file-based environments for the development of robotic and automated production systems are lectured. Robot and workstation simulation development, from single-robot stations to complete production lines and zones are discussed including simulation software of information from sensor and mobile device to robotics and automated guided vehicle. The applications of industrial communications and sensors technology as well as mobile device are discussed. The data in smart factory are characterized by teaching. An equipment as sensor or mobile device is clarified to capture the real-time data. Then, the students are allowed to work on the case studies of how the industry employs these technologies in controlling and monitoring the process. They also present the discovered implementation of sensor and mobile device form the self-study. Next, Lab for industrial intelligent sensors are construct to gain students' learning experiences. Afterwards, the strengths and weaknesses of these technologies are demonstrated. A field trip of an automobile industry is employed to reveal the usability of sensor and mobile device.

The instructor summarizes principles of traditional manufacturing and points out a production unit, which can work autonomously using robotics and automated guided vehicle. The applications of robot and automated guided vehicle searching from the internet are shared in the class. The students obtain experiences with laboratory of such technologies. The discussion on feasibility of employment of robot and automated guided vehicle is focused. Then, the students present their project of DFD diagrams of the case study factory. Next, the project-based learning and problem-based learning are used to share ideas of "Factory of the Future" and the results are validated by the assessment rubric of CLOs. Likewise, this case-based learning on this topic is presented. Finally, instructor summarizes the course.

3 Course Implementation

This section provides an implementation of the digital factory subject at KMUTNB. The time distribution of this subject includes 4 teaching and learning methods based on LOVE dimensions: Learning (L), Observing (O), Visiting (V), and Experimenting (E) (Kengpol, Koohathongsumrit, & Meethom, 2020). In every week, students must find the DFD of case study and present the strength, weakness, opportunity, and threat. Problem-based learning by main project: student presentation twice for their projects. The self-study as an active absorption takes 4 hours. The lecture as a passive absorption takes 30 hours. The visiting factory as passive immersion takes 6 hours. Finally, the workshop and laboratory as active immersion take 45 hours. The learning environments of the digital factory subject in a classroom are showed in Figure 1.

Figure 1. learning environments of the digital factory subject in a classroom.

In this course, the pilot teaching is proceeded in the second term of 2019 between June to October. There are 12 graduated students, who register for the subject. At the end of course, instructors are allowed to evaluate the CLOs of each student by using the assessment rubrics for all CLOs. The interview, self-report test, and performance measurement are adopted to approximate levels of each CLO with respect to the students. Each CLO has different expected levels: at least 3 for the first, fourth, and fifth CLOs; and at least 4 for the second and third CLOs. The levels of CLOs are illustrated in Table 4. For example, the second student can explain the difference between traditional and digital factory both in the classroom and examination. Hence, the level of this CLO is equal to 2. According to Table 4, it shows that 37 levels are accepted while 23 levels are failed. Therefore, it is necessary to improve the levels.

Table 4. Levels for all CLOs.

Student	CLO					Student	CLO					Student	CLO					Student	CLO				
	1	2	3	4	5		1	2	3	4	5		1	2	3	4	5		1	2	3	4	5
1	4	3	2	3	3	4	3	3	2	3	5	7	5	4	5	3	4	10	2	2	4	2	3
2	1	3	4	3	4	5	2	4	2	2	4	8	5	4	3	3	4	11	4	2	4	2	4
3	4	3	2	3	5	6	4	4	5	3	4	9	4	2	3	2	5	12	1	2	4	2	4

4 Course Improvement

Curriculum improvement is the process of continuously making instruction better depending on student needs (Tam, 2014). The outputs of course improvement is to aid instructors to serve effective PLOs, CLOs, learning experiences, new knowledges, and innovations based on the teaching and learning methods combining the course syllabus (Willemse et al., 2017). Under some circumstances, new modules are added; the current modules are dropped or improved. Furthermore, the existing modules are transformed to be a different type of teaching and learning methods. Actually, the course improvement clarifies its effectiveness after implementing. It can prove that students' CLOs are either absolutely complete or definitely incomplete. The feedbacks of course implementation always used to modify the CLOs and syllabus in company with other improvements in curriculum design. Finally, the outputs of course improvement provide pilot programs or courses, and the selection of compatible and appropriate instructional materials.

After implementing the course, it finds that the time spending for teaching and learning is not enough, especially for visiting factory. Some students cannot create their imagine for the smart manufacturing in Industry 4.0. In contrast, some students, who have past experiences from their jobs or businesses can apply the knowledge in the real-life case study. For the non-experience students, the repetitive teaching and learning are performed for the incomplete sub modules or main modules. Likewise, the failed students are assigned more than an hour and a half of homework. Moreover, they are invited to watch the same clips about again to learn about digital factory instead of the visiting, in which the virtual smart factory is constructed to be a simulation related to digital manufacturing technologies. The new homework for the analysis of work stations and production lines are assigned to the students. Each student is assigned a case study representing a problem of smart factory in Industry 4.0. The course assessment is then applied for the measurement of CLOs' levels. Every student must describe the benefit for the business processes with factory life-cycle. The improved levels of each CLO are given in Table 5.

Table 5. Improved levels for all CLOs.

Student	CLO					Student	CLO					Student	CLO					Student	CLO				
	1	2	3	4	5		1	2	3	4	5		1	2	3	4	5		1	2	3	4	5
1	4	4	4	3	3	4	3	5	5	3	5	7	5	4	5	3	4	10	3	4	4	4	3
2	3	4	4	3	4	5	3	4	5	5	4	8	5	4	5	3	4	11	4	4	4	3	4
3	4	4	4	3	5	6	4	4	5	3	4	9	4	4	5	4	5	12	3	5	4	3	4

Table 5 showing the improved levels are satisfied. Therefore, it can summarize that the CLOs of students are achieve the intended learning outcomes from completing the course. At the end of course, the students, who are set up for success in Industry 4.0 acquire a better understanding of the specific knowledge and skills. After ending the course, the results applied with the case study are continuous improved by collaborating with the case study's authorities every month.

5 Discussion and Conclusion

Many applications for smart manufacturing used in Thailand are rapidly developed and installed. The jobs in Thailand are not lacking but skills needed in jobs of the smart manufacturing for Industry 4.0 are necessary. Hence, universities must play a significant task in nurturing high-skill talent the industrial needs for sustainable economic growth. The digital factory subject is one of 16 courses created in MSIE 4.0 and is developed to serve management science applied in digital technology for design, modeling, operating the manufacturing process. Many digital technologies: the cyber physical framework, virtual reality/augmented reality, additive manufacturing, sensor and mobile device technologies, robotics/automated guided vehicle for product design, data communication, monitor process, and production control are provided in the digital factory. These technologies increasingly offer cost reduction without loss of quality. This study shows the elements of academic course design: PLOs, course objectives, CLOs, assessment methods, course syllabuses, and teaching guidelines. Moreover, the implementation of the course is also presented. The course's improvement reveals the guidelines for the enhancement of students' knowledges. The benefits of this study support instructors to reach the completion of learning outcomes. Students are able to demonstrate in terms of knowledge, skills, and values upon fulfillment of the course. It can assume that students can apply their knowledges and learning experiences for future working life and the ever-changing technological challenges. For the future study, the remaining courses are examined with a new scoring and grading assessment model. The new course is created by the proposed guideline-based the Delphi method developed by (Meethom & Koohathongsumrit, 2020)

6 References

Arts, J. G., Jaspers, M., & Joosten-ten Brinke, D. (2016). A case study on written comments as a form of feedback in teacher education: so much to gain. *European Journal of Teacher Education, 39*(2), 159-173. doi:10.1080/02619768.2015.1116513

Buchholtz, N. F., Krosanke, N., Orschulik, A. B., & Vorhölter, K. (2018). Combining and integrating formative and summative assessment in mathematics teacher education. *Zdm, 50*(4), 715-728. doi:10.1007/s11858-018-0948-y

Chung, H., Lee, S., & Kim, J. (2015). Learning Concept Sequencing through Semantic-based Syllabus Design and Integration. *Indian Journal of Science and Technology, 8*(18). doi:10.17485/ijst/2015/v8i18/76687

Davis, J. M. (2016). Toward a Capacity Framework for Useful Student Learning Outcomes Assessment in College Foreign Language Programs. *The Modern Language Journal, 100*(1), 377-399. doi:10.1111/modl.12319

Dixson, D. D., & Worrell, F. C. (2016). Formative and Summative Assessment in the Classroom. *Theory Into Practice, 55*(2), 153-159. doi:10.1080/00405841.2016.1148989

Gottipati, S., & Shankararaman, V. (2017). Competency analytics tool: Analyzing curriculum using course competencies. *Education and Information Technologies, 23*(1), 41-60. doi:10.1007/s10639-017-9584-3

Guberman, R., & Leikin, R. (2013). Interesting and difficult mathematical problems: changing teachers' views by employing multiple-solution tasks. *Journal of Mathematics Teacher Education, 16*(1), 33-56. doi:10.1007/s10857-012-9210-7

Hammami, S., Saeed, F., Mathkour, H., & Arafah, M. A. (2019). Continuous improvement of deaf student learning outcomes based on an adaptive learning system and an Academic Advisor Agent. *Computers in Human Behavior, 92*, 536-546. doi:10.1016/j.chb.2017.07.006

Heitink, M. C., Van der Kleij, F. M., Veldkamp, B. P., Schildkamp, K., & Kippers, W. B. (2016). A systematic review of prerequisites for implementing assessment for learning in classroom practice. *Educational Research Review, 17*, 50-62. doi:10.1016/j.edurev.2015.12.002

Jian, Q. (2019). Effects of digital flipped classroom teaching method integrated cooperative learning model on learning motivation and outcome. *The Electronic Library, 37*(5), 842-859. doi:10.1108/el-02-2019-0024

Kang, H. S., Lee, J. Y., Choi, S., Kim, H., Park, J. H., Son, J. Y., . . . Noh, S. D. (2016). Smart manufacturing: Past research, present findings, and future directions. *International Journal of Precision Engineering and Manufacturing-Green Technology, 3*(1), 111-128. doi:10.1007/s40684-016-0015-5

Kengpol, A., Koohathongsumrit, N., & Meethom, W. (2020). *Time analysis of teaching and learning method based on LOVE model*. Paper presented at the The Impact of the 4th Industrial Revolution on Engineering Education., Bangkok, Thailand.

Kent, C., Laslo, E., & Rafaeli, S. (2016). Interactivity in online discussions and learning outcomes. *Computers & Education, 97*, 116-128. doi:10.1016/j.compedu.2016.03.002

Koohathongsumrit, N., & Luangpaiboon, P. (2020). *Multi-objective risk assessment management via zero-one desirability programming model: Thailand – Cambodia beverage logistics solutions*. Paper presented at the The 5th International Conference on Knowledge Engineering and Applications, Tokyo, Japan.

Meethom, W., & Koohathongsumrit, N. (2018). Design of decision support system for road freight transportation routing using Multilayer Zero One Goal Programming. *Engineering Journal, 22*(6), 185-205. doi:10.4186/ej.2018.22.6.185

Meethom, W., & Koohathongsumrit, N. (2020). A decision support system for road freight transportation route selection with new fuzzy numbers. *Foresight*. (article in press)

Nitkiewicz, T., Ayutthaya, D. H. N., Koomsap, P., Lima, R. M., & Chattinnawat, W. (2019). The quality of education on workplace safety master studies - the issue of teaching methods. *System Safety: Human - Technical Facility - Environment, 1*(1), 661-669. doi:10.2478/czoto-2019-0084

Okutsu, M., DeLaurentis, D., Brophy, S., & Lambert, J. (2013). Teaching an aerospace engineering design course via virtual worlds: A comparative assessment of learning outcomes. *Computers & Education, 60*(1), 288-298. doi:10.1016/j.compedu.2012.07.012

Ounsri, A., Tabkosai, P., Kengpol, A., & Tuammee, S. (2020). Design of a decision support system for functional beverage flavoring. *Applied Science and Engineering Progress, 13*(2). doi:10.14416/j.ijast.2018.12.006

Reinholz, D. (2015). The assessment cycle: a model for learning through peer assessment. *Assessment & Evaluation in Higher Education, 41*(2), 301-315. doi:10.1080/02602938.2015.1008982

Reynolds, H. L., & Kearns, K. D. (2016). A Planning Tool for Incorporating Backward Design, Active Learning, and Authentic Assessment in the College Classroom. *College Teaching, 65*(1), 17-27. doi:10.1080/87567555.2016.1222575

Sackey, S. M., & Bester, A. (2016). Industrial engineering curriculum in industry 4.0 in a South African context. *South African Journal of Industrial Engineering, 27*(4), 101-114. doi:10.7166/27-4-1579

Stoller, A. (2015). Taylorism and the logic of learning outcomes. *Journal of Curriculum Studies, 47*(3), 317-333. doi:10.1080/00220272.2015.1018328

Taba, H. (1962). *Curriculum development: Theory and practice*. New York: Harcourt: Brace & World.

Tam, M. (2014). Outcomes-based approach to quality assessment and curriculum improvement in higher education. *Quality Assurance in Education, 22*(2), 158-168. doi:10.1108/qae-09-2011-0059

Vanderlinde, R., van Braak, J., & Hermans, R. (2009). Educational technology on a turning point: curriculum implementation in Flanders and challenges for schools. *Educational Technology Research and Development, 57*(4), 573-584. doi:10.1007/s11423-009-9126-9

Willemse, T. M., de Bruïne, E. J., Griswold, P., D'Haem, J., Vloeberghs, L., & Van Eynde, S. (2017). Teacher candidates' opinions and experiences as input for teacher education curriculum development. *Journal of Curriculum Studies, 49*(6), 782-801. doi:10.1080/00220272.2016.1278043

A Survey of Requirements for Thailand's Industry 4.0: The Perspectives from Academics and Entrepreneurs

Nitidetch Koohathongsumrit[1], Nanthawat Phakkulhab[2], Athakorn Kengpol[2], Warapoj Meethom[2]

[1] Department of Statistics, Faculty of Science, Ramkhamhaeng University, Bangkok, Thailand
[2] Department of Industrial Engineering, Faculty of Engineering, King Mongkut's University of Technology North Bangkok, Bangkok, Thailand

Email: Nitidetch.k@rumail.ru.ac.th, Nanthawat.p@eng.kmutnb.ac.th, Athakorn@kmutnb.ac.th, Warapoj.m@eng.kmutnb.ac.th

Abstract

The main objective of this study is to explore various requirements for improving skills and knowledges needed for Thailand's 4.0 industry. The findings are used to develop the Master's Degree Program in Industrial Engineering for Thailand Sustainable Smart Industry (MSIE 4.0). The aim of this created program-based needs of instructors and employers is to serve high skilled and graduated students for commercial entrepreneurs. Likewise, academics can improve their teaching and learning approaches via the curriculum. In this study, the respondents are instructors and employers, who have working experience ranged from 0 to 10 years and greater. There are 225 participants from Bangkok and its suburbs, North, South, Northeast and West of Thailand agree to participate in the study. The respondents are allowed to assess their needs based on 16 required skills and knowledges: enterprise management in digital economy, project management for industry 4.0, smart operations management, quality management for extended enterprise, sustainable supply chain management, digital factory, advanced optimization, intelligent decision support systems, applied data analytics, cyber-physical industrial systems, collaborative manufacturing systems, additive manufacturing for industry 4.0, innovative product design and development, human-centric design for operator 4.0, customer experience-driven design, and leadership communication and people development in digital era. The results can promote the short training courses, which can be used to enhance the knowledge of instructors, graduates, and employers accurately. Moreover, the course learning outcomes (CLOs) of each subject in MSIE4.0 are focused and designed based on the guidelines of this study.

Keywords: Curriculum Requirements; Student Learning Outcomes; Required Skills; Industry 4.0.

1 Introduction

The rise of new digital industrial technology known as Industry 4.0 is a transformation that makes it possible to gather and analyze data across machines, enabling faster, more flexible, and more efficient processes to produce higher-quality goods at reduced costs (Oztemel & Gursev, 2020). This revolution improves the flexibility, speed, productivity, and quality of the production process including the foundation for the adoption of new business models (Li et al., 2017). Hence, manufacturers are facing a significant reskilling effort to capitalize on new opportunities while maintaining legacy automation environments. Those changes are powered by emerging technologies, offering a better way to organize and manage all standard processes within the manufacturing industry. The major problem of Industry 4.0 in Thailand is lacking of workers together with the rise of technologies of smart manufacturing (Koohathongsumrit & Luangpaiboon, 2020). This problem is preventing manufacturers from capitalizing on these trends due to as a result of lacking a properly skilled workforce (Hariharasudan & Kot, 2018). It is essential to promote vocational education and skill development in the country. The significant efforts are continuously increasing on skill development for Industry 4.0.

The Curriculum Development of Master's Degree Program in Industrial Engineering for Thailand Sustainable Smart Industry (MSIE 4.0) project funded by the European Commission aims to develop a magister scientiae degree (MSc) for industrial engineering (IE) aligned with needs of Industry 4.0. The outcomes of this project are based on cooperation between 6 Thai and 3 European Union universities that after identifying the gap between the currently running programs and the needs of industry and students have prepared modernized studying program. Some activities of MSIE 4.0 are depicted in Figure 1. The curriculum is developed to propose students' learning outcomes covered Industry 4.0 technologies, management, and design approaches by the backward planning because of focusing the learning experiences rather than the teaching and learning methods including expertise (Kengpol, Koohathongsumrit, & Meethom, 2020; McElhinny, Dougherty, Bowling,

& Libarkin, 2014). Hence, graduated students are ready to work in Industry 4.0 and contribute to its sustainability based on the overarching curriculum. One of the components is needs of stakeholders, which can be used to identify a course in the curriculum. The course refers to many types of contents e.g. program learning outcomes (PLOs), course objectives, course learning outcomes (CLOs), dispositions, durations, course syllabus, learners, instructors, activities, resources, teaching guidelines, skills to be acquired, lexis, language structure, and assessment methods (Mingsakul, Usadornsak, Tuntitippawan, & Kengpol, 2020; Skerrett, 2010). Moreover, the course can be viewed as a measurable, observable, and specific statement that clearly indicates what a student should know and be able to do as a result of learning (Fogleman, McNeill, & Krajcik, 2011).

Figure 1. Some activities of MSIE 4.0.

For MSIE 4.0, The process of defining courses starts with the draft of PLOs and the challenge for consortium members on achieving them with IE courses. The draft list of courses has been the outcome of brain storming session of consortium members available on the meeting. The courses have gone through similar process as the list of PLOs. The consortium members have come to the short list of the courses with scoping, joining and re-orienting the courses submitted at the beginning. The list of courses is defined and illustrated in Table 1.

Table 1. List of MSIE 4.0 courses.

No.	Course name	Course status
1	Enterprise Management in Digital Economy (EMDE)	elective
2	Project Management for Industry 4.0 (PMI)	elective
3	Smart Operations Management (SOM)	core
4	Quality Management for Extended Enterprise (QMEE)	elective
5	Sustainable Supply Chain Management (SSCM)	elective
6	Digital Factory (DF)	core
7	Advanced Optimization: Techniques and Industrial Applications (AO)	elective
8	Intelligent Decision Support Systems (IDSS)	elective
9	Applied Data Analytics (ADA)	core
10	Cyber-Physical Industrial Systems (CPIS)	elective
11	Collaborative Manufacturing Systems (CMS)	elective
12	Additive Manufacturing for Industry 4.0 (AMI)	elective
13	Innovative Product Design and Development (IPDD)	elective
14	Human-Centric Design for Operator 4.0 (HCDO)	compulsory
15	Customer Experience-Driven Design (CEDD)	elective
16	Communications and People Skills Development for Engineering Leaders (CPSD)	elective

The aim of this study is to explore the required skills and knowledges for the smart technology in Thailand's industry 4.0 from academics and industrial entrepreneurs. The benefits of this study provide a guideline to develop the master's degree program for industrial sectors as well as the foundation for the quality of study and the success of a degree program.

2 Materials and Methods

This study is a survey research, which is the collection of the required skills and knowledges in Industry 4.0 attained by asking individuals questions either in person, on paper, by phone or online (Ruel, Wagner III, & Gillespie, 2016). The methods of this study aid instructors to gather data from its source that can be used to develop the new curriculum. The academics and industrial entrepreneurs are allowed to express their perspectives for the needs of skill in such situation. There are four steps to complete the gap of research, as described below (Delobelle et al., 2010; Rowley, 2014).

2.1 Participant Selection

Participant selection is the process of selecting a representative group from the population under study(Kramer et al., 2014). The Population of this study is academics and industrial entrepreneurs in Thailand. The academic is a full-time instructor in different universities apart from MSIE 4.0's partners. Regarding the industrial entrepreneurs can be defined as chief executive of industrial manufacturing company in Thailand. The invitations are individually sent to the interested population via email. If the respondents accept the invitations, they are determined as the participants. Therefore, a sample of this study is the respondents of target groups, who accept the invitations.

2.2 Questionnaire Design

The tool of this study is a questionnaire, which refers to a research instrument consisting of a list of standardized questions to gather useful information on the required skills and knowledges in Industry 4.0 from one or more participants (Mardani et al., 2016; Meethom & Koohathongsumrit, 2018). The questions are answered by the participants in order to provide information for a report or a survey (de Boer, Timmerman, Pijl, & Minnaert, 2012). The online questionnaire is created based on five sections: (1) organization/university, (2) industrial type, (3) working area, (4) working experience, and (5) the required skills and knowledges. More details on the questionnaire can be found via this URL: https://forms.gle/TeCvvY4xh9zPCDBU9. In the questionnaire, questions are designed to elicit information regarding the aforementioned measures. The number of questions in section 1 to 4 are equal to 4 whereas the questions in section 5 are equal to 16. The participants are allowed to choose the best answer in sections 1, 3 and 4 while section 2 and 5 permit the participant choose more than one answer. For the first section, the participants can select their characteristics: academic, industrial, and others fields. The second section presents the types of organizations: IE (T1), seafood processing (T2), logistics and transport (T3), packaging and commerce (T4), electronics (T5), automotive (T6), tourism (T7), agricultural processing (T8), construction and manufacturing (T9), aerospace (T10), petrochemical (T11), automation (T12), wood/furniture (T13), information technology (T14), textile industry (T15), manufacturing (T16), packaging (T17), and others (T18). The working areas in the third section are divided into Bangkok and its suburbs, North, South, Northeast and West. In the fourth section, the working experiences (years) can be classified into seven groups: less than or equal to 1 year (0-1), greater than 1 year but less than or equal to 3 years (2-3), greater than 3 years but less than or equal to 5 years (4-5), greater than 5 years but less than or equal to 7 years (6-7), greater than 7 year but less than or equal to 9 years (8-9), equal to 10 years, and greater than 10 years (>10). This study, the last section is the required skills and knowledges in Industry 4.0, the names of 16 courses are determined as the questions, which demonstrate the needs of skills and knowledges for Industry 4.0. In addition, the participants can check the course objectives by ticking on its names. The details of each course are shown in Table 2. However, the limitation of this questionnaire is that the requirements are assumed an equal importance. The participants can send an email for the intensity of importance to the MSIE 4.0's members.

Table 2. Objectives of 16 MSIE 4.0's courses.

Course	Objective
EMDE	This course aims to provide the students with knowledge and competences on using integrated and system solutions in advancing the management to the requirements of Digital Economy. In this course students will learn on how to adopt management, its strategies and functions to smart and sustainable solutions that 4.0 era has brought to enterprises. Students will learn how to use ICT management tools and solutions to enhance transformation from traditional to digital business operation and models.
PMI	This course concentrates to prepare graduates to perform in and manage projects and teams in the new highly agile digitized challenging smart industries. These projects will be developed by interdisciplinary distributed teams using digital platforms. The guidelines for dealing with a project service for each customer each time are presented as an increase in customized services that ultimately can become a service for each customer.
SOM	The course focuses to develop competences on design and implementation of continuous and efficient operations while creating a digital copy of the end-to-end process. Using real world data to understand, evaluate, and simulate the end-to-end operation to improve and manage all operations efficiently. Emphasis is on cross-enterprise integration of the physical and virtual systems among various functions including operation strategy, process design and planning, facility location and design, forecasting, scheduling and inventory control.
QMEE	This course aims to develop technical skill for students to implement quality control and monitoring system that cover both process operation and supply chain operations. A complete paragraph including a brief introduction connecting the course to sustainable smart industry, and what instructors would like to cover in the course
SSCM	This course aims to acquire the ability to create an effective value chain with the use of intelligent and flexible production technologies and modern communication as part of the interaction network between its participants. This course enables students to gain/improve knowledge of supply chain management that covers key issues regarding supply network design, inventory control and management, delivery contract, bullwhip and information exchange, distribution strategy, strategic alliance, purchasing strategies, pricing strategies, etc.
DF	This course presents utilization of digital technology for modeling, and communications to configure, model, simulate, assess, and operate a manufacturing process. A new set of rules for smart factory, including increased agility, new technology solutions, transparent communication, standardized planning processes, a shortened product development, and cross-functional teams is provided.
AO	The objective of this course is to provide the students knowledge on the application of various optimization techniques which can help making decisions for practical problems in industries. Modeling concepts and applications of linear, integer, nonlinear, and dynamic programming as well as network models are addressed. Meta-heuristic techniques are also discussed to obtain solutions for large scale practical problems.
IDSS	The target of this course is to give students the up-to-date of decision-making concepts, process, strategies, and technologies that are often used to support decision making in real-world issues coupled with agile approach and industry 4.0 specification, and design decision support system by mini project. A decision support system with embedded artificial intelligence techniques exhibiting some or all of the abilities indicative of intelligent behavior is proposed.
ADA	This course aims to impart knowledge on statistical techniques needed for data analysis, and various data mining techniques and algorithms used in practical problems that require processing big data for decision making purpose. Moreover, many techniques and processes of data analytics automated into mechanical processes and algorithms that work over raw data for human consumption are clarified.
CPIS	The main characteristics of this course to express systems of collaborating computational entities which are in intensive connection with the surrounding physical world and its on-going processes, providing and using, at the same time, data-accessing and data-processing services available on the internet. The applicaion, components, selection rules, programming methodology, specific aspects related to different measured physical parameters, data storage, reporting and communications are included.
CMS	The course is creating knowledge and is developing technical competence for better understanding of future emerging sustainable smart manufacturing systems. This course is also presenting and analyzing modern methods and techniques, which will compete on design and operation of agile, lean, green, and sustainable manufacturing systems. Teaching technique is centered on project based learning type activities allowing flexible learning formats.

Table 2. Cont.

Course	Objective
AMI	This course aims to describe the sustainable rapid development of personalized complex design in various disruptive applications, especially in manufacturing and medical. The students are trained to gain the competence in additive manufacturing and related technology. The students will learn fundamental knowledge of additive manufacturing and reverse engineering and their applications of in manufacturing, medical and other sectors. Besides, they will learn and practice design for additive manufacturing.
IPDD	The subject of the course concerns the creative design of innovative products that are technological innovation or modification of existing technological solutions. As a result, designed products should find their application in Industry 4.0 related businesses and its problems. The goal of this course is discussion of issues related to development and marketing innovative products, including searching for ideas and creating a concept based on creative thinking techniques and methods of entrepreneurial problem solving, selecting ideas and development of prototypes, taking into account user needs and the latest scientific research.
HCDO	Human-centric design is a unique approach to solve problems of products, process, environments, and other human operations challenging with incompatibilities of human needs, abilities and limitations. The objective of this course is to evaluate and design tasks, equipment, products, processes, jobs, environments and other elements in working systems in order to optimize human wellbeing and overall system performance.
CEDD	This course aims to build student competence in design customer experience with knowledge on a concept of customer experience management (CEM) and on a systematic approach for an experience design process. In this course, the students will learn customer perception, customer involvement, and customer experience. Besides, they will learn and practice how to design customer journey and to prevent failure of offering in a team environment.
CPSD	This course aims to develop the best of each person in the context of their professional practice, will create a competitive advantage. Additionally, the communication between different cultures and for different types of audiences will make the best of leaders. This course aims to prepare graduates for leadership in companies, communicating effectively and developing people to their best.

2.3 Data Collection

The questionnaires are separately distributed to the participants between October 2019 and March 2020. The link of questionnaire is then sent to the participants via email. In some cases, the hard copies of questionnaires are also distributed to the participants, who give their affiliations in recommendation form of invitation. The respondents have to answer the questions on their own. For the fifth sections, the participants can give their data more than one answer.

3 Results and Discussion

This section describes the number of participants and the findings. The general information of participants as organization/university, industrial type, working area, and working experience are characterized. With regard to the required skills and knowledges, they are analyzed by the ratio and proportion. There are 225 participants, who accept the invitations. They contain 207 participants from industrial sectors and 18 instructors from the universities in Thailand. The participants are classified based work areas. Table 3 shows that there are 10 academics and 97 entrepreneurs from Bangkok and its suburbs, 3 academics and 43 entrepreneurs from North, 2 academics and 21 entrepreneurs from South, 4 academics and 32 entrepreneurs from Northeast, and 14 entrepreneurs from West. The academics from West do not response to participate in this study.

Furthermore, the participants can be divided into 17 groups based on the types of organizations, Table 4 illustrates that there are 18 participants from T1, 6 participants from T2, 35 participants from T3, 20 participants from T4, 17 participants from T5, 27 participants from T6, 3 participants from T7, 9 participants from T8, 12 participants from T9, 2 participants from T10, 1 participants from T11, 7 participants from T12, 5 participants from T13, 11 participants from T14, 8 participants from T15, 31 participants from T16, and 13 participants from T17. However, participants from other types of organizations do not cooperate in this study.

Table 3. Participants in this study.

Sector	Work Area					Total
	Bangkok/ its suburbs	North	South	Northeast	West	
Academics	10	3	2	3	0	18
Industrial Entrepreneurs	97	43	21	32	14	207
Total	107	46	23	35	14	225

Table 4. Participants grouped by types of organization.

	Types of Organization																		Total
	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	
Participant	18	6	35	20	17	27	3	9	12	2	1	7	5	11	8	31	13	0	225

According to the working experience, the participants consist of 7 different groups, as mentioned in Section 2.2. The first group has 52 participants; the second group has 55 participants; the third group has 45 participants; the fourth group has 36 participants; the fifth group has 21 participants; the sixth group has 12 participants; and the last group has 4 participants, as given in Table 5. The results show that the number of participants grouped by working expriences and the response rate have a negative correlation.

Table 5. Participants grouped by working experiences.

	Working Experiences (Years)							Total
	0-1	2-3	4-5	6-7	8-9	10	>10	
Participant	52	55	45	36	21	12	4	225

For the fifth section, the participants answer and check the skills and knowledges, which are presented as the MSIE 4.0's courses. They can give their scores more than one choice. If the participant checks the course, it means the skills and knowledges in such course is essential to work in Industry 4.0. The participants' answers are transformed and interpreted by the percentage of observations, as shown in Table 6. Nonetheless, the maximum needs of skills and knowledges corresponding to each course are equal to 225.

Table 6. Participants' answers of skills and knowledges needed in Industry 4.0.

	Course															
	EMDE	PMI	SOM	QMEE	SSCM	DF	AO	IDSS	ADA	CPIS	CMS	AMI	IPDD	HCDO	CEDD	CPSD
Academics	3	2	4	4	13	12	5	6	7	4	4	6	5	4	4	4
(Percentage)	(16.61)	(11.11)	(22.22)	(22.22)	(72.22)	(66.67)	(27.78)	(33.33)	(38.89)	(22.22)	(22.22)	(33.33)	(27.78)	(22.22)	(22.22)	(22.22)
Industrial Entrepreneurs	47	48	77	55	154	158	59	79	160	67	111	47	103	57	62	73
(Percentage)	(22.71)	(23.19)	(37.20)	(26.57)	(74.40)	(76.33)	(28.50)	(38.16)	(77.29)	(32.37)	(53.62)	(22.71)	(49.76)	(27.54)	(29.95)	(35.27)
Total	50	50	81	59	167	170	64	85	167	71	115	53	108	61	66	77
(Percentage)	(22.22)	(22.22)	(36.00)	(26.22)	(74.22)	(75.60)	(28.44)	(37.78)	(74.22)	(31.56)	(51.11)	(23.56)	(48.00)	(27.11)	(29.33)	(34.22)

Based on Table 6, the skills and knowledges needed based on academics' perspectives can be rank in descending order as SSCM > DF > ADA > IPDD, IDSS > IPDD, AO > SOM, QMEE, CPIS, CMS, HCDO, CEDD, CPSD > EDME > PMI. The SSCM is taken the most necessary course due to the highest percentage of required skills and knowledges as 72.22 percent. DF and ADA take the second and third most necessary course. For the industrial entrepreneurs' perspectives, they need the ADA because of the highest percentage. The industrial entrepreneurs' ranking is ADA > DF > SSCM > CMS > IPDD > IDSS > SOM > CPSD > CPIS > CEDD > AO > HCDO > QMEE > PMI > EMDE, AMI. With regard to the total participants, the top four courses are DF at 75.60 percent, SSCM and ADA at 74.22 percent for each course, and CMS at 51.11 percent. The remaining courses are IPDD at 48.00 percent, IDSS at 37.78 percent, SOM at 36.00 percent, CPSD at 34.22 percent, CPIS at 31.56 percent, CEDD at 29.33 percent, AO at 28.44 percent, HCDO at 27.11 percent, QMEE at 26.22 percent, AMI at 23.56 percent, and EMDE including PMI at 22.22 percent. The participants' answers of skills and knowledges needed in Industry 4.0 are depicted in Figure 2. Furthermore, the results demonstrate that the most important required skills and knowledges needed in Thailand's Industry 4.0 is DF with 75.6 percent, followed by SSCM and ADA with 74.22 percent for each course, and CMS with 51.11 percent. These courses are the application of digital technologies that create opportunities for differentiation in the marketplace, for enhancing the efficiency of the production system and improving on-time performances.

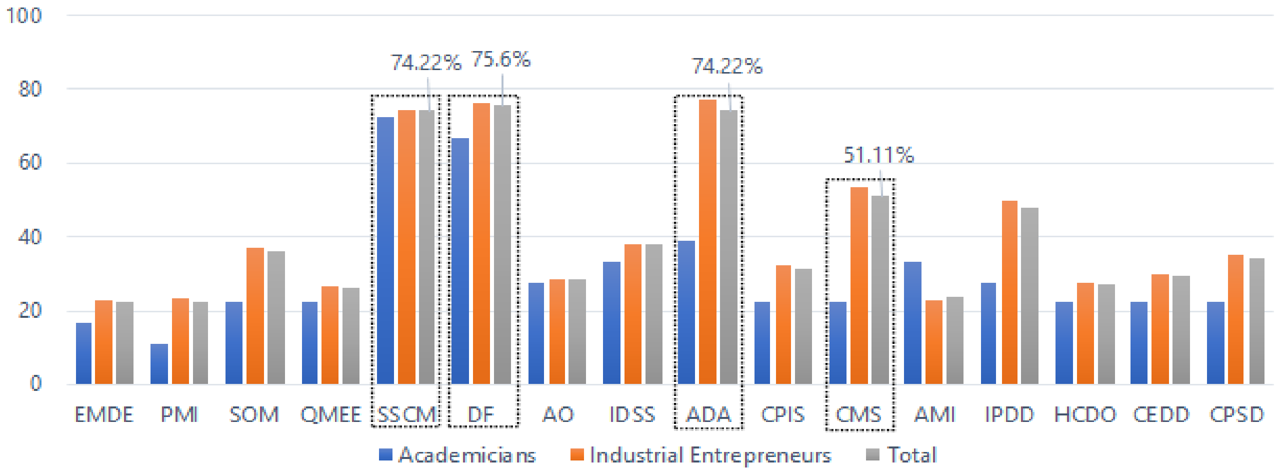


Figure 2. Participants' answers of skills and knowledges needed in Industry 4.0.

The findings show that the perspectives of academics and entrepreneurs are not different. The essential skills for industry 4.0 can be categorized into six skills: technology, programming, digital, thinking, society, and personality skills. The hard skills for industry 4.0 include the processes of inspecting, cleansing, transforming, and modeling data with the goal of discovering useful information for supply chain, data processing, smart manufacturing, and digital technology in plants. The soft skills are an interaction between manpower and machine. All kinds of skills for using of artificial intelligence are necessary concentrated to promote the controlling and monitoring a digital machinery in order to increase productivity. However, an education in Thailand has changed dramatically due to the outbreak of coronavirus diseases (COVID-19). As a result, the 16 courses are undertaken remotely and on digital platforms. Whereby, semesters after the ending of the outbreak, the online and traditional learnings are simultaneously proceeded.

4 Conclusions

The objective of this study is to investigate the needs of skills and knowledges for designing the master curriculum for IE. The skills and knowledges of MSIE 4.0 are classified into 16 different courses: SSCM, DF, AO, IDSS, ADA, CPIS, CMS, AMI, IPDD, HCDO, CEDD, and CPSD. The participants of this study are academics of IE and industrial entrepreneurs, who work in Thailand. The questionnaire is designed and individually distributed to the 225 participants. The results show that the most significant required skills and knowledges needed in Thailand's Industry 4.0 based on the perspectives of academics and industrial entrepreneurs are SSCM, DF, ADA, and CMS followed by the remaining courses in descending order as IPDD, IDSS, SOM, CPSD, CPIS, CEDD, AO, HCDO, QMEE, AMI, and EMDE as well as PMI. The contributions of this study provide guidelines for in-demand skills and knowledges needed in Thailand's Industry 4.0 as well as more coherent learning paths. For the future study, a CLO for every course is developed to identify contributions of each course in the master curriculum of science in IE. The requirements can be collected by the proposed guideline-based the Delphi method developed by Meethom and Koohathongsumrit (2020)

5 References

de Boer, A., Timmerman, M., Pijl, S. J., & Minnaert, A. (2012). The psychometric evaluation of a questionnaire to measure attitudes towards inclusive education. *European Journal of Psychology of Education, 27*(4), 573-589. doi:10.1007/s10212-011-0096-z

Delobelle, P., Rawlinson, J. L., Ntuli, S., Malatsi, I., Decock, R., & Depoorter, A. M. (2010). Job satisfaction and turnover intent of primary healthcare nurses in rural South Africa: a questionnaire survey. *J Adv Nurs, 67*(2), 371-383. doi:10.1111/j.1365-2648.2010.05496.x

Fogleman, J., McNeill, K. L., & Krajcik, J. (2011). Examining the effect of teachers' adaptations of a middle school science inquiry-oriented curriculum unit on student learning. *Journal of Research in Science Teaching, 48*(2), 149-169. doi:10.1002/tea.20399

Hariharasudan, A., & Kot, S. (2018). A Scoping Review on Digital English and Education 4.0 for Industry 4.0. *Social Sciences, 7*(11). doi:10.3390/socsci7110227

Kengpol, A., Koohathongsumrit, N., & Meethom, W. (2020). *Time analysis of teaching and learning method based on LOVE model*. Paper presented at the The Impact of the 4th Industrial Revolution on Engineering Education., Bangkok, Thailand.

Koohathongsumrit, N., & Luangpaiboon, P. (2020). *Multi-objective risk assessment management via zero-one desirability programming model: Thailand – Cambodia beverage logistics solutions*. Paper presented at the The 5th International Conference on Knowledge Engineering and Applications, Tokyo, Japan.

Kramer, J., Rubin, A., Coster, W., Helmuth, E., Hermos, J., Rosenbloom, D., . . . Lachowicz, M. (2014). Strategies to address participant misrepresentation for eligibility in Web-based research. *Int J Methods Psychiatr Res, 23*(1), 120-129. doi:10.1002/mpr.1415

Li, X., Li, D., Wan, J., Vasilakos, A. V., Lai, C.-F., & Wang, S. (2017). A review of industrial wireless networks in the context of Industry 4.0. *Wireless Networks, 23*(1), 23-41. doi:10.1007/s11276-015-1133-7

Mardani, A., Jusoh, A., Zavadskas, E. K., Zakuan, N., Valipour, A., & Kazemilari, M. (2016). Proposing a New Hierarchical Framework for the Evaluation of Quality Management Practices: A New Combined Fuzzy Hybrid Mcdm Approach. *Journal of Business Economics and Management, 17*(1), 1-16. doi:10.3846/16111699.2015.1061589

McElhinny, T. L., Dougherty, M. J., Bowling, B. V., & Libarkin, J. C. (2014). The Status of Genetics Curriculum in Higher Education in the United States: Goals and Assessment. *Science & Education, 23*(2), 445-464. doi:10.1007/s11191-012-9566-1

Meethom, W., & Koohathongsumrit, N. (2018). Design of decision support system for road freight transportation routing using Multilayer Zero One Goal Programming. *Engineering Journal, 22*(6), 185-205. doi:10.4186/ej.2018.22.6.185

Meethom, W., & Koohathongsumrit, N. (2020). A decision support system for road freight transportation route selection with new fuzzy numbers. *Foresight*.

Mingsakul, W., Usadornsak, C., Tuntitippawan, N., & Kengpol, A. (2020). Reduction of scrap in anodization process: a case study in a cosmetic packaging industry. *Applied Science and Engineering Progress, 13*(1). doi:10.14416/j.ijast.2018.11.007

Oztemel, E., & Gursev, S. (2020). Literature review of Industry 4.0 and related technologies. *Journal of Intelligent Manufacturing, 31*(1), 127-182. doi:10.1007/s10845-018-1433-8

Rowley, J. (2014). Designing and using research questionnaires. *Management Research Review, 37*(3), 308-330. doi:10.1108/mrr-02-2013-0027

Ruel, E., Wagner III, W. E., & Gillespie, B. J. (2016). *The Practice of Survey Research: Theory and Applications*. Thousand Oaks, California: SAGE Publications.

Skerrett, A. (2010). Lolita, Facebook, and the Third Space of Literacy Teacher Education. *Educational Studies, 46*(1), 67-84. doi:10.1080/00131940903480233

A student perspective on the blended learning experience in a project based context - A case of the blended learning experience, and how it affected students ability to manage, collaborate, and communicate in an international cross-disciplinary project

Johannes Kruse Hellmers[1], Robert Nedergaard Nielsen[1]

[1]Aalborg University, Aalborg, Denmark

Email: jhellm14@student.aau.dk, rnni17@student.aau.dk

Abstract

Based on an expectation from the authors on the beneficial learning outcome from joining the Erasmus+ project Improving Employability Through Internationalization And Collaboration, namely that this would strengthen their intercultural competence, improve their ability to take part in agile collaboration and strengthen their project management skill, they signed up for the project. This paper will present a case-based study of the authors experience, and the knowledge gained on top of the study curriculum, of joining such a project. It will shortly describe the project, analyse areas in which the authors gained significant extra-curricular skills, and describe outcomes of the process. This will result in the authors suggesting advice to future teachers and students embarking on similar learning experiences, that they make need to find projects with interesting and relevant problems as these heighten motivation and challenges both the technical and interpersonal skills of the students involved. The conclusion based on these is that a blended learning experience such as is described, will have significant benefits to the intercultural competence of students, as long as this is made explicit as an outcome in the beginning. It will also conclude that the main challenge to cross-disciplinary work lies in communication.

Keywords: Blended learning, international collaboration, student experiences.

1 Introduction

In this submission, the goal of the authors is, to better understand the experiences with a blended learning experience through careful examination of the problems that arose in the given multinational and interdisciplinary nature of the project.

The initial goal of joining an international project, where to gain more experience in work across both borders and disciplines. This goal was reinforced by the multiple pleasant experiences of working with projects in problem based learning at Aalborg University, and was seen by the Danish student as a way to further challenge the abilities not challenged by ordinary lectures and textbook exercises.

In the following, a description of the project setup, an evaluation of the project's challenges and results, a discussion about these and a conclusion on the findings are done.

By understanding the case of this project's context, the authors hope to bring a more personal view of such experiences to educators. This means also that the generality of this experience is not going to be in focus for the submission, mainly because of the constrained formal knowledge in the field of educational research.

2 Project setup

The project itself is part of the Erasmus+ project Improving Employability Through Internationalization And Collaboration (EPIC)(Pedersen, Kirkova, Kuladinithi, & Janssen, 2019) and is a collaboration between three parties. Four Danish network engineering students, a Turkish software student and six Brazilian production engineering students.

As the EPIC project spans a large variety of students from different universities and with different progress, the amount of ECTS points vary for each person. As such this is important to note, when evaluating such an experience, in the case of this project, the points were distributed as seen in Table 1.

Table 1: Overview of course load of the participants.

Country	ECTS pr. person
Denmark	20
Brazil	2
Turkey	8

The stated goal of the project was to use the competencies of the three groups to create a system that could improve the waste collection in Brazil's capital, Brasilia.

2.1 Process

The collaboration was initiated with a kick-off seminar in Hamburg. This was a week long seminar that gave insights in to different subjects, amongst them were an intercultural workshop, giving a brief introduction to Hofstede's cultural dimensions, and how these can be applied when managing an intercultural process (Figure 1), a talk about taking up a large scale Sustainable Development Goal(SDG) challenge as students and social activities.

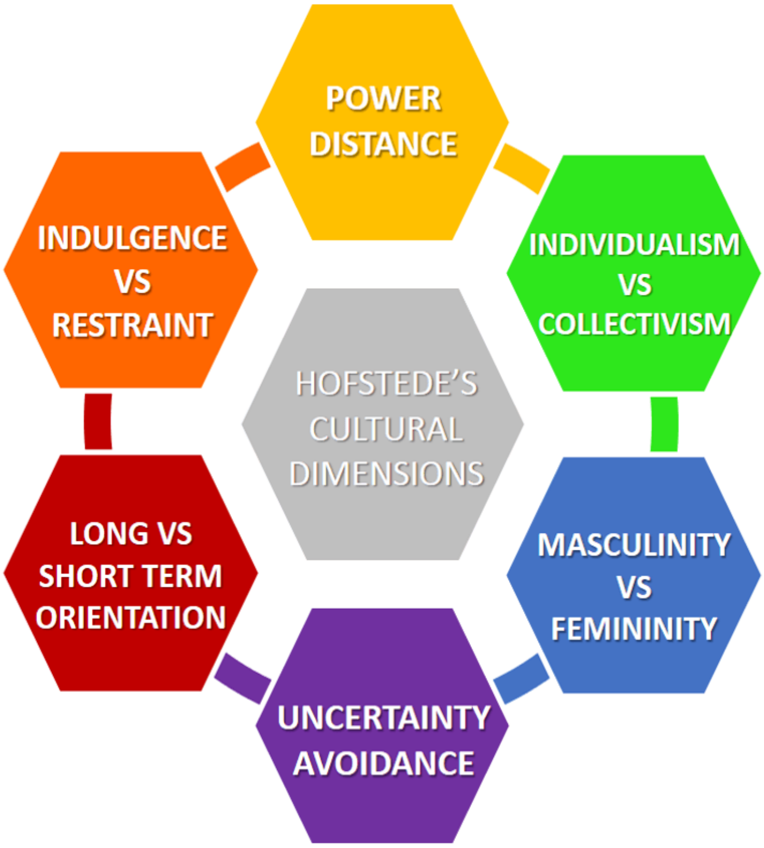


Figure 1: Hofstede's cultural dimensions (2017).

2.2 Communication

During the seminar, the group also defined how to communicate during the virtual collaboration phase. As the EPIC team had already created a Slack channel for the students and supervisors it was chosen to continue using Slack for written communication. As a part of this discussion it was also decided that the group should have video meetings during the collaboration phase, here it was chosen to use Google hangouts as it is accessible to everyone through a browser. These communication agreements can be summarized as:

- A weekly update on the joint Slack, explaining what has been done during the week and potential problems.
- Online meetings every 14 days, where results and problems can be discussed in order to find a solution together.

2.2.1 Assessment

As a part of the EPIC project the group were also asked to create some criteria to assess the other members' contribution to the project. The idea was then to run an assessment three times during the collaboration after the kick-off seminar in Hamburg, in the middle of the collaboration and towards the end.

The group decided on the criteria:

- Good meeting structure and meeting feedback.
    - Definition: To establish good meeting structure, all teams are supposed to answer the following questions after every meeting:
        - Did we get expected information from the other teams during the meeting.
        - Are we following the schedule and are we satisfied with the results so far?
        - How efficient was meeting timewise.
- Correct use of agreed online tools.
    - Definition: The Team members should use the slack channel and respond to messages at least once a week.
- Cultural Awareness
    - Definition: Students act respectfully during the meeting and understand each other’s point of view.
        - Did I have any communication challenges within the team during the meeting.
        - Was I able to express myself efficiently?
        - Are we being considerable about cultural differences?

These assessments should then be used in the following meeting in order to evaluate whether or not the members lived up the expectations from the other group members.

2.3 Content

This seminar was also used for generating an initial concept for a system that could help mitigate some of the problems. The initial concept the group came up with can be seen on Figure 2. The concept consists of a number of sensors placed in the waste containers, a network system that can facilitate the communication from the sensors to a centralized server.

The server will then store the measurements from the sensors and process it into a format that could be used in a route optimization algorithm and for creating a dashboard giving the company an overview of the status of their containers.

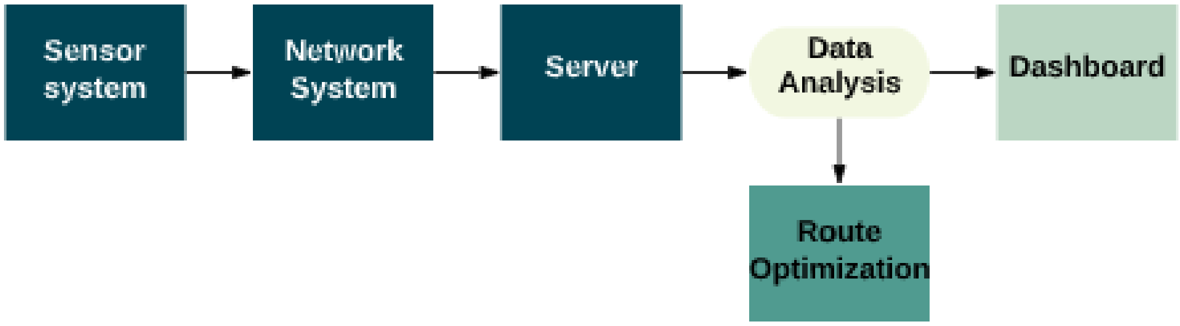


Figure 2: Illustration of the initial concept created by the group.

This initial concept was then divided up into subsystems with a goal of making each group of students to work in their field of study. The Danish network engineering students would make the sensors, the network system for sending the measurements and a server that could provide the data from the measurements to the others. As a part of the division process the interfaces between the subsystems were defined, and a prioritisation of tasks were devised, so progress could be made more effective. This division can be seen on Table 2.

Table 2: Deliverables of the groups.

Team	Deliverables
Network engineers	• Sensor system, capable of measuring waste level. • Network system for sending measurements to a centralized server.
Production engineers	• Facilitating communication to the waste management company. • Dashboard for displaying sensor data.
Software engineer	• Route optimization.

3 Evaluation and results

During the first weeks of the virtual collaboration phase, it was experienced what can happen when working in an intercultural project, as the group had forgotten to take local holidays into account. This resulted in next to no communication and process on the project during this first period. Upon experiencing this the preparation done in Hamburg became incredibly relevant, as this had given the students a more positive approach to tackling the challenge of cultural differences and brought a more adaptive mindset.

As the load from the universities was much higher during the beginning of the semester the weekly updates disappeared as the three parties did not feel that they had made enough progress to make meaningful updates, and the 14 days meeting schedule were found to be a suitable time frame for updating each other. During the final development phase, it could have been useful to utilize the weekly meetings, as the larger steps in development led to misunderstandings in what progress was made.

Looking at the total project period meetings every fortnight worked quite well giving people a chance to inform themselves on the progress of the goals and tasks stated at kick-off. Having the meeting as a video call resulted in fewer misunderstandings compared to only communicating with sound as interpretations and gestures were helping breach the gap of the language barrier that exists between the students. The video also helped with making the project group feel more socially connected, than an audio or text format would have.

The Danish group decided that everyone should participate in the meetings giving everyone an idea of what is going on and to make sure the right message came across and were understood correctly.

The project was also drastically affected by the COVID-19, as the lockdown limited the Danish students' access to parts needed in order to develop the hardware used in the final system.

The lockdown also inhibited the teams in each country to meet physically. This impacted the overall flow of information and made smaller frustrations into more heavy discussion.

International travel restrictions have also made an impact on the timeframe, as the systems cannot be fully implemented and tested on location until such restrictions are lifted.

4 Discussion

During the project, the authors have experienced different challenges both by working in an international, cross-disciplinary project and a project created based on the goals of the study curriculum. However, these are the challenges that will actually teach them how to work in an intercultural and cross-disciplinary context. The challenges started during the kick-off seminar in Hamburg in the process of finding a solution to the problem satisfying the requirements for accreditation by the universities involved, were solved by each subgroup of the project. This means that the all the students at least managed to break even on investing time and effort in an international project.

The Danish students' collaboration with the production engineering students from Brazil made an even bigger impact, by forcing them to evaluate the way that they as network engineering students communicate a proposed solution and the progress in developing this solution. This process of communicating the chosen technology and its working helped them realize how much of the communication was dependent on the recipients having the same technical understanding as them. This made it clear that the true understanding of the underlying subject was not as clear and originally thought. Upon realising that the language barrier and different backgrounds they were forced to reformulate explanations during meetings. The need to explain how the Danish students were solving challenges to an audience without their own technical language seems to have a beneficial impact on learning outcomes (Cohen, Kulik, & Kulik,1982).

5 Conclusion

The most valuable lesson that the authors have drawn from the experience of doing a project in an international and multidisciplinary setting, is to value the importance of regular communication. Such communications must be culturally aware, and otherwise empathic towards the receiver in order to be successful. The communication must aim to clarify a framework of clear requirements for interfaces, when the project is split into teams sitting each in their part of the world.

The idea to bring people to the same location at the projects beginning there becomes a foundation of possible success, as such a meeting can give the students the tools to communicate effectively. In the authors opinion the project would have been impacted to a severe degree if this had been foregone.

Another important takeaway for the authors, upon making the project, is that embarking on interdisciplinary learning experiences enhances more than just the ability to collaborate, but that this also helps to deepen the extent of the theoretical knowledge for students.

The project also helped underscore again that working in the setting of problem-based learning, especially in collaboration with an outside partner, helps the motivation of students, as commitments to deliver are a natural part of the process.

6 References

Cohen, P. A., Kulik, J. A., & Kulik, C.-L. C. (1982). Educational Outcomes of Tutoring: A Meta-analysis of Findings. *American Educational Research Journal*, *19*(2), 237–248

Hofstede's Cultural Dimensions. (2017, June 17). B2U - Business-to-You.Com. https://www.business-to-you.com/hofstedes-cultural-dimensions/

Pedersen, J. M., Kirkova, M., Kuladinithi, K., & Janssen, N. V. H. (2019). EPIC: Making Multinational Student Projects Happen. *International Symposium on Project Approaches in Engineering Education (PAEE)*, *9*, 219-228.

Experience with the accreditation of technical studies in Poland and Thailand's

Robert Ulewicz[1], Kanchana Sethanan[2]

[1] Czestochowa University of Technology, Poland
[2] Khon Kaen University, Thailand

Email: robert.ulewicz@pcz.pl, ksethanan@gmail.com

Abstract

This article gives an overview of the Poland and Thailand's technical education system with regard to both its quantitative and qualitative scenario and upholds the value of accreditation in quality improvement and quality assurance of educational programmes. The article presents similarities and differences in the treatment of quality through the accreditation and certification procedure for compliance with the requirements of ISO 9001 and the possibility of complementary use of these tools in the process of improving the quality of education in Polish and Thai universities. The following aspects have been considered in the accreditation and certification considerations: comparison of the accreditation procedure, analysis of the mechanism for improving the quality of education in the light of the accreditation and certification procedure, presentation of accreditation standards in the light of process management, the role of stakeholders in improving quality.

Keywords: Accreditation; Quality assurance, Stakeholders.

1 Introduction

Education, like any other activity, is subject to the quality assessment rule for services rendered. The assessment is made by all stakeholders related to this activity (Ulewicz & Blaskova, 2018; Grebski & Grebski, 2019). Although everyone evaluates, the process of assessing the quality of education is not a simple process. First of all, it is difficult to immediately verify the learning outcomes, as these are only possible to be assessed after at least some part of the process has been completed (Lima, Dinis-Carvalho, Flores, & Hattum-Janssen, 2007, Ulewicz, 2014). Even people who are directly subject to the educational process are able to assess it only after some time has passed, often not even immediately after graduation (Koomsap, Ayutthaya, Nitkiewicz, Lima, & Luong, 2019; Padlowska, 2014). A lot of scientific work has been devoted to the definition of quality, and most authors have agreed that a correct and unambiguous definition is impossible. We encounter even greater problems when we want to determine what is the quality of education. It is also believed that the concept of quality cannot be easily adapted to the needs of education (Dabylova, Sroka, & Alibekova, 2020). The uniqueness of the learning process makes it extremely difficult to apply quality assessment procedures known from other areas of human activity, such as production activities (Anttila & Jussila, 2018). Without questioning this statement, however, you can indicate minimum requirements for the quality of the learning process (Wiśniewska-Sałek, Ayutthaya, Mequita & Chattinnawat, 2019; Grebski & Grebski, 2018). This assessment is especially important in the area of a technical education where high mathematical skills are very desired to be able to learn modern data analysis i.a. prediction (Pietraszek, Gadek-Moszczak, & Torunski, 2014; Kot & Ślusarczyk, 2014), fuzzy multiple-comparisons (Pietraszek, Kolomycki, Szczotok, & Dwornicka, 2016), non-parametric modeling (Dwornicka, Radek, Krawczyk, Osocha, & Pobedza, 2017) or development of decision support (Pacana, Pasternak-Malicka, Zawada, & Radon-Cholewa, 2016). It should be remembered that universities create human capital resources necessary to meet the needs of the regional labor market, to take up challenges in the area of R&D or to implement the latest technologies (Jelonek, & Mesjasz-Lech, 2017; Grabara, Hussain & Szajt, 2020)

2 Assessment of education quality

There are many types of university assessment in the literature. The curriculum assessment of the university is well known, which is conducted in relation to fields of study, level and profile of education, and comprehensive assessment, which consists in assessing activities aimed at ensuring the quality of education at the university.

The program and comprehensive evaluation functions in the Polish reality of the higher education system. In the case of program evaluation, the main subject of analysis and evaluation are mainly didactic processes and their learning outcomes related to its specific program (field of study). This assessment also includes selected elements of a comprehensive assessment regarding internal mechanisms for ensuring the quality of education. In the area of higher education was formed four classic models currently used in the evaluation process of the functioning of the university. The presented models can be used both to evaluate the quality of education as well as to the activity of the university. Models are shown in Figure 1. Models of evaluation of the functioning of higher education can be divided into two classes - due to the entity that directly participate in the evaluation (Gates, Augustine, Benjamin, Bikson,, Kaganoff, Levy, Moini, & Zimmer, R 2002, Dura, Moraru, & Isac, 2016). The first type is a group of methods focused on the same university and evaluating various aspects of its operation, while the second focuses attention on students, in an indirect way assessing the work of university as an institution.

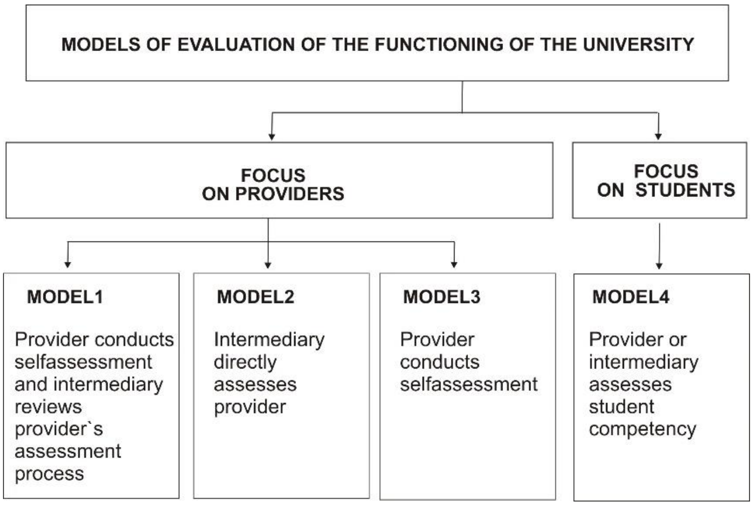


Figure 1. Models of evaluation of the functioning of the university

The first model is called self-esteem controlled by an external body and was established on the basis of business solutions. It consists of internal establishing evaluation criteria by the institution which is the subject of an evaluation, and then verifying the fulfilment of these criteria by an external entity. This choice has a chance to succeed regardless of system conditions, but it is preferably suited for systems aimed at improving, of decentralized, with a high degree of heterogeneity. But this is not a model that guarantees the measurability of the work of higher education. This condition is met, on the other hand, by evaluation carried out by an external institution, which, however, does not work in decentralized structures, low-financed. Moreover, such choice may prove to be little effective tool for improving the functioning of academic units. Methods based on gained assessment in the course of teaching students competences perform well in typical decentralized higher education systems. However, these are usually models of "cost-intensive" - associated with the estimation of added value of the teaching process by comparing the achievements "at the entrance" and "exit" from the system. In the literature (Cheng, & Tam, 1997, Ulewicz, Sethanan, Nitkiewicz, & Wiśniewska-Sałek, 2020) are described four methods of quality assurance in higher education:

- Licensing - involves granting university the rights to its functioning. The Licensing unit checks whether the school meets formal requirements.
- Evaluation of the quality - is based on the judgment/certificate about the level of quality of education. The level of quality of education is assessed based on a comparison of achievements of university with specific requirements/standards. When assessing quality of universities the same criteria are determined, taking into account the diversity of the program and forms of education. The evaluation is made by external unit.

- Accreditation - consists in ensuring that the university meets the standards, which guarantee the quality of education. Purpose of this method is to increase confidence in the university and to reduce external oversight.
- Overview - this method involves the review of internal mechanisms to ensure the quality of education at the university and its improvement. This review consists of checking the correctness and effectiveness of the functioning of these mechanisms by external unit.

In the Polish education quality assessment system, quality assessment is combined with accreditation, the possession of which is necessary for conducting educational activities. The presented methods allow for the delivery of solutions to ensure the quality of education at universities, however, they differ among themselves with the boundaries impact on quality. Table 1 provides an overview of the characteristics of quality assurance systems at universities of technology.

Table 1. Features of quality assurance at the university of technology

Systems	Range	Influence on quality	Stakeholder engagemen t	Objective
Licensing	generally compulsory	little	little	license to operate
Quality assesment	often compulsory	perceptibl e	little	a comparison of quality, funding
Accreditation	compulsory PKA* other voluntary KAUT**	significant	big	threshold quality assurance
Overiew	voluntary	very big	very big	continuous quality improvement

* PKA - Polish Accreditation Commission

** KAUT European Accreditations/Accreditation Commission of Universities of Technology

In Polish conditions of the higher education system, technical universities must be accredited by the Polish Accreditation Commission - this is an obligation arising directly from the Act on Higher Education, Technical universities may voluntarily apply for foreign / industry accreditation, e.g. KAUT. So far, there has not been a situation in Poland that the technical faculty with PKA accreditation did not receive positive KAUT accreditation, nor was the reverse situation noted. KAUT accreditation is included in the environmental accreditation.

In Thailand There are various different kinds of HEIs including (1) designated national research universities receiving special funding and support to be developed into globally competitive universities from the government, (2) open universities which are large public universities having comparatively low admission standards compared to the designated national research universities, (3) the so-called "Rajabhat Universities and Rajamangala Universities of Technology which are also public universities upgraded from teacher training colleges and Institutes of Technology, respectively, and (4) the publicly controlled universities so-called "autonomous universities" (https://wenr.wes.org/2018/02/education-in-thailand-2).

For the assessment of education quality in Thailand, quality assessment is also combined with accreditation. Both public and private universities institutions are required to conduct annual internal quality assurance reviews, which are externally audited by the Higher Education Commission (OHEC) every five years. Generally, the indicators assess input, process, and output/outcome factors. The main components and compulsory indicators for internal assessment are such as: (1) graduate production, (2) research, (3) student development activities, (4) academic servicers to community, or (5) system and mechanism for quality assurance.

Additionally, a new curriculum offered by the Higher Education Institutions (HEIs) is also reviewed the approval processes by the OHEC. The "Office for National Education Standards and Quality Assessment" (ONESQA), an external quality review agency, is charged with assessing the HEIs' quality assurance mechanisms. However, if institutions decline to improve identified quality problems within a specified period of time, they are subject to closure (https://wenr.wes.org/2018/02/education-in-thailand-2).

Table 2. Features of quality assurance of the university Thailand

Systems	Range	Influence on quality	Stakeholder engagement	Objcective
- Licensing	- compulsory	- moderate	- moderate	- license to operate
- Quality assesment	- compulsory	- perceptible	- moderate	- a comparison of quality, funding
- Accreditation	- compulsary	- significant	- significant	- threshold quality assurance
- Overiew	- compulsary	- significant	- significant	- continuous quality improvement

3 ACCREDITATION

Technical universities in Poland are subject to assessment by the Polish Accreditation Commission or environmental agencies such as KAUPT. It is worth looking at what the assessment of the quality of education looks like in Poland. Theoretically, quality management means continuous improvement of the organization. Improvement is a learning process that involves uncertainty and making mistakes. One can put forward the thesis that Polish higher education lacks a holistic approach to quality. This can be demonstrated by the importance attached to details. Unlike ESG, despite continuous positive changes, the PKA quality assessment process is heavily codified and focuses on legality and documentation review. Therefore, PKA still has a purely controlling function, not a perfecting one. After the PKA review procedure was amended, the assessment scale was also changed, currently we only have a positive and negative assessment. Positive assessment is granted for 6 years. In the old four-stage system there was a distinctive, positive, conditional and negative rating. The following scale shall be used to assess the degree of compliance with the specific program evaluation criteria:
1) criterion met,
2) the criterion met partly,
3) criterion not met.
The structure of the program evaluation criterion is shown in Figure 2.

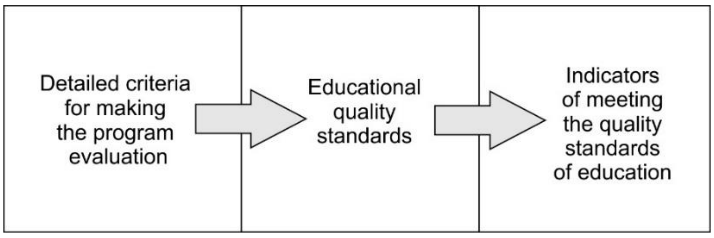


Figure 2. Construction of the program evaluation criterion

Table 3 presents the criteria for the PKA program evaluation in relation to ESG 2015.

Table 3. Criteria for program evaluation PKA (Poland), ESG 2015, and OHEC (Thailand)

Criteria for program evaluation of PKA (Poland)	ESG 2015	OHEC Thailand
1. Design of the study program: concept, learning objectives and learning outcomes	1.1. Policy for quality assurance (reference to quality policy) 1.2. Design and approval of programmes	1. Monitoring Curriculum Standard
2. Implementation of the study program: program content, schedule of the implementation of the study program and forms and organization	1.2. Design and approval of programmes 1.3. Student-centred learning, teaching and assessment	2. Graduates

of classes, teaching methods, apprenticeships, organization of the teaching and learning process		
3. Admission to studies, verification of student achievement of learning outcomes, passing individual semesters and years, and diploma	1.4. Student admission, progression, recognition and certification 1.3. Student-centred learning, teaching and assessment	3. Current Students
4. Competences, experience, qualifications and the number of staff conducting education as well as the development and improvement of staff	1.5. Teaching staff	4. Instructors
5. Infrastructure and educational resources used in the implementation of the study program and their improvement	1.6. Learning resources and student support	5. Curriculum, Teaching and Learning, Learners Evaluation
6. Cooperation with the socio-economic environment in the design, implementation and improvement of the study program and its impact on the development of the field of study		6. Educational Resources Service
7. Conditions and methods of raising the degree of internationalization of the education process in the field of study		
8. Supporting students in learning, social, scientific or professional development and entering the labor market as well as development and improvement of forms of support	1.6. Learning resources and student support	
9. Public access to information on the study program, its implementation conditions and results achieved	1.8. Public Information	
10. Quality policy, design, approval, monitoring, review and improvement of the study program	1.1. Policy for quality assurance 1.2. Design and approval of programmes 1.7. Information management 1.9. On-going monitoring and periodic review of programmes 1.10. Cyclical external quality assurance	

The purpose of KAUT accreditation is:

- assessing the quality of education in the fields of study, in order to determine whether the criteria adopted as the basis for assessment are sufficiently fulfilled to grant accreditation,
- improving the quality of education by making a multi-faceted assessment of study programs and the conditions for their implementation,
- providing reliable information on the quality of education in an accredited course to various stakeholders,
- creating and disseminating high standards of education quality.

The assumptions of KAUT accreditation in relation to PKA accreditation are similar. KAUT places much more emphasis on the impact and participation of external stakeholders as well as on the confirmation and validation of engineering competences and skills. KAUT accreditation is granted for 2 years if the criteria are not fully met or for 5 years. At present, an average of three hundred thousand students study in Poland in over 352 technical faculties reserved at 18 technical universities. Only 70 fields of study have current KAUT accreditation, which accounts for less than 20% of technical fields.

The weakness of these accreditation systems is the lack of qualitative assessment mechanisms for the design of study programs correlated with the graduate's vision on the labor market. Under this area subject assessment should be the key competence of the graduate program. The assessment of intended learning outcomes should include the characteristics of knowledge, skills and competences verified in the form of checked learning outcomes. The evaluation of the program, its content and theirs is also significant matching the learning outcomes assigned to them and maintaining the right balance between the various categories of effects. The weakness of the system is the inability to redefine learning outcomes during the learning cycle - despite the fact that the labor market has redefined its needs. The problem of flexibility in adjusting program content as well as learning outcomes is not easy due to the accreditation and legislative aspects. In areas where we do not have clearly defined criteria, there is a problem with the so-called subjective expert judgment.

For the process to obtain a curriculum approval, in Thailand, there are 3 steps which are (1) Faculty review, (2) university review, and (3) the Higher Education Commission (OHEC) and Office of the Civil Service Commission review (see Figure 3). From Figure 3, in the first stage of review, curriculum development committee deliver the curriculum (both new and existing curriculum) to the faculty committee to review. If the curriculum is met all criteria, then it is screened by the university committee before submitted to the educational council for review. Again, if the curriculum is met all standards, it is approved by the university council. The final stage is the Higher Education Commission (OHEC) and the Office of the Civil Service Commission review. Recognition and recommendation from the OHEC may be required. However, if the curriculum is met all requirements, it is approved by the OHEC and received the letter of degree verification by the Office of the Civil Service Commission.

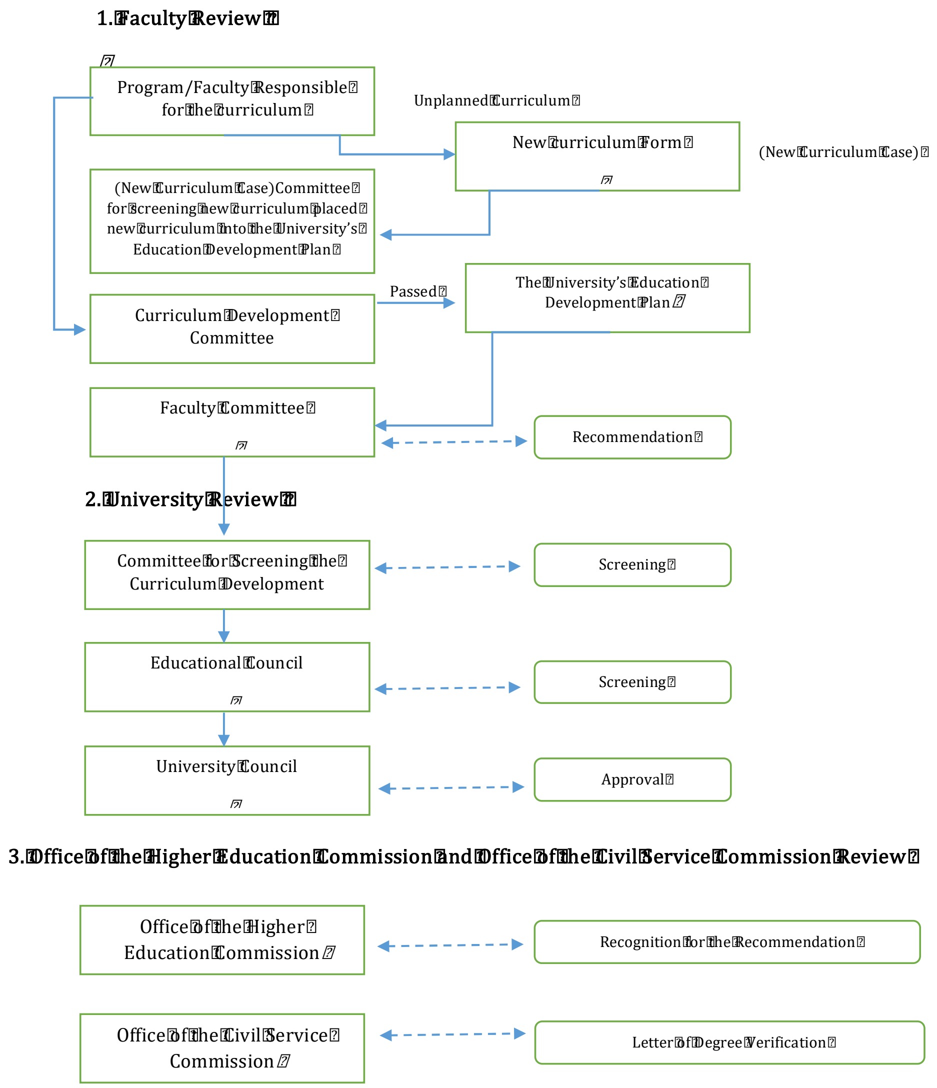


Figure 3. Curriculum approval procedure of Thailand

4 Conclusion

Measuring the quality of university work is currently one of the key elements in building a positive image and the basis of the accreditation process. The globalization process leading to universal access to educational services, as well as the increase in the number of universities, generates doubts about the quality of educational services they offer. The implementation of monitoring systems and education quality management systems being the basis for consistent action to improve the quality of becomes a certain solution in this regard. In Polish conditions, accreditation is confirmation of meeting the assumed criteria. The weakness of this system is the lack of information on how to improve the quality of education and the degree of additivity of the university to rapid changes related to the requirements of external stakeholders. The Polish Accreditation Commission sees the necessity of changes and introduces comprehensive accreditation, which aim will be to assess the effectiveness of internal education quality assurance systems, with particular emphasis on the role of internal and external stakeholders in the process of quality improvement. Similar activities occur in the case of accreditation in Thailand. However, unlike Poland, the institution controlling the functioning of the education quality assurance system is the Office National Education Standards and Quality Assessment (ONESQA), which is responsible for assessing the university's quality assurance mechanisms. In Poland, the program and comprehensive assessment, which includes the assessment of quality assurance mechanisms, is carried out by the same institution, the Polish Accreditation Commission.

5 References

Anttila, J., Jussila, K. (2018). Organizational learning in developing the integrated quality management, *Production Engineering Archives, 18*, 3-13, doi: 10.30657/pea.2018.18.01

Dabylova, M., Sroka, M., & Alibekova, G. (2020). New challenges in education processes at technical faculties in Asian countries of the former Soviet Union. *Production Engineering Archives, 26(1)*, 15-18, doi:10.30657/pea.2020.26.04

Dwornicka, R., Radek, N., Krawczyk, M., Osocha, P., & Pobedza, J. (2017). The laser textured surfaces of the silicon carbide analyzed with the bootstrapped tribology model, *26th International Conference on Metallurgy and Materials METAL 2017*, 1252-1257.

Dura, C., Moraru, R.I., Isac, C. (2016). Reshaping education within the university of petroșani under the influences of the labor market. *Polish Journal of Management Studies*, *14(1)*, 63-73. doi: 10.17512/pjms.2016.14.1.06

Cheng, Y.C., Tam, W.M., Multi-models of quality In education, *Quality Assurance In Education*, 5(1), 22–31

Gates, S., Augustine, C., Benjamin, R., Bikson, T., Kaganoff, T., Levy, D., Moini, J., Zimmer, R.. (2002). Ensuring Quality and Productivity in Higher Education. *An Analysis of Assessment Practices, „ASHE-ERIC Higher Education Report"*, 29 (1).

Grabara, J., Hussain, H.I., Szajt, M. (2020). Sustainable university development through sustainable human resources and corporate entrepreneurship: The role of sustainable innovation and work environment. *Amfiteatru Economic*, 22 (54), 480-495.

Grebski, M., & Grebski, W. (2019). Project-Based Approach To Engineering Technology Education. *Production Engineering Archives, 25*, 56-59, doi: 10.30657/pea.2019.25.11

Grebski, W., & Grebski, M. (2018). Keeping Higher Education Aligned With The Requirements And Expectations of the Knowledge-Based Economy, *Production Engineering Archives 21*, 3-7. doi: 10.30657/pea.2019.25.11

Jelonek, D., & Mesjasz-Lech, A. (2017). The role of universities in the region development. Case study of the Faculty of Management of Czestochowa University of Technology. Perspective of 20 years of experience, *Przegląd Organizacji*, 8 (931), 61-67.

Koomsap, P., Ayutthaya, D.H. Na, Nitkiewicz, T., Lima, R.M. Luong, H.T. (2019) Course design and development: Focus on student learning experience, *International Symposium on Project Approaches in Engineering Education*, 9, 144-153.

Kot, S., Ślusarczyk, B. (2014). Problems in the development of higher education in Poland. *World Transactions on Engineering and Technology Education*, 12(4), 675-680

Lima, R. M., Dinis-Carvalho, J., Flores, M. A., & Hattum-Janssen, N. V. (2007). A case study on project led education in engineering: students' and teachers' perceptions. *European Journal of Engineering Education, 32(3*), 337 – 347

Pacana, A., Pasternak-Malicka, M., Zawada. M., & Radon-Cholewa, A. (2016). Decision support in the production of packaging films by cost-quality analysis, *Przemysl Chemiczny*, 95, 1042-1044.

Padlowska, A. (2014). The strategy of the development of the higher education in Poland on the Warsaw University of Technology example. *Polish Journal of Management Studies*, *9*, 205-216.

Pietraszek, J., Gadek-Moszczak, A., & Torunski, T. (2014). Modeling of Errors Counting System for PCB Soldered in the Wave Soldering Technology, *Advanced Materials Research*, 874, 139-143.

Pietraszek, J., Kolomycki, M., Szczotok, A., & Dwornicka, R. (2016). The Fuzzy Approach to Assessment of ANOVA Results, *Lecture Notes in Artificial Intelligence*, 9875, 260-268.

Ulewicz, R., Blaskova, M. (2018) 'Sustainable development and knowledge management from the stakeholders' point of view, *Polish Journal of Management Studies*, 18(2), 363–374. doi: 10.17512/pjms.2018.18.2.29.

Ulewicz, R., Sethanan, K., Nitkiewicz, T., & Wiśniewska-Sałek, A. (2020). Quality of educational services. *Quality – Yesterday, Today, Tomorrow*, *21(1)*, 293–305. doi:10.30657/hdmk.2020.18

Ulewicz, R. (2014). Application of servqual method for evaluation of quality of educational services at the university of higher education, *Polish Journal of Management Studies*, 9, 254–264.

Wiśniewska-Sałek, A., Hussadintorn Na Ayutthaya, D., Mequita, D., & Chattinnawat, W. (2019). Industry 4.0 - "Employee 4.0" in the Light of Teaching and Learning, *Quality Production Improvement-QPI, 1(1)*, 9-18. doi: https://doi.org/10.2478/cqpi-2019-0002

Standards of developing study program. An example of Polish legislation in higher education.

Anna Wiśniewska-Sałek[1], Dorota Jelonek[2], Elżbieta Wysłocka[1], Edyta Kulej-Dudek[3], Marcin Zawada[4]

[1-4] Czestochowa University of Technology, Faculty of Management, Poland

Email: anna.wisniewska-salek@wz.pcz.pl, dorota.jelonek@wz.pcz.pl, elzbieta.wyslocka@wz.pcz.pl, edyta.kulej-dudek@wz.pcz.pl, marcin.zawada@wz.pcz.pl

Abstract

Turbulent business environment requires employees to have skills adjusted to changing economic conditions. A potential employee should plan his or her education so that acquired knowledge allows them to be agile. Additionally, the fourth industrial revolution and more specifically assumptions thereof underline employment of persons with both, high competences strictly dictated by the job position, so-called hard skills, and soft skills, that is, social and interpersonal skills. Such a situation forces educational institutions to develop curricula so that acquired competences correspond with the market needs. The article presents the proposition of developing curricula for higher education. The process of developing the conception of curriculum constituting the element of developing faculties has been presented herein. The practical dimension of the article is based on the solutions binding in the European legislation and experiences resulting from participation in projects.

Keywords: Curriculum; education; Industry 4.0; Project Approaches.

1 Introduction

Developing the curriculum results from the need of implementation thereof and the demand therefor. Such an impulse may be given by both, a business entity, as well as a teaching employee or even an interested student. Irrespectively of a person indicating the need to develop the curriculum, it is important for all stakeholders (both, internal and external to the same extent) to support legitimacy of development thereof. The literature describing the rules of developing curricula mainly comprises national legal acts (acts and ordinances – in Poland it is the Ministry/Minister of Science and Higher Education (MNiSW; Act 2.0), European norms/practices (European Commission, 2007; European Higher Education Area and Bologna Process (EHEA) and requirements of institutions verifying and certifying the education process at a university (Polish Accreditation Committee (PKA), National Education Systems (EACEA); European Quality Assurance Register for Higher Education (EQAR); "University of Leaders" (UL); "Studies with Future" or "Education Quality Leader" (SzP). Additional and very valuable sources of information comprise many published solutions in the scope of developing curricula implemented by universities or scientific articles describing so-called "educational trends".

The education system must fulfil high standards so that the shared knowledge and acquired skills described by Lima et al., (2017) and Ayen & Nitkiewicz (2018), correlate with industrial needs. Therefore, continuous control of the education system, that is, the education quality, is important. One can read about such solutions in publications by Ulewicz (2017), Ulewicz et al. (2020) and Nitkiewicz et al. (2019), Klimecka-Tatar et al. (2014) and Ulewicz & Sethanan (2019). Continuous improvement of curricula due to the use of e.g. distance education techniques described by Jelonek et al. (2014), Wysłocka (2015) and Dudek & Kulej-Dudek (2016), is very important in the era of remote work and distance learning. The use of such opportunities allows implementation of the assumption of balanced development in order to ensure economic viability, systematic education and environmental balance (Zawada et al., 2016; Pisut et al., 2019), as well as the future of education (Jelonek et al., 2015). Furthermore, it is important to adjust education to the requirements of the fourth industrial revolution Industry 4.0, described by Wiśniewska-Sałek (2014), so that the qualifications of graduates correspond with the labour market needs and constitute a response thereto. Thus, it may be stated that, as presented by Wiśniewska-Sałek with co-authors (2019), an employee becomes Employee 4.0.

2 Legal aspects of developing curricula in Poland

The basic requirement that should be met in order to start the procedure of developing curriculum, in compliance with the Act on Higher Education (Dz.U., 2018a), is education in the scientific fields and disciplines adopted by the Organisation for Economic Cooperation and Development (OECD). The University assigns the faculty to at least 1 discipline and establishing studies at a given faculty, level and profile requires a permit issued by the Minister of Science and Higher Education. Whereas, agreeing on the curriculum requires consultations with the student government. Studies of a specific faculty may be conducted in a form of full-time and/or part-time studies (conditions that should be met respectively are as follows: at least half of ECTS points/less than a half of ECTS points covered with the curriculum should be obtained within studies with a direct participation of academic teachers).

The level of the studies distinguishes: (i) first cycle degree studies, (ii) second cycle degree studies and (iii) long-cycle Master's degree programme. The duration of particular levels is the following: (i) at least 6 semesters (and in the case of obtaining engineering competences at least 7 semesters), (ii) from 3 to 5 semesters and (iii) from 9 to 12 semesters. There is a possibility of prolonging this period of time in the case of part-time studies.

The profile of students is a practical profile that, according to the name, develops students' practical skills and general academic profile, where classes are related to the academic activity conducted at the university. Furthermore, the practical profile assumes the students' necessity to complete internship for a period of 6 months by first cycle degree students and long-cycle Master's degree students and a period of 3 months by second cycle degree students. Additionally, the Polish legislation provides for the possibility of education at postgraduate studies (at least 3 semesters – obtaining full qualifications at 6th, 7th or 8th level of the Polish Qualifications Framework "PQF" (Dz.U., 2016) and providing specialist education (at least 3 semesters – obtaining full qualifications at 5th level of the PQF: classes developing practical skills).

The curriculum specifies: learning effects, description of the process leading to obtaining learning effects and the number of ECTS points attributed to specific classes (ECTS point = 25-30 hours of student's work). Also classes conducted with the use of distance education methods and techniques. In the case of curricula preparing to studies in the professions: a doctor, a dentist, a pharmacist, a nurse, a midwife, a laboratory diagnostician, a physiotherapist, a paramedical practitioner, a veterinarian, an architect or a teacher, it is required to adjust them to educational standards.

One of the conditions of graduating studies comprises obtaining the learning effects specified in the curriculum for: first cycle degree studies – 180 ECTS points, second cycle degree studies – 90 ECTS points and for long-cycle Master's degree programme – 300 ECTS points (9-10 semesters) and 360 ECTS points (11-12 semesters). Another condition constitutes passing the diploma exam and positive assessment of the diploma thesis. A graduate is a student, who obtained the diploma of graduating studies at a particular faculty and profile. The diploma confirms obtaining higher education and professional title of: Bachelor, Engineer (first cycle degree studies); Master, Master Engineer (second cycle degree studies and long-cycle Master's degree programme). In the case of specialist education it is a certificate of a certified specialist or a certificate of a certified specialist technologist.

3 Quality of education – evaluation compliant with the Polish law

In the Polish legislation a body providing evaluation in the form of curriculum assessment or complex assessment is the Polish Accreditation Committee (PKA). The complex assessment (which will be binding as of October 2020) is conducted upon the request of the university, which has only positive curriculum assessment. The idea of complexity refers to the assessment of the effectiveness of measures undertaken to the benefit of ensuring the quality of education with regard to all fields in which the education is provided. Whereas, the curriculum programme concerns cyclical assessment of the quality of education at the faculty and concerns verification of: curricula; teaching and academic employees; infrastructure used in the educational process; cooperation with the socio-economic environment. Additionally, the degree of internationalisation and support provided for students in the learning process are also taken into consideration. This type of assessment is initiated by PKA upon the request of the university or the Minister. Evaluation of the quality is completed with issuing a positive or negative assessment for a period of 6 years. A positive assessment or a refusal to issue a positive assessment is given in the complex assessment for a period of 3-8 years. Quality is evaluated on the grounds of the assessment, accreditation or certificate of the entity assessing the quality of education conducted by the Polish Accreditation Committee (PKA) or entered into the European Quality Assurance Register for Higher Education (EQAR).

3.1 New faculty (field of study)

At the Czestochowa University of Technology, pursuant to the Polish legislation, among others, the statute and the rules and regulations of studies at the University are binding in the process of developing a faculty (and thus, developing curricula). These documents hierarchize particular organisational units in order to give opinion on the relevance of developing a given faculty. The final decision on development, transformation or liquidation belongs to the rector upon his or her initiative or upon the request of the dean of the relevant department. The unit specifying the guidelines which should be fulfilled in the scope of developing and introducing changes to curricula is the University's Senate. Formally, this application has to be given an opinion by the Curriculum Board, Teaching Manager, Senate Committee and Student Government beforehand. Such a system is aimed at obtaining opinions of numerous environments in order to maximise the chance for successful implementation thereof. In the formal process of drawing up an application for developing a new faculty one should follow the binding application published by the Polish Accreditation Committee (the document is compliant with the guidelines included in the Ordinance of the Minister of Science and Higher Education (Dz.U., 2018b).

Apart from general characteristics, a formal application for establishing a faculty should also include: (i) conception of education (that is, relation between studies and the university's strategy, socio-economic needs and compliance thereof with the learning effects, as well as assigning the faculty to the scientific discipline); (ii) justification of establishing the studies; (iii) description of measures to the benefit of improving the curriculum and ensuring the quality of education; (iiii) description of conducted scientific activity in the discipline; (iiiii) description of competences expected from the candidate for studies; (iiiiii) description of the terms and conditions of studies with the manner of organising and implementing the process leading to obtaining learning effects (the list of academic teachers proposed for conducting classes should be included); (iiiiiii) information regarding the infrastructure (that is, description of laboratories, workshops, devices and equipment, necessary for education); (iiiiiiii) information regarding providing the possibility of using library resources and electronic knowledge resources (Virtual Science Library, Digital Rental of Academica Scientific Publications). Additionally, the following appendixes should be attached: (i) legal acts and rector's statements regarding establishing studies at a specific faculty, level and profile; (ii) planned schedule of implementing the curriculum (as divided into semesters and years of the education cycle; (iii) opinion of the student government on the curriculum; (iiii) academic teachers' declaration (employment term at the university and number of working hours); (iiiii) documentation confirming being at a disposal of relevant infrastructure; (iiiiii) description of library resources and (iiiiiii) document confirming concluding an agreement with employers with regard to the acceptance of a specific number of students for internship. (PKA)

3.2 Curriculum

While starting work on the curriculum, the duration of a semester (15 weeks) should be taken into consideration in order to evenly plan the student's workload. Having assumed establishing studies in the field of social sciences and management and quality science discipline with general-academic profile at the level of full-time second cycle degree studies, while awarding the professional title of Master, in total 90 ECTS points should be assumed. Therefore, the curriculum should provide for obtaining by the student 30 ECTS points in each semester (90 ECTS/4 semesters).

While formulating the curriculum, developing a syllabus for the subject or a group of subjects should also be taken into account, irrespectively of the form of conducting such classes to which the learning effects and curriculum content ensuring obtaining such effects are assigned. A total number of hours of these classes as well as manners of verification and assessment of learning effects which will be obtained by the student during the whole learning cycle should be specified. Moreover, the total number of ECTS points should be given: (i) which the student has to obtain within the framework of classes conducted with the direct participation of an academic teacher; (ii) which the student has to obtain within the framework of classes in the field of humanities or social sciences (at least 5 ECTS points); (iii) which the student has to obtain within the framework of this internship (together with specification of the scope, principles and form of completing internship). Furthermore, the curriculum should include: physical education classes (60 hours: 0 ECTS – for first cycle degree studies and long-cycle Master's degree studies conducted in the form of full-time studies), the possibility to select classes which have been assigned with ECTS in the scope not lower than 30% of the number of ECTS points. Construction of classes within the curriculum should be compliant with the profile of studies: practical – developing practical skills; general-academic – preparing to conducting scientific activity (participation therein).

While establishing the curriculum one should assume a certain pattern of assigning ECTS points to subjects. While knowing that each semester is assigned with 30 ECTS (even workload of the student) and 1 or 2 hours of a given subject per week, the manner presented in table no. 1 can be assumed.

Table 1. Example extract from the curriculum (first semester), second cycle degree studies.

Number of ECTS points	Type of subject	exam/test	Student's workload	Type of classes
5	economic sciences	exam/test	125 h / 5 ECTS	2h - lecture 2h - exercises
5	engineer-technical sciences	exam/test	125 h / 5 ECTS	2h - lecture 3h - laboratory
5	quality sciences	exam/test	125 h / 5 ECTS	1h - lecture 2h - project 2h - laboratory
4	management sciences	test	100 h / 4 ECTS	1h - lecture 2h - project
4	IT sciences	test	100 h / 4 ECTS	1h - lecture 2h - laboratory
3	mathematics sciences	test	75 h / 3 ECTS	1h - lecture 1h - exercises
2	social sciences	test	50 h / 2 ECTS	2h - project
2	foreign language	test	50 h / 2 ECTS	2h - discussion session
30 ECTS			**750 h / 30 ECTS**	**26 h (per week)**

The number of hours of direct contact with the lecturer amounts to 50% of the time which student has to devote to learning curriculum content. Such a result of the indicator provides the possibility of working with the student (the possibility of explaining doubts) and the time to independently study thoroughly and acquire skills. Furthermore, the type of conducted classes is also important. The more project work (using one of the teaching methods Project Based Learning, described in the literature i.a. by Mesquita et al. (2018)) or laboratories are provided for in the curriculum, the more learning effects can be assumed by implementation thereof, through practical skills. New curricula should be focused on acquiring knowledge through its practical aspect.

Another important element is to establish the curriculum in the direction preparing the student to start employment at a specific business activity. The Polish legislation assumes that a student should be provided with a possibility to select subjects in the number corresponding with 30% of the total number of ECTS points. The university's practice shows that two of the above factors can be ensured by introducing to the curriculum so-called education in the scope of e.g. economic faculty or otherwise educating in the scope of a specific specialty/specialisation. Then, it can be assumed that the first semester is a certain base of general faculty-related knowledge for second cycle degree studies. Whereas, the second semester assumes several general subjects and several subjects to choose from. Chosen subjects should be compliant with the offered education in the scope from the third semester. Main task thereof should constitute introducing a student to matters related to the specific specialty. So that he or she can consciously select (from the second year of studies in the case of second cycle degree studies and after the second year in the case of first cycle degree studies) what they wish to specialise in, when they become a potential employee. Foreign language constitutes value added to each curriculum. In the first two semesters it is recommended to teach a foreign language so that e.g. the learnt vocabulary prepares to the profession of an engineer, an IT specialist or management staff. A detailed proposition of such a curriculum has been presented in table no. 2.

Table 2. Example extract from the curriculum (second semester), second cycle degree studies.

Number of ECTS points	Type of subject	exam/test	Student's workload	Type of classes
5	economic sciences	exam/test	125 h / 5 ECTS	2h - lecture 2h - exercises
5	engineer-technical sciences	exam/test	125 h / 5 ECTS	2h - lecture 3h - laboratory
5	management and quality sciences	exam/test	125 h / 5 ECTS	2h - lecture 2h - project
3	management sciences	test	75 h / 3 ECTS	2h - project 1h - exercises
2	subject in the scope of education (specialty A)	test	50 h / 2 ECTS	1h - lecture 1h - laboratory
2	subject in the scope of education (specialty B)	test	50 h / 2 ECTS	1h - lecture 1h - project
2	subject in the scope of education (specialty C)	test	50 h / 2 ECTS	1h - lecture 1h - exercises
2	mathematics sciences	test	50 h / 2 ECTS	2h - project
2	social sciences	test	50 h / 2 ECTS	2h - exercises
2	foreign language	test	50 h / 2 ECTS	2h - discussion session
30 ECTS			**750 h / 30 ECTS**	**28 h (per week)**

Another two semesters should include in their offer specialisation subjects in a foreign language. It provides the student with the future possibility of working in international teams. An important aspect, especially of the last year of studies, is the diploma thesis. Separation of the function of a supervisor (substantive supervision) and person conducting the seminar (formal supervision) should be underlined, since in the process of writing this type of thesis, a direct contact with the lecturer is especially important. The curriculum should also assume which subjects will allow introducing a student to the "world of science" such as e.g. scientific research methodology. Moreover, it is worth taking into account interdisciplinary subjects, which will broaden the student's horizons allowing him or her to look at certain patterns in a non-standard manner. Conducted subjects in the scope of mathematical sciences should take into consideration such learning effects so that a student can freely conduct analyses and be able to draw conclusions. Furthermore, subjects providing a student with a possibility of conducting their own research or engaging a student in scientific research conducted at the University's unit are also important. An example of such a curriculum has been provided for in table no. 3.

Table 3. Exemplary extract from the curriculum (third and fourth semester), second cycle degree studies for education in the scope of (specialty A).

Number of ECTS points	Type of subject	exam/test	Student's workload	Type of classes
		third semester		
5	subject in the scope of education (specialty A)	exam/test	125 h / 5 ECTS	2h - lecture 2h - laboratory
5	subject in the scope of education (specialty A)	exam/test	125 h / 5 ECTS	2h - lecture 2h - project
4	subject in the scope of education (specialty A) in a foreign language	test	100 h / 4 ECTS	1h - lecture 1h - exercises 1h - project
		test	100 h / 4 ECTS	1h - lecture

4	subject in the scope of education (specialty A) in a foreign language			1h - exercises 1h - laboratory
3	subject in the scope of education (specialty A)	test	75 h / 3 ECTS	1h - project 1h - laboratory
3	scientific research methodology	test	75 h / 3 ECTS	1h - lecture 1h - project
2	diploma seminar I	test	50 h / 2 ECTS	2h - seminar
2	preparation to writing a diploma thesis I	test	50 h / 2 ECTS	2h - project
2	interdisciplinary subject	test	50 h / 2 ECTS	1h - lecture
30 ECTS			**750 h / 30 ECTS**	**23 h (per week)**
		fourth semester		
5	subject in the scope of education (specialty A)	exam/test	125 h / 5 ECTS	2h - lecture 2h - laboratory
5	subject in the scope of education (specialty A)	exam/test	125 h / 5 ECTS	2h - lecture 2h - project
4	subject in the scope of education (specialty A) in a foreign language	test	100 h / 4 ECTS	1h - lecture 1h - exercises 1h - project
4	subject in the scope of education (specialty A) in a foreign language	test	100 h / 4 ECTS	1h - lecture 1h - exercises
3	scientific research methodology	test	75 h / 3 ECTS	2h - project
2	diploma seminar II	test	50 h / 2 ECTS	2h - seminar
5	preparation to writing a diploma thesis II	test	125 h / 5 ECTS	2h - project
2	interdisciplinary subject	test	50 h / 2 ECTS	1h - lecture
30 ECTS			**750 h / 30 ECTS**	**20 h (per week)**

It should be remembered while developing curricula for various specialties from the formal point of view to establish their mirror reflection. Such behaviour guarantees that each student obtains assumed learning effects to the same degree, irrespectively of the specialty binding at one faculty.

4 Conclusion

Developing a new faculty with the consideration of all formal procedures should be primarily justified with the labour market. The continuously developing industry in the era of adjusting and/or implementing assumptions of the fourth industrial revolution needs "Employee 4.0". Staff with specific specialist competences and high soft skills constitute a real challenge for the whole education system at each level of teaching.

Development of the faculty should constitute a response to the contemporary trends in the labour market and dynamic changes in the economy, society and technology. Furthermore, a faculty should be an answer to the changing employment systems (e.g. self-employment) and development of modern management techniques in organisations, both, small- and medium-sized companies, and large corporations. Therefore, participation of all economy participants in developing curriculum is so important.

A good example of such a co-participation is the project "Curriculum Development of Master's Degree Program in Industrial Engineering for Thailand Sustainable Smart Industry – MSIE4.0" (https://msie4.ait.ac.th/). One curriculum is developed by project contractors from 9 universities. During development of the curriculum, good practices in higher education from Thailand, Portugal, Romania and Poland were used. Then, a research was conducted among entrepreneurs (Chattinnawat, 2018a) and students (Chattinnawat, 2018b) in particular countries/universities. This activity was aimed at learning about preferences of internal and external stakeholders regarding educational needs adjusted to work in the environment Industry 4.0. The analysis of the research led to finally specifying 16 courses (https://msie4.ait.ac.th/msie-4-0-pilot-testing-courses/) implemented within the framework of engineering second cycle degree studies. A team of a few persons from various countries worked on each course. It allowed adjusting contents to expected learning effects which were the most important in the process of developing the curriculum. Such a value system was conditioned with the universality of teaching. Irrespectively of the market in which a student will potentially work, he or she will have skills and competences to work in the environment Industry 4.0. Prepared courses were also subject to testing as a tool allowing improving their weaknesses and reinforcing strengths. The whole process is subject to continuous verification by persons experienced in the scope of the quality control. Such activities allow ongoing corrective actions and ensure continuity of works. Additional advantage of developing such curricula constitutes the global view on the needs of all participants of the world labour and education market. Then, mental boundaries do not exist and each individual person perceiving the contemporary world differently sees the same objective - good future.

At the Department of Management of the Czestochowa University of Technology, all faculties must obtain approval of local business representatives in order to be proceeded. Cyclicity of meetings of the Department authorities with the so-called Advisory Board of Business Representatives allows listening to the voice of employers and their needs on an ongoing basis. Such measures enable updating already existing curricula so that they evolve in correlation with business trends. Also new faculties are proposed by local entrepreneurs. The voice of employees and students is equally important. Both groups participate in works of various committees operating at the Department, which allows stakeholders to co-develop the environment of work and education so that it fulfils their expectations. Continuous improvement of employees in the scope of new teaching methods and techniques, as well as measures undertaken by the Quality Committee (within the framework of the internal education quality assurance system) with co-participation of internal and external stakeholders allow ongoing development of faculties (including curricula) of studies offered at the Department of Management. Whereas, educational objectives, taken into account while developing curricula, constitute the essence of obtaining assumed qualifications and skills by the University graduate.

Acknowledgements

This publication is a partial outcome of project „Curriculum Development of Master's Degree Program in Industrial Engineering for Thailand Sustainable Smart Industry (MSIE4.0)" that has been funded with support from the European Commission (Project Number: 586137-EPP-1-2017-1-TH-EPPKA2-CBHE-JP).

Co-funded by the Erasmus+ Programme of the European Union

5 References

Ayen, Z., & Nitkiewicz, T. (2018). Identifying Key Criteria in Development of Industrial Engineering Education. *MATEC Web of Conferences, 183*. doi: 10.1051/matecconf/201818304008.

Chattinnawat, W. (2018a). Work Package 1: Task 1.3 Industrial Questionnaire Analysis (Thai+Eu Company). Curriculum Development of Master's Degree Program in Industrial Engineering for Thailand Sustainable Smart Industry. Available at: https://msie4.ait.ac.th/category/gallery/reports/. Access in: May 30, 2020.

Chattinnawat, W. (2018b). Work Package 1: TASK 1.3 Student Questionnaire Analysis (Thai+Eu Student). Curriculum Development of Master's Degree Program in Industrial Engineering for Thailand Sustainable Smart Industry. Available at: https://msie4.ait.ac.th/category/gallery/reports/. Access in: May 30, 2020.

Dudek, D., & Kulej-Dudek, E. (2016). E-learning in the Faculty of Management of Czestochowa University of Technology: Results and Challenges. *Journal of International Scientific Publications - Educational Alternatives, 14*. 622-632.

Dz.U. (2016). Journal of Laws of 2016, item 64. Official website http://prawo.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20160000064. Access in: May 30, 2020.

Dz.U. (2018a). Journal of Laws of 2018, item 1668. Official website https://prawo.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20180001668. Access in: May 30, 2020.

Dz.U. (2018b). Journal of Laws 2018, item 1861. Official website http://prawo.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20180001861

EACEA. Official website https://eacea.ec.europa.eu/national-policies/eurydice/content/quality-assurance-higher-education-50_pl. Access in: May 30, 2020.

EHEA. Official website http://www.ehea.info/ . Access in: May 30, 2020.

EQAR. Official website https://www.eqar.eu/. Access in: May 30, 2020.

European Commission. (2007). Official website http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1432585582363&uri=URISERV:c11089

Jelonek, D., Illes, C. B., & Dunay, A. (2015). The Entrepreneurship in Poland and in Hungary. Future Entrepreneurs Education Perspective. *Polish Journal of Management Studies, 12*(1), 48-58.

Jelonek, D., Nowicki, A., & Ziora, L. (2014). The Application of E-Learning in the Didactic Process at the Faculty of Management in Czestochowa University of Technology: Organization, Tools, Model. *Proceedings of Informing Science & IT Education Conference (InSITE)*, 143-156.

Klimecka-Tatar, D., Ulewicz, R., & Zygoń, O. (2014). The Quality of Education at the Universities. [In] Borkowski, S., & Rosak-Szyrocka, J. (Eds.). *Evaluation of People and Products Features*, University of Maribor, Faculty of Logistics, 56-68.

Koomsap, P., Luong, H. T., Lima, R. M., Nitkiewicz, T., Chattinnawat, W., & Na Ayutthaya, D. H. (2019). Roles of MSIE Graduates to Support Thailand Sustainable Smart Industry. *Advances in Transdisciplinary Engineering, 10*. 75-84. doi:10.3233/ATDE190110.

Lima, R. M., Dinis-Carvalho, J., Sousa, R. M., Arezes, P., & Mesquita, D. (2017). Development of competences while solving real industrial interdisciplinary problems: a successful cooperation with industry. *Production*, *27*(spe), doi: 10.1590/0103-6513.230016.

MNiSW. Official website https://www.gov.pl/web/nauka/ or http://www.bip.nauka.gov.pl/. Access in: May 30, 2020.

Mesquita, D., Chagas, R.L.C.P., Lima, R.M., Chagas, J.M. (2018). Assessment Models in Two Project Based Learning (PBL) Approaches: an exploratory study. *International Symposium on Project Approaches in Engineering Education, 8*. 612-619.

MSIE4.0" Official website https://msie4.ait.ac.th/ . Access in: May 30, 2020.

Nitkiewicz, T., Na Ayutthaya, D. H., Koomsap, P., Lima, R. M., & Chattinnawat, W. (2019). The Quality of Education on Workplace Safety Master Studies - the Issue of Teaching Methods. *System Safety: Human - Technical Facility - Environment, 1*(1), 661-669. https://doi.org/10.2478/czoto-2019-0084.

OECD. Official website https://konstytucjadlanauki.gov.pl/tlumaczenie-nowej-klasyfikacji-dziedzin-nauki-i-dyscyplin-naukowych-oraz-dyscyplin-artystycznych-na-jezyk-angielski. Access in: May 30, 2020.

PKA. Official website https://www.pka.edu.pl/. Access in: May 30, 2020.

SzP. Official website http://www.studiazprzyszloscia.pl/strona-11. Access in: May 30, 2020.

UL. Official website http://www.uczelnia-liderow.pl/glowna. Access in: May 30, 2020.

Ulewicz, R. (2017). The Role of Stakeholders in Quality Assurance in Higher Education. *Human Resources Management & Ergonomics, 11*(1), 93-107.

Ulewicz, R., & Sethanan, K. (2019). Quality of Educational Services - Industry 4.0 Requirements. [In] Drljaca, M. (Ed.). Quality - Yesterday, Today, Tomorrow. *Croatian Quality Managers Society, 20*(1). 137-149.

Ulewicz, R., Sethanan, K., Nitkiewicz, T., & Wiśniewska-Sałek, A. (2020). Quality of Educational Services. [In] Drljaca, M. (Ed.). Quality - Yesterday, Today, Tomorrow. *Croatian Quality Managers Society, 21*(1). 293-305. doi: 10.30657/hdmk.2020.18.

Ustawa2.0. Official website https://konstytucjadlanauki.gov.pl/. Access in: May 30, 2020.

Wiśniewska-Sałek, A. (2019). Knowledge Management - Education in the Light of Industry 4.0. [In] Ulewicz, R., Nikolic, R. R. (Eds.). *System Safety: Human - Technical Facility – Environment*. 969-977. doi: 10.2478/czoto-2019-0123.

Wiśniewska-Sałek, A., Na Ayutthaya, D. H., Mesquita, D., & Chattinnawat, W. (2019). Industry 4.0 - "Employee 4.0" in the Light of Teaching and Learning. [In] Ulewicz, R., & Hadzima, B. (Eds.). *Quality Production Improvement, QPI 1*(1). 9-18. doi: 10.2478/cqpi-2019-0002.

Wysłocka, E. (2015). E-Learning in the Management of Polish Companies. *Polish Journal of Management Studies, 11*(1), 188-199. GICID: 01.3001.0011.5855.

Zawada, M., Pabian, A., Bylok F., & Kucęba, R. (2016). Sustainable Employees of Future Enterprises - European Perspective. *International Journal of Management and Applied Science, 2*(9). 55-59.

LOVE model-based assessment of teaching practices within industrial engineering master programs in Poland and Thailand

Tomasz Nitkiewicz[1], Duangthida Hussadintorn Na Ayutthaya[2], Małgorzata Koszewska[3], Karolina Wiszumirska[4], Magdalena Wojnarowska[5], Pisut Koomsap[2]

[1] Department of Business Informatics and Ecosystems, Faculty of Management, Czestochowa University of Technology, Poland
[2] Department of Industrial Systems Engineering, School of Engineering and Technology, Asian Institute of Technology, Thailand
[3] Dep. of Production Management and Logistics, Faculty of Management and Production Engineering, Lodz University of Technology
[4] Department of Industrial Products and Packaging Quality, Institute of Quality Science, Poznań University of Economics and Business
[5] Dep. of Product Technology and Ecology, Institute of Quality Science and Product Management, Cracow University of Economics

Email: tomasz.nitkiewicz@wz.pcz.pl; duangthidaHNA@gmail.com; malgorzata.koszewska@p.lodz.pl; karolina.wiszumirska@ue.poznan.pl; wojnarom@uek.krakow.pl; pisut@ait.asia

Abstract

The objective of the paper is to compare teaching approaches and practices that are used on master programs within industrial engineering and related fields. The comparison is made on selected Polish and Thai universities that provided students and graduates for the research survey. Students and graduates from four Polish and six Thai universities have participated in the survey in academic year of 2018/2019. The programs of their studies were master level programs with direct relation to industrial engineering. The teaching methods within the study are structured and classified within the framework of the LOVE model – a learning experience-based model that serves for the assessment and classification of teaching methods. The comparison is based on the students' assessment of their experiences related to the specific teaching methods used within the course of their studies. The comparative analysis criteria come from the classification of teaching methods to one of the following experience-oriented categories: L – learning, O – observing, V – visiting and E – experimenting. The results are interpreted regarding the coverage of specific experience categories within the studying program, relation between the presence and assessment score of specific methods and categories and cross-country analysis of the results. The preliminary results of the study show that there is a significant difference between the viewpoints and perceptions of the students from two compared countries on the teaching methods. Polish students expressed that the top three most efficient methods are guided practical exercises, laboratory classes and discussion. For Thai students, lectures, case studies and discussion were rated as the top three most efficient methods. With the LOVE model classification, it seems that Polish students appreciate learning and experimenting, while for Thai students it's a mixture of observing and learning experiences.

Keywords: active learning, industrial engineering, teaching and learning methods, quality in higher education, LOVE model.

1 Introduction

The concept of the paper is based on two key features: 1) experience-based approach to the assessment of teaching and learning methods (TLMs) and 2) comparison of Polish and Thailand students with respect their preferences on TLMs. The first feature is applied through LOVE model. It is a learning experience-based model that serves for the assessment and classification of teaching methods applied in engineering-oriented education. LOVE model is originally presented by its authors (Hussadintorn Na Ayutthaya and Koomsap 2017a), but it is important to present its background and underpinned concepts and its building blocks. First of all, model is oriented on students experience and in that sense it follows the principles of experience economy 4E model as developed by Pine and Gilmour (1998) and transfers them to the field of engineering education. Secondly, vast catalogue of TLMs classified within four categories of LOVE model make it more a tool for assessment of whole curricula and programs then of single courses. Bearing that in mind, LOVE model should be referred to active learning strategies (Freeman et al. 2014; Christie and Graaff 2017; Lima et al. 2017a), curriculum development pathways (Hodge et al. 2008; Healey and Jenkins 2009; McTighe and Wiggins 2012) or designing teaching and learning approach methodologies (Dunlosky et al. 2013; Mesquita et al. 2015; Lima et al. 2017b) that aim at grabbing whole studying programs and design its learning outcomes. Thirdly, the idea behind LOVE model is to provide guidance for curriculum designers on how to deliver diversified and meaningful experience for students in order to make them not only valuable graduates, but also good researchers (Hussadintorn Na Ayutthaya and Koomsap 2018). Such an approach has a very long history and is commonly recognized in literature (Hodge et al. 2008; Healey and Jenkins 2009; Wallin et al. 2017) and in practice, especially in engineering education, and has many different variants or implementation strategies. Finally, LOVE model contributes to the vast and diversified field of engineering education assessment and classification, with a specific focus on teaching and learning methods. Perhaps, the scope of classification and assessment is quite original, since it is the experience of students in relation to the TLMs applied, but it could be easily adopted to serve for mainstream assessment and classification toolbox. Example of classification criteria to be applied in engineering education are numerous, but just to give an example we could refer to Bloom's revised taxonomy (Krathwohl 2002) that provides framework for classification of program learning outcomes and for designing the development strategy of a curriculum. Both, LOVE model and Bloom's taxonomy are capable of providing specific guidelines for designing the curriculum, but each one of them is focused on its different elements or aspects. The assessment and evaluation of studying programs is even more complex issue with a huge reporting on its application. Obviously, LOVE model based assessment is not available yet. The scope of our paper, if considered from more general perspective, could be faced towards educational approach or TLM assessment. In the literature, there are many results of researches and assessment presented, focusing for example on active or research approach (Freeman et al. 2014; Wallin et al. 2017) or meta-analysis of assessments (Wieman 2014).

The model applies the following experience-oriented categories: L – learning, O – observing, V – visiting and E – experimenting. Detailed classification of teaching and learning methods according to LOVE model is presented in Figure . The model has been developed quite recently (Hussadintorn Na Ayutthaya and Koomsap 2017a) but has been already widely discussed in the literature and applied for assessment and development of studying programs (Hussadintorn Na Ayutthaya and Koomsap 2017b, a, 2018; Koomsap et al. 2019).

The key recommendation from the creators of the LOVE model is to provide diversified learning experiences throughout studying period in order to achieve complex attitude towards gaining new knowledge and competences. In other words, each one of the experience categories should be significantly represented in educational program as a whole, and in each one of its components. On the other hand, none of the experience types is strong enough to provide complex and meaningful transfer of knowledge and competences. Finally, the assumption of LOVE model is to give more attention to immersive and active types of learning experiences in order to make them more efficient while studying outcomes, namely competences and knowledge are concerned.

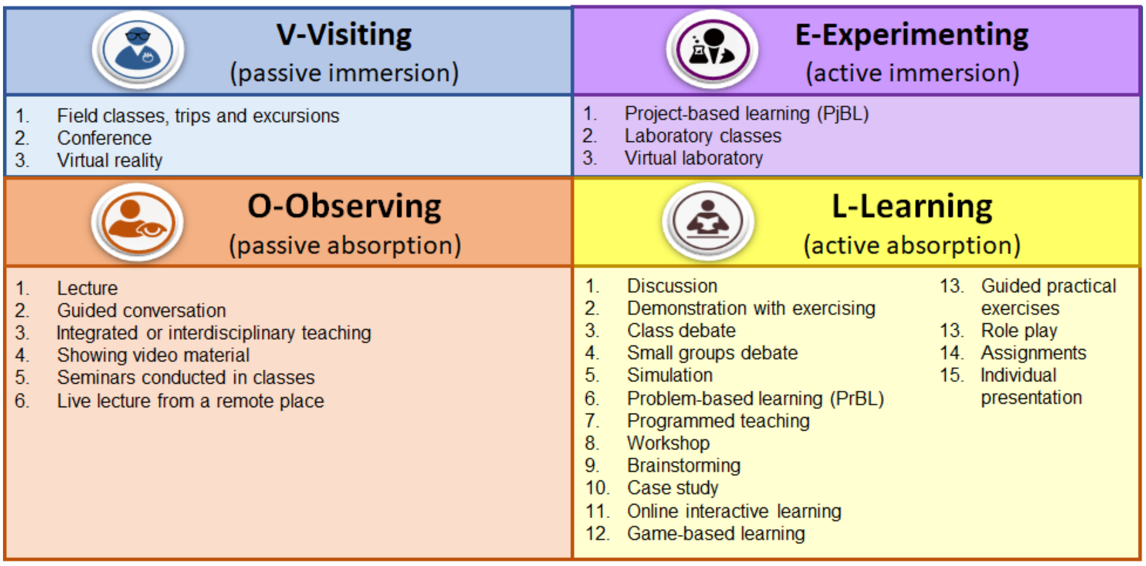


Figure 1. Classification of teaching and learning methods in LOVE model (Hussadintorn Na Ayutthaya et al. 2019)

The scope of the paper is limited to the comparison of Polish and Thai master students and graduates of industrial engineering related programs. The comparison is focused on student's assessment of teaching and learning methods used during their education process. The comparison is based on students and graduates responses and is focused on comparing the coverage for specific TLMs with its assessment with respect to make students learning experience more efficient and meaningful. In order to standardize the types of experiences while studying LOVE model is used. The selection of the two countries for performing comparative studies is made on the practical possibilities of accessing the students and graduates to complete survey. It is also connected to the assumption that these two countries could significantly differ with regard to the student's approach of TLMs. The additional objective of the paper is to verify the usefulness of LOVE model and the results of its application for such a comparative study with students responds as a major data source.

2 Research methodology

The survey was conducted in the form of computer assisted web interview (CAWI) in the period of October – December 2018. The comparative sample consisted of 100 Thai and 89 Polish respondents. Table 1 presents basic characteristics of the surveyed sample of students. Basic differences between Polish and Thai students samples are related to its age structure (more diversified in Thailand while in Poland most of the students are entering university right after their secondary education) and related to it academic status (in Thailand only half of the students were enrolled during the survey, while in Poland it is over 80%), and significantly bigger share of female students in Poland.

Table 1. Basic characteristics of respondents

Characteristics of respondents	PL	THA	Total
Age			
20 - 25	73	25	98
26 - 30	7	37	44
31 - 35	4	20	24
36 - 40	4	10	14
41 - 45	1	5	6
46 and more	0	3	3
Gender			
Female	60	44	104
Male	29	56	85
Academic status			
A Master's student on the 1st year	20	15	35
A Master's student on the 2nd year and more	43	34	77
A graduate with the Master's degree during the past 2 years	12	30	42
A graduate with the Master's degree during the past 5 years	3	16	19
A graduate with the Master's degree during the past 10 years	5	3	8
Other	6	2	8

The students of ten different universities have participated in the survey. The list of universities is presented in Table 2. The leading criterion for selection of students was their enrolment into master program of industrial engineering or related.

Table 2. List of Universities participating in surveying students

Name of the University	Country and city	Number of respondents
Asian Institute of Technology	Thailand, Bangkok	30
Lodz University of Technology	Poland, Lodz	25
Thammasat University	Thailand, Thammasat	24
Częstochowa University of Technology	Poland, Czestochowa	23
King Mongkut's Institute of Technology Ladkrabang	Thailand, Ladkrabang	22
Cracow University of Economics	Poland, Cracow	20
Poznan University of Economics	Poland, Poznan	19
Chiang Mai University	Thailand, Chiang Mai	16
Khon Kaen University	Thailand, Khon Kaen	4
King Mongkut's University of Technology North Bangkok	Thailand, Bangkok	4
	Total	189

The selection of programs was based on its reference industrial engineering body of knowledge. "Industrial engineering" itself it is not so common program of studies in Poland, since it is actually offered in one university only (Otouczelnie.pl 2020). Among similar studying programs, management and production engineering is the most popular one, having more than 10000 candidates in the past 2 academic years (MNiSW 2017, 2018). Therefore, the selection of programs for comparative analysis was widened to include the following leading topics: industrial engineering and development, industrial engineering and management, workplace safety engineering, logistics and supply chain engineering and commodity science and material engineering. According to Lima et al. (2012) all the programs included refers directly to industrial engineering and management areas of knowledge. The number of respondents with regard to studying programs is presented in Table 3. The differentiation between the programs held in Thailand and in Poland is reflected in studying period (2 years in Thailand and 1,5 year in Poland), programs structure (1 or 2 semesters dedicated to master thesis only in Thailand, while joined studying and thesis work in Poland), or number of courses and credits, but since the teaching and learning methods are the point of interest for this research, these differences are not discussed here.

Table 3. Sample structure with regard to studying program and country

Leading topics of studies	PL	THA	Total
Industrial / production engineering and management	58	37	95
Industrial engineering / development	3	57	60
Workplace safety engineering	18	0	18
Logistics and supply chain engineering	9	3	12
Other	1	3	4
Total	89	100	189

The questionnaire was designed to cover two major issues: the coverage of different teaching and learning methods in studying programs and the assessment of its effectiveness from the perspective of students. Altogether, questionnaire consisted of 6 identifying questions, 3 questions on courses and TLM applied and 1 question for open remarks. It is important to mention that the list of possible answers for question on coverage of different TLMs included all the methods from LOVE model.

3 Results of student assessment of teaching practices

As for the most applied TLMs, the lectures and guided practical exercises hold the 1st and 2nd spot both in Poland and Thailand. For Polish students, the TLMs that follows comes from learning and experimenting groups, while for Thai students, the group of learning methods together with some of the observing type of methods. The application of TLMs for Thai students seem to be more balanced while for Polish students we could observe some more significant diversity.

The results of the survey are to be interpreted for the comparing purposes between Polish and Thai students. Just to safe space and keep the paper brief, the results are presented in form of combined graphs (Figure 2 and Figure 3), while the tables with results are annexed to the paper. The first look, at the results of the survey, gives the impression that there is a significant difference between the viewpoints and perceptions of the students from two compared countries on the TLMs. Figure 2 and Figure 3 compare the results of the most applied and considered to be the most efficient TLMs for Polish and Thai students respectively.

Polish students expressed that the top three most efficient methods are guided practical exercises, laboratory classes and discussion. We could observe that the efficiency assessment does not follow the intensity of TLMs applications throughout the course of the studies. For Thai students, lectures, case studies and discussion were rated as the top three most efficient methods. Here, we could observe that the efficiency assessment follows the intensity the methods are used. Despite direct relation to the preferences of students, it could be interpreted as some type of trust in teacher's selection of TLMs and perhaps more master – student relationship.

With the LOVE model classification, it seems that Polish students appreciate learning and experimenting, while for Thai students it's a mixture of observing and learning experiences.

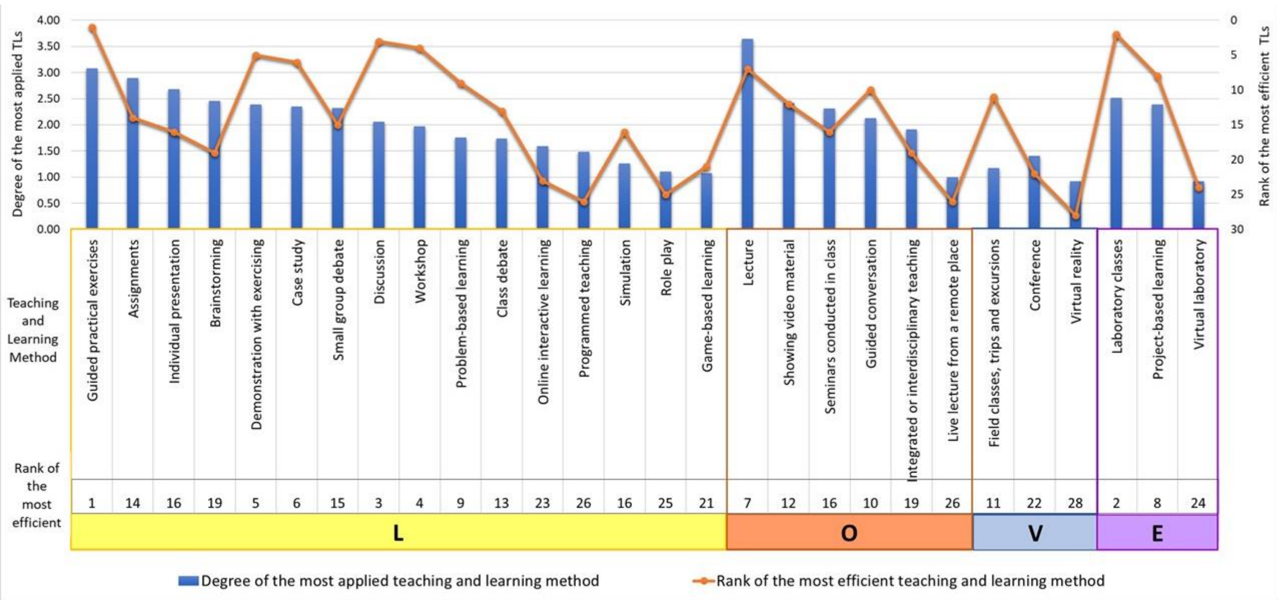


Figure 2. Comparison between the most applied and the most efficient TLMs in engineering education from Polish students' viewpoint [n=89]

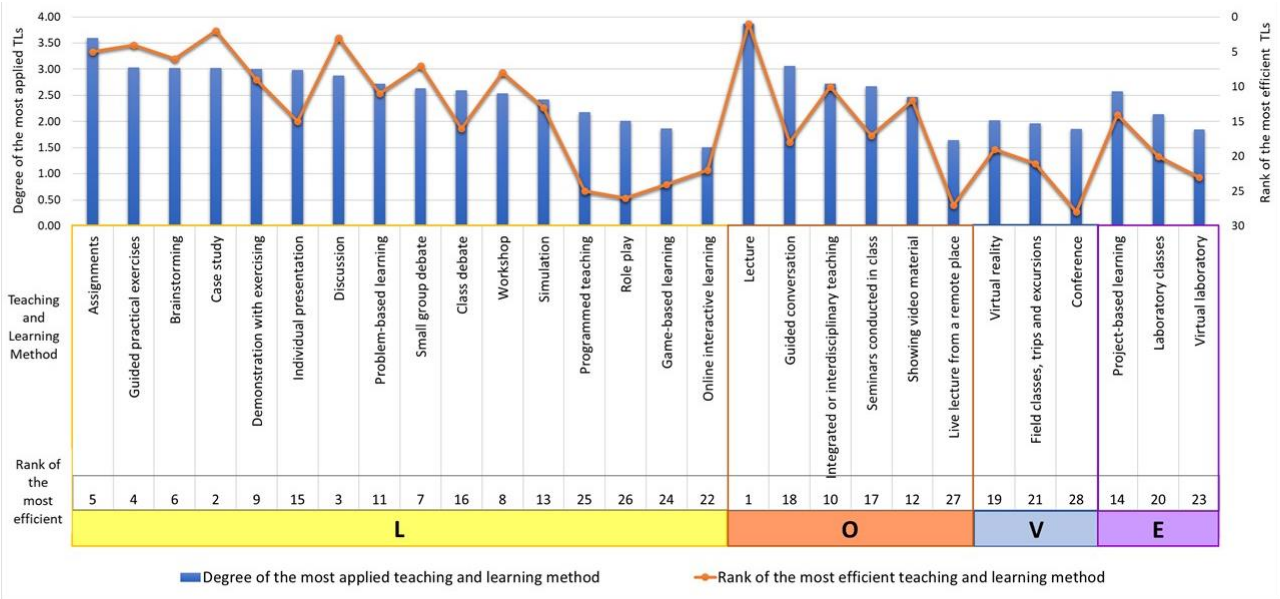


Figure 3. Comparison between the most applied and the most efficient TLMs in engineering education from Thai students' viewpoint [n=100]

For Polish students, 6 out of 10 the most efficient TLMs belong to learning experience category. For Thai students it is even more dominating with 8 out of 10 the most efficient methods belonging to learning experience category. The most significant difference comes with investigating the remaining courses in the most efficient 10. For Polish students the laboratory class is assessed as the 2nd most efficient while for Thai the lectures are assessed as the 1st most efficient ones. The remaining courses in the top 10 for Thai students belong to the observing type of activities while for Polish students it is split between observing and experimenting type of activities.

4 Discussion and conclusions

The distance between the degree of the application and the efficiency evaluation could be also interpreted as a need to increase or decrease the intensity of use of specific TLMs. The need to increase the intensity could be observed for case studies, discussion, guided practical exercises and group debate for Thai students. For Polish students its more often the case, and such a need could be observed for discussion, workshop, problem-based learning, field classes, laboratory classes, project-based learning, guided practical exercises, demonstration and exercises, case studies and some other minor cases. In general, for Polish students the differences between the application and assessment occur quite often and many cases with the possible need to decrease the intensity of specific TLMs could be also observed. It is the case for programmed teaching, brainstorming, individual presentation, assignments, online interactive learning and to some extent lectures. For Thai students the need to decrease the intensity of specific is highly visible as well. It concerns, among others, guided conversations, programmed teaching, role play, remote lectures, conferences, game-based learning and to some extent all the experimenting type of TLMs. Possibly, these type of learning experiences are not highly valued by students. The overall assessment of lectures is quite similar to the findings of Wieman (Wieman 2014) that showed significant lack of efficiency for passive learning approaches in comparison to active ones. Surprisingly, it is evidently confirmed for Polish students while not so clearly for Thai students.

The results for Thai students, concerning the application level of TLMs and to same point its assessment is similar to what have been presented from the point of view of the teachers (Hussadintorn Na Ayutthaya et al. 2019). As for Polish students it has never been investigated so far and the results should lie a new background for engineering educations research, as well as, LOVE model application for its assessment. The comparative analysis showed that the two samples of industrial engineering education is perceived differently by Thai and Polish students. The different content concerning TLMs leads to quite different assessment of the efficiency of specific TLMs. To get the overview of the study we could say that the studying culture could have impacted the results by the aligning students' assessment with TLMs applications in Thailand while making it more contesting for Polish students. It seems that LOVE model is appropriate tool for that type of comparison because of its wide coverage for engineering TLMs and clear classification of the experiences gained throughout the educational process.

Since it is the curricula that are investigated the conclusions should refer to its approach while TLMs are concerned. The recommendations that comes from the study could be classified into two different groups: redefining potential and growing potential methods. First group of recommendations are the methods that need redefining its potential. These are the methods with relatively high application level with significantly lower efficiency assessment. This could be the case for learning type experience connected to such a method as assignments, individual presentations or brainstorming for Polish students, and also individual presentation, class debate or role play and game-based learning for Thai students. It seems that these types of experiences have quite a significant role to play in educational process but need to be adjusted to student's capacity and modernized through changes of approach and techniques. For Thai students it is surprising that visiting and experimenting types of TLMs could also fit to that category and should be revised in a sense of its contribution to student's competence building experiences. The category of methods that need redefining would certainly account for remote teaching methods, such as remote lectures, online interactive learning or virtual reality classes, which are not close to meet its own potential at the moment. This the case for both Thai and Polish students and should be carefully considered by curriculum developing universities, especially, in the context of epidemical threat and limitations to the direct contact classes. Again, it is difficult to find direct and clear connection to the results of other studies due to LOVE model configuration. Our results, and to some extend the LOVE model design, confirms the findings of the studies that indicate the importance of research tasks throughout the education process (Hodge et al. 2008; Wallin et al. 2017). Somehow, the results are indicating that there is no easy implementation of active learning methods and its implementation is not guaranteeing the success. As Hora (Hora 2014) claims, even passive TLMs could play its role efficient enough if well use in educational process. On the other hand, the use of active and attractive methods is not always appreciated and well perceived by students, as could be observed in some case in our research.

Second group of recommendations are the methods that should participate more in educational process due to its high significance to industrial engineering field of knowledge as well as its experience building capacity. For sure, for Polish experimenting type of experience is the most need for industrial engineering graduate and should be provided in good quality and to a proper extent. For Thai students it is more difficult to indicate the specific group of experiences that should be intensified throughout the educational process. Certainly, it is the case for some learning methods, like case studies, discussion and to some extent workshops. We could not observe such a need with reference to visiting or experimenting type of experiences.

Acknowledgement

This work is the outcome of project "Curriculum Development of Master's Degree Program in Industrial Engineering for Thailand Sustainable Smart Industry (MSIE 4.0)" that has been funded with support from the European Commission (Project Number: 586137-EPP-1-2017-1-TH-EPPKA2-CBHE-JP). This publication reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

5 References

Christie M, Graaff E de (2017) The philosophical and pedagogical underpinnings of Active Learning in Engineering Education. Eur J Eng Educ 42:5–16. https://doi.org/https://doi.org/10.1080/03043797.2016.1254160

Dunlosky J, Rawson KA, Marsh EJ, et al (2013) Improving Students' Learning With Effective Learning Techniques. Psychol Sci Public Interes 14:4–58. https://doi.org/10.1177/1529100612453266

Freeman S, Eddy SL, McDonough M, et al (2014) Active learning increases student performance in science, engineering, and mathematics. Proc Natl Acad Sci U S A 111:8410–5. https://doi.org/10.1073/pnas.1319030111

Healey M, Jenkins A (2009) Developing the student as a researcher through the curriculum. Innov Pract 2:3–15

Hodge D, LePore P, Pasquesi K, Hirsh M (2008) It Takes a Curriculum: Preparing Students for Research and Creative Work. Lib Educ 94:

Hora MT (2014) Limitations in experimental design mean that the jury is still out on lecturing. Proc. Natl. Acad. Sci. U. S. A. 111:E3024–E3024

Hussadintorn Na Ayutthaya D, Koomsap P (2017a) ASSESSMENT OF STUDENT LEARNING EXPERIENCE WITH ' LOVE .' In: Proceedings of INTED2017 Conference 6th-8th March 2017, Valencia, Spain. pp 1973–1982

Hussadintorn Na Ayutthaya D, Koomsap P (2017b) Identify Student Participation in Co-Creation of Learning Activities. Inted2017 11Th Int Technol Educ Dev Conf 5298–5307

Hussadintorn Na Ayutthaya D, Koomsap P (2018) An Application of ' LOVE ' Model for Assessing Research Experience. In: Peruzzini M (ed) Transdisciplinary Engineering Methods for Social Innovation of Industry 4.0. pp 712–720

Hussadintorn Na Ayutthaya D, Koomsap P, Lima RM, Nitkiewicz T (2019) Learning Experience from Teaching and Learning Methods in Engineering Education: Instructors' Viewpoint, In: , Valencia. In: 13th International Technology, Education and Development Conference

Koomsap P, Hussadintorn Na Ayutthaya D, Nitkiewicz T, et al (2019) Course Design and Development: Focus on Student Learning Experience. In: PAEE/ALE'19 Preparing Teachers and Students for Challenging Times in Engineering Education. pp 144–154

Krathwohl DR (2002) A revision of Bloom's taxonomy: An overview. Theory Pract 41:212–218

Lima RM, Andersson PH, Saalman E (2017a) Active Learning in Engineering Education: a (re)introduction,. Eur J Eng Educ 4:1–4. https://doi.org/10.1080/03043797.2016.1254161

Lima RM, Dinis-Carvalho J, Sousa RM, et al (2017b) Ten Years of Project-Based Learning (PBL) in Industrial Engineering and Management at the University of Minho. In: Guerra A, Ulseth R, Kolmos A (eds) PBL in Engineering Education. SensePublishers, Rotterdam, pp 33–51

Lima RM, Mesquita D, Amorim M, et al (2012) An Analysis of Knowledge Areas in Industrial Engineering and Management Curriculum. Int J Ind Eng Manag 3:75–82

McTighe J, Wiggins G (2012) Understand By Design Framework

Mesquita D, Lima RM, Flores MA, et al (2015) Industrial Engineering and Management Curriculum Profile: Developing a Framework of Competences. Int J Ind Eng Manag 6:121–131

MNiSW (2017) Informacja o wynikach rekrutacji na studia na rok akademicki 2017/2018 w uczelniach nadzorowanych przez Ministra Nauki i Szkolnictwa Wyższego. Warszawa

MNiSW (2018) Informacja o wynikach rekrutacji na studia na rok akademicki 2018/2019 w uczelniach nadzorowanych przez Ministra Nauki i Szkolnictwa Wyższego. Warszawa

Otouczelnie.pl (2020) www.otouczelnie.pl. In: Inżynieria Przem. Stud. - Spec. / ścieżka kształcenia. https://www.otouczelnie.pl/artykul/1836/Zarzadzanie-i-inzynieria-produkcji. Accessed 6 Jul 2020

Pine BJ, Gilmore JH (1998) Welcome to the experience economy. Harv Bus Rev 76:97–105

Wallin P, Adawi T, Gold J (2017) Linking teaching and research in an undergraduate course and exploring student learning experiences. Eur J Eng Educ 42:58–74. https://doi.org/10.1080/03043797.2016.1193125

Wieman CE (2014) Large-scale comparison of science teaching methods sends clear message. Proc Natl Acad Sci 111:8319–8320. https://doi.org/10.1073/pnas.1407304111

Table 4. Survey results for Polish students [n=89]

L/O/V/E	Teaching and Learning Method	Most Applied Teaching and Learning Method									Efficient Teaching and Learning Method							
		0	1	2	3	4	5	Sum	**Mean**	SD	5	4	3	2	1	Sum	Sum product	**Rank**
	Discussion	12	18	31	13	11	4	89	**2,06**	1,34	5	12	5	3	3	28	97,00	**3**
	Demonstration with exercising	5	17	28	21	13	5	89	**2,39**	1,26	6	0	11	5	2	24	75,00	**5**
	Class debate	17	24	25	14	6	3	89	**1,74**	1,30	3	3	3	2	2	13	42,00	**13**
	Small group debate	6	22	22	20	14	5	89	**2,33**	1,33	2	3	0	6	1	12	35,00	**15**
	Simulation	28	26	22	11	1	1	89	**1,26**	1,13	1	2	6	1	2	12	35,00	**16**
	Problem-based learning	9	28	34	13	4	1	89	**1,75**	1,04	6	3	3	0	3	15	54,00	**9**
	Programmed teaching	24	25	24	7	7	2	89	**1,48**	1,30	1	0	0	1	1	3	8,00	**26**
L	Workshop	14	18	26	21	8	2	89	**1,97**	1,28	2	9	8	0	9	28	79,00	**4**
	Brainstorming	4	13	32	24	10	6	89	**2,46**	1,20	2	1	1	7	1	12	32,00	**19**
	Case study	3	21	25	23	16	1	89	**2,35**	1,15	3	6	5	8	4	26	74,00	**6**
	Online interactive learning	19	25	24	15	6	0	89	**1,60**	1,19	2	0	0	4	2	8	20,00	**23**
	Game-based learning	34	28	18	5	3	1	89	**1,08**	1,13	2	1	2	2	3	10	27,00	**21**
	Role play	31	31	19	4	3	1	89	**1,10**	1,10	1	0	1	1	1	4	11,00	**25**
	Guided practical exercises	3	6	17	25	31	7	89	**3,08**	1,19	12	10	7	7	5	41	140,00	**1**
	Assignments	4	7	25	20	24	9	89	**2,90**	1,29	2	2	1	5	6	16	37,00	**14**
	Individual presentation	5	8	27	23	22	4	89	**2,69**	1,22	2	1	3	4	4	14	35,00	**16**
O	Lecture	5	5	8	6	40	25	89	**3,64**	1,41	5	0	7	2	9	23	59,00	**7**
	Guided conversation	7	26	19	24	12	1	89	**2,12**	1,23	1	8	2	4	1	16	52,00	**10**

	Integrated or interdisciplinary teaching	7	30	27	16	7	2	89	**1,91**	1,16	1	1	5	1	6	14	32,00	**19**
	Showing video material	8	16	21	22	19	3	89	**2,42**	1,33	3	3	3	4	6	19	50,00	**12**
	Seminars conducted in class	6	20	28	15	15	5	89	**2,31**	1,32	0	4	3	3	4	14	35,00	**16**
	Live lecture from a remote place	40	25	14	5	4	1	89	**1,00**	1,19	0	0	2	0	2	4	8,00	**26**
V	Field classes, trips and excursions	32	32	10	9	5	1	89	**1,17**	1,24	7	1	0	5	2	15	51,00	**11**
	Conference	23	29	23	8	4	2	89	**1,40**	1,22	3	0	1	3	1	8	25,00	**22**
	Virtual reality	46	21	10	8	3	1	89	**0,92**	1,21	0	0	1	1	2	4	7,00	**28**
E	Project-based learning	10	12	26	19	18	4	89	**2,39**	1,36	5	3	2	5	3	18	56,00	**8**
	Laboratory classes	13	7	24	17	22	6	89	**2,52**	1,48	11	4	7	5	3	30	105,00	**2**
	Virtual laboratory	47	20	13	3	3	3	89	**0,92**	1,28	1	2	1	0	1	5	17,00	**24**

Table 5. Survey results for Thai students [n=100]

L/O/V/E	Teaching and Learning Method	Most Applied Teaching and Learning Method									Efficient Teaching and Learning Method							
		0	1	2	3	4	5	Sum	**Mean**	SD	5	4	3	2	1	Sum	Sum product	**Rank**
L	Discussion	2	21	16	23	24	14	100	**2,88**	1,40	5	19	10	8	5	47	152,00	**3**
	Demonstration with exercising	2	18	19	16	29	16	100	**3,00**	1,42	4	3	6	2	5	20	59,00	**9**
	Class debate	6	23	20	16	26	9	100	**2,60**	1,46	2	1	2	5	1	11	31,00	**16**
	Small group debate	7	23	20	14	21	15	100	**2,64**	1,56	2	2	9	9	8	30	71,00	**7**
	Simulation	6	25	21	26	13	9	100	**2,42**	1,38	0	5	2	8	4	19	46,00	**13**
	Problem-based learning	4	22	19	20	23	12	100	**2,72**	1,44	5	5	0	1	3	14	50,00	**11**
	Programmed teaching	15	26	17	19	14	9	100	**2,18**	1,55	1	0	0	0	1	2	6,00	**25**
	Workshop	9	23	18	18	19	13	100	**2,54**	1,55	3	4	6	2	8	23	61,00	**8**
	Brainstorming	0	20	16	21	28	15	100	**3,02**	1,36	5	4	4	10	2	25	75,00	**6**
	Case study	2	19	18	14	30	17	100	**3,02**	1,45	13	9	10	8	11	51	158,00	**2**
	Online interactive learning	37	24	14	10	6	9	100	**1,51**	1,62	0	2	1	2	3	8	18,00	**22**
	Game-based learning	20	31	13	21	8	7	100	**1,87**	1,50	0	1	1	1	2	5	11,00	**24**
	Role play	21	25	15	19	11	9	100	**2,01**	1,59	0	0	2	0	0	2	6,00	**26**
	Guided practical exercises	1	15	19	25	25	15	100	**3,03**	1,31	10	17	3	2	5	37	136,00	**4**
	Assignments	1	11	10	16	29	33	100	**3,60**	1,37	1	4	8	12	9	34	78,00	**5**
	Individual presentation	1	16	24	14	32	13	100	**2,99**	1,35	2	0	4	5	5	16	37,00	**15**
O	Lecture	1	7	15	5	25	47	100	**3,87**	1,38	31	6	4	2	8	51	203,00	**1**
	Guided conversation	3	15	18	17	31	16	100	**3,06**	1,41	0	2	5	1	3	11	28,00	**18**
	Integrated or interdisciplinary teaching	3	23	17	23	24	10	100	**2,72**	1,39	5	2	2	5	5	19	54,00	**10**
	Showing video material	3	28	20	28	10	11	100	**2,47**	1,36	4	4	3	2	1	14	50,00	**12**
	Seminars conducted in class	3	25	22	17	18	15	100	**2,67**	1,47	1	1	4	3	2	11	29,00	**17**
	Live lecture from a remote place	31	29	12	10	9	9	100	**1,64**	1,63	0	0	1	1	0	2	5,00	**27**
V	Field classes, trips and excursions	19	29	19	11	14	8	100	**1,96**	1,56	1	2	1	2	1	7	21,00	**21**
	Conference	26	25	18	9	12	10	100	**1,86**	1,66	0	0	0	0	2	2	2,00	**28**
	Virtual reality	16	30	20	14	10	10	100	**2,02**	1,54	2	2	1	1	1	7	24,00	**19**
E	Project-based learning	7	25	16	18	23	11	100	**2,58**	1,51	2	4	3	3	3	15	44,00	**14**
	Laboratory classes	14	29	20	14	12	11	100	**2,14**	1,56	0	2	3	2	2	9	23,00	**20**
	Virtual laboratory	26	24	19	10	12	9	100	**1,85**	1,63	1	1	0	4	0	6	17,00	**23**

Problem-based learning (PBL) implemented in Manufacturing Processes

Apiwat Muttamara[1], Patittar Nakwong[2], Sawat Pararach[3]

[1,3] Faculty of Engineering, Thammasat University, Khlong Luang, Pathum Thani, Thailand
[2] Faculty of Science and Technology, Department of Applied Science, Phranakhon si Ayutthaya Rajabhat University, Ayutthaya, Thailand

Email: mapwat@engr.tu.ac.th, patittar.n@gmail.com, psawat@engr.tu.ac.th

Abstract

Manufacturing processes course is one of the compulsory subject for industrial engineering course. Problem Based Learning (PBL) implemented into traditional teaching methods. The study indicates that PBL may be an effective complementary method for manufacturing processes. Students need opportunities to practice the newly acquired skills. Before class, rather than beginning with a single question that is multilayered and complex, use a sequence of questions to build knowledge. The paper elaborates approaches to daily products selection and unites to acquire knowledge, self-studying, group discussion and presentation. Class discussion provides an appropriate opportunity to give knowledge in depth. The possibility of offering the students and the efficiency of PBL were also evaluated and discussed.

Keywords: Problem based learning; PBL; Manufacturing Processes; Industrial Engineering.

1 Introduction

It has been many years for Thai education to support project-based learning (PBL) to succeed their education goals. PBL offers the different educational strategies that are not same as the traditional lecture. Barrows and Tamblyn (1980) published their study on abilities of medical students after trials with new learning and teaching styles. The PBL enhance learning by activate students to work in teams and solve problems together, while developing contents knowledge, idea, reasoning, and interpersonal skills (Jones et al., 2013). Moreover, the involvement with problem-solving also helps to keep students interest in course contents, that they are learning skills needed to be successful in the field (White, 2001; Hmelo-Silver, 2004; Dahms and Stentoft, 2008). Since its emergence within the engineering education, a growing interest in using PBL has been noticed, which is aligned with current efforts to move from decontextualized presentation of technical content to holistic integration of content and practice (Sheppard et al., 2008). Despite an increasing number of literature evidence, a limited number of researchers has provided systematic studies of PBL(Galand et al., 2012)

Manufacturing Processes course is an undergraduate course designed to provide the basic skills and knowledge in the areas of manufacturing processes & materials and is part of the core mechanical engineering curriculum (Zhou & Donaldson,2010). Unlike other math-based engineering courses. Consequently, the students may not be able to see the connection and may lose interest in learning the subject {Manu}. So, PBL has a correspondence to gain experience from learning by themselves (Dewey, 1938). Thammasat School of Engineering (TSE) is a young engineering program in its 2nd year. The manufacturing process is being taught for Industrial Engineering and Mechanical Engineering course. A field trip has been included for this course. For practical, students and teacher are able to bridge the gap between what’s been taught in the classroom and what’s been practiced on the manufacturing floor.

1.1 Manufacturing Processes Course

Learning and understanding Manufacturing Processes aids our understanding of the world and all around us. Manufacturing Processes phenomena can be described at multiple levels of representation which are interconnected and related in terms of information. There are three levels of Manufacturing Processes representations, namely the Create for example casting, modify (machining, forming) and assembly (Welding, fitting) (Mikell P. Groover,2010). This course provides the student with an introduction to industrial manufacturing from the viewpoint of mechanical technology. Successful completion of the course will provide the student with the benefits, limitations, and applications of different machine tools and engineering materials for product manufacturing. Manufacturing process engineering came from the technological development and profound change of the steel industry. Adaptability of machinery to a variety of manufacturing processes is studied. Each process is covered from a technical perspective; correct terms are introduced so that the student will be able to use the language of the engineer or technologist.

The students completing this course will be able to:

- Describe basic materials properties, behaviours, and failure modes and their relevance to manufacturing processes.
- Describe basic physical and mechanical properties (emphasis metals), behaviours, and failure modes and their relevance to manufacturing processes.
- Determine the interrelationships between thermal, elastic, and strength properties and their influence on manufacturing costs, efficiency, and quality.
- Describe basic heat treating methods for metals and their purposes.
- Describe selected metal forming operations and calculate the associated force and energy requirements.
- Select appropriate coating and surface enhancement processes, and understand their limitations.
- Evaluate the forces associated with standard machining, turning, and grinding operations.
- Describe molding and casting processes for metals.
- Describe manufacturing processes for powder metal alloys.
- Understand basic product design and manufacturability.
- Understand different machining operations Traditional manufacturing (Milling, turning, grinding) and non-traditional manufacturing (EDM, ECM, Laser, water Jet and others) and describe various machineries

During the last phase of the project, the student is asked to identify a manufacturing issue associated with the chosen process and/or material, conduct research on the issue, provide a solution to the resolution of the issue, write a report on the work, and present the work to the class. Surveys are conducted to evaluate the effectiveness of the approach. It is expected that by letting student choose their own manufacturing topic, the students will be more motivated to learn and learn more effectively.

2 Classroom Implementation

At the present, course syllabus was distributed to all students. All students read by themselves and picked their topics based on their interest and stated why they are interested in the particular manufacturing process. For introduction, we discuss about the topics that we are going to focus. The first case, using the PBL to brainstorm. The case study is as follows: “A young industrial engineer works in a company that want to launch coffee product which guarantees to awaken your sober morning and get you ready for the chaotic day in the city. Design container considered marketing concept. Packaging plays a pivotal role in the branding process of the product, attracting customers and providing customers what they're looking for when they take the product home” Figure 1 shows types for coffee’s containers.

Figure 1. Types of containers.

2.1 Investigating/ Discussion problem

The students make grouped and seat together to discuss the problem. They were grouped for 4-5 students, refine their lists. It was starting by listing down each fact from the problem statement. lists of FACTS (what we know), IDEAS (related thoughts and hypotheses), LEARNING ISSUES (what we need to know more about), and ACTIONS (what we need to do), noted their thoughts both on 1 sheet of A4 paper. They noted information through their own exploration of the resources, and they discuss findings with their group members to compile the growing list of evidence that will form the basis of their argument in the final group presentation. Any ideas related to the problem and ideas were generated and summarized by each member and noted down. Then they will discuss learning issues that can help them to solve the problem. Finally, they search for information from every resource including books, journal, notes, using internet. All of these processes were listed in FILA table as shown in Table 1.

Table 1. FILA

Facts	Ideas	Learning Outcomes (Issues)	Actions
– There are many choices for container for Coffee. – What are the differences between plastic, glass and metal for manufacturing processes?	– Needs experiences and general knowledge. – Needs to share the information with the other participants.	– How it's made? –What are challenges and benefits of each manu-facturing processes? -What are the cost for manufacturing processes? -What are the concepts of teaching and learning in this course?	– Finding information on the internet about each manu-facturing. – Do the discussion with all the group members. – Finish the assign-ment before the deadline.

During the classroom discussion and group sharing, students rarely add on additional points from other groups or edit their work during the classroom discussion. During discussion, the teacher noticed that many students are more self-centered, they only focus on completing their own tasks and do not care about others' ideas. The students' work and the teacher's description matched the classroom observation. The students want to finish the assignment which students but not to listen to other groups sharing. The first group initially listed all coffee's packaging in the market. They pointed sustainable packaging, which might be not involved with our topics. They can explain some manufacturing processes for Example, blow molding for PET. For this chance, we checked basic knowledge for Material sciences that they passed last semester. Teacher discussed all group for materials for deep drawing process of soft drink vessel. Some students confused aluminum, stainless steel, and steel coated by tin. For this time, they have to carry the real part, magnetic checking and discuss their properties. The final points showed that the student started to realize relationship between materials & manufacturing processes and cost for manufacturing and that they have known from experience. This might occur during final discussion and noted to the FILA table before presentation. After finished presentation, we discussed about EG (Electro Galvanized Steel Sheet) and GI (Hot Dipped Galvanized Steel). This topic we will study in this course after midterm examination under surface treatment. However, there was no attempt shown in making corrections or indications. The teacher had explicitly discussed about phase diagram that they have already passes and confused about austenite phase and magnetic properties. Thus, it can be explained that the student might intently wrote idea from their experiences and researches. Therefore, for future lessons, it is recommended to use the FILA chart in the landscape orientation. Both students show misunderstandings for some basic background. This can be related back to the inaccurate explanation by the teacher during the first phase. Students filled up this idea by answering the teacher's question: "Rust can corrode the steel., What are the chemicals in the equation? Why does not stainless steel rust." The teacher's unprepared state had caused students' misconception, it also reflects students understanding of theory and their behaviour during class discussion. In PBL, students should also learn to be a good listener in addition to being an active speaker.

Before final examination, several videos on manufacturing were created for normal people as a learning resource and freely shared via YouTube. The videos were assigned for students to practice replacing fieldtrip. Teacher started the case study with How It's Made for LPG cylinder tank. Unfortunately, students cannot see the real part in classroom. They were assigned to investigate by themselves at home or canteen. The student must draft manufacturing processes chart, start from raw steel sheet to finish product. The students utilized innovative way, such as video from YouTube to present the subject content and demonstrated their research capability and present their project. Figure 2 shows example for Incredible gas cylinders manufacturing process from YouTube. The students were asked to find out cycle time and production time for 1 tank on the production line and also they were asked to find out other manufacturing methods in order to replace producing for the same product.

Figure 2. Example for Incredible gas cylinders manufacturing process.
(Source : https://www.youtube.com/watch?v=U7Vj5-Z8wD8)

It is worth noting that the focus of finding production times in order to confirm the student's knowledge for name the processes. Presentation helps this happen by allowing the students to interact with their friends and teacher. In order to find other manufacturing processes created thinking through ideas and making them approachable as product. Throughout the discussion after presentation, the students were given opportunities to express their opinion, reflect on their ideas and learn from them.

3 Teaching Evaluation

The teaching evaluation used the questionnaire with the 5-point Likert scale to gather level of satisfaction about PBL in this course on students' opinions. The questionnaire distributed to all students (55 students), 31 of questionnaires were collected. The evaluation criteria range from 5 (strongly satisfied) to 1 (strongly dissatisfied). Mean scores are interpreted with regard to the satisfaction level as follow:

4.50 – 5.00 means strongly satisfied
3.50 – 4.49 means very satisfied
2.50 – 3.49 means weakly satisfied
1.50 – 2.49 means dissatisfied
1.00 – 1.49 means strongly dissatisfied

Table 2. Level of satisfaction about PBL in this course

	N (Number of participants)				
strongly satisfied	3				
very satisfied	9				
weakly satisfied	14				
dissatisfied	2				
strongly dissatisfied	3				
Total	**N**	**Minimum**	**Maximum**	**Mean**	**S.D.**
	31	1	5	3.22	1.05

As can be from the table 2, most of students (14 students or 45.2%) were weakly satisfied. Only 3 students or 9.7% were strongly satisfied and also 3 students were strongly dissatisfied. As the result, we can say that the students were weakly satisfied for satisfaction about PBL in this course (Mean=3.22 and S.D.=1.05). At the end of the questionnaire, open-ended question asked about feeling for PBL in this course. A student raised comments: "PBL should be taught by experienced lecturers, the PBL was not suited for many students, our lecturer cannot handle all students. Only 2-3 students could understand that teacher taught."

Not surprisingly, students were treated familiar with the equation on traditional math-based engineering course with the traditional passive lecture. So, students feel the much difference of responses between the two courses. While passively familiar traditional math-based engineering course, students may like to individually study and practice for exercises. For manufacturing course, they have to find out idea, practice skill, thinking process and made their project presentations. Some of them suggested that the topic of their interest really helped them to learn but it is out of syllabus which were not found in the exam paper.

4 Conclusion

Problem-based learning (PBL) was implemented to Industrial and Mechanical engineering students via teaching for Manufacturing processes. Students involved in problem-based learning acquire knowledge. This technique stimulates learning in problem-solving contexts, active learning and team participation. Some soft skill was practiced among the students such as leadership, interpersonal and self-directed learning skill. They are also trained to be punctual, actively generating creative ideas and good motivator to the friends.

As the results, the following recommendations are made for future. Our classroom discussion is less than that of course planning. Its overall effectiveness needs to be further evaluated with more samples. Teacher should improve teaching practice. The ways for improving may include technology. The explosion of connection in our culture due to technology has been nothing short of amazing. Because many students and different basic knowledge. It should divide to small group with the same knowledge level. Imagine for practices form clip VDO may extend to special guests and field trips. (Brian Gaten, 2020).

Acknowledgement

This publication is a partial outcome of project, Curriculum Development of Master's Degree Program in Industrial Engineering for Thailand Sustainable Smart Industry (MSIE4.0)" that has been funded with support from the European Commission (Project Number: 586137-EPP-1-2017-1-TH-EPPKA2-CBHE-JP). We are grateful to the Thammasat School of Engineering(TSE) for the support.

Co-funded by the Erasmus+ Programme of the European Union

5 References

Barrows, H. S. & Tamblyn, R.M. (1980). Problem-based Learning: An Approach to Medical Education, (Springer, New York, USA).

Jones, B., Epler, C., Mokri, P., Bryant, L. & Paretti, M. (2013). The effects of a collaborative problem-based learning experience on students' motivation in engineering capstone courses. Interdisciplinary Journal of ProblemBased Learning, 7 (2), 34-71.

White, H. (2001). Problem-based learning. Speaking of Teaching, 11 (1), 1-7.

Hmelo-Silver, C. (2004). Problem-based learning: what and how do students learn?. Educational Psychology Review, 16 (3), 235-266.

Dahms, M. & Stentoft, D. (2008). Problem based learning in engineering education: a development option for Africa? In Proceedings of 4th African Regional Conference on Engineering Education (ARCE-2008), Tanzania.

Sheppard, S., Macatangay, K., Colby, A., Sullivan, W. & Shulman, L. (2008). Educating engineers: designing for the future of the field.

Galand, B., Frenay, M. & Raucent, B. (2012). Effectiveness of problem-based learning in engineering education: a comparative study on three levels of knowledge structure. International Journal of Engineering Education, 28 (4), 939-947.

Zhou, Z. & Donaldson, A. (2010). Work in Progress - Project-Based Learning in. Manufacturing Process. *40th ASEE/IEEE Frontiers in Education Conference*. T1J-1. October 27 - 30, Washington, DC.

Groover, M. P. (2010). FUNDAMENTALS OF MODERN MANUFACTURING Materials, Processes, and Systems. Fourth Edition: John Wiley & Sons.

Dewey, J. (1938). Experience and Education, Collier and Kappa Delta Pi, New York, USA.

Sky creative HD, (2020). Incredible gas cylinders manufacturing process: Amazing LPG cylinders production line. YouTube: https://www.youtube.com/watch?v=U7Vj5-Z8wD8

Gaten, B. (2020). Practical Tips for Improving Your Teaching Practice, https://blog.sharetolearn.com /curriculum-teaching-strategies/practical-tips-for-improving-teaching-practice/

ERASMUS+ CBHE PROJECT, Curriculum Development of Master's Degree Program in Industrial Engineering for Thailand Sustainable Smart Industry, https://msie4.ait.ac.th/

Developing lean competencies through serious games

Gabriela Witeck[1], Anabela C. Alves[1]

[1]ALGORITMI Centre, Department of Production and Systems, School of Engineering, University of Minho, Guimarães, Portugal

Email: gabiwiteck@gmail.com, anabela@dps.uminho.pt

Abstract

Lean Production is a methodology largely implemented across industries and services. This methodology adds value to companies, as it derives from the main idea "doing more with less", where less means with fewer resources, less product development time, less human effort, among others to provide high performance in daily activities. As a company requires adequacy of Lean Thinking, the philosophy behind Lean Production, it leads to a concern in the manner of training and educating of its employees. Lean Thinking requires competencies to be successfully understood and pursued all the time. Partly due to human and social capital being key factors for the functioning of society and economy, in recent years there has been an increased interest in competencies, as knowledge and skills are not enough anymore. In this context, higher education engineering and innovative organizations seeks to complement the training of theirstudentsandprofessionals, through specific courses with serious games simulating typical day-to-day issues in business matters. The serious games methodology involve "learning by doing", in which students can develop and improve skill sets in real-world context, recognizing themselves as protagonists of their learning. Experiential learning or "learning by doing", does notonly implyexposition of the theory, but the resolution of an unstructured problem, it also proposes decision-making to solve such a problem. Thus, the Lean Thinking mind-set needs serious games and other active learning methodologies to become truly meaningful and to provide new competencies to the professional. This mind-set is a valuable differential in the current market, with increasingly flexible job rotations, more on-demand jobs than long-term contracts, and its demand of skills incompetitions, like quick learning and logical reasoning. This articlediscussesthe importance of serious games for Lean students and professionals to acquire competencies. The research was, predominantly, based on a conceptualreview of papers that described serious games and hands-on activities. Based on these, some evidence elements from the papers that match essential competences of Lean Education: System-thinking, Environment and Ethics were collected.

Keywords: Lean Education; Competencies; Serious Games; Hands-on Activities.

1 Introduction

Lean Production (LP)has been a prominent strategy methodology in the past three decades (Alves et al., 2019; Krafcik, 1988; Samuel et al., 2015; Schonberger, 2019; Womack et al., 1990).Lean Thinking (LT) is the philosophyunderneath LP that adds value to companies as it derives from the main idea "doing more with less". To concretize such idea, Womack and Jones (1996) identify five principles that should be followed: 1) Value; 2) Value Stream; 3) Flow; 4) Pull Production and 5) Pursuit Perfection. This philosophy is a consistency of knowledge whose essence is the ability to reduce costs and increase productivity by eliminating wastethrough problem solving, in a systematically way. This implies rethinking how to lead, manage and develop people. It is through the full engagement of people with their jobs that are able to identify improvement'sopportunities with sustainable gains. Their roots are in Toyota Production System (TPS) tenets that is based on Respect-for-People and continuous improvement (Monden, 1998; Ohno, 1988; Shingo, 1989) till today (Toyota Motor Corporation, 2018).

LT associated with operational excellence at all levels follows guides for the success of any organization in a long-term sustainable viability. As a company requires adequacy of LT, the philosophy behind LP, it leads to a concern in the manner of training and educating of its employees. The Lean Education (LE) requires contents, but, mainly, competencies to be successfully understood and pursued all the time(Alves, 2019; Alves et al., 2020; Alves et al., 2017; Flumerfelt et al., 2015).Such competencies are related to: System-thinking, i.e. being capable to comprehend the whole picture, not just a part of it(Flumerfelt et al., 2016; Flumerfelt et al., 2014; Kahlen et al., 2013); Sustainability as they will be aware of how Lean wastes (transports, inventory, motion, waiting, overproduction, over-processing and defects)impact on environmental actions (Abreu et al., 2017; Alves, 2018; Moreira et al., 2010); Ethics by adopting an ethical behaviour that starts with Respect-for People, as main tenet of TPS (Flumerfelt et al., 2013, 2012). This implies motivation, collaboration and cooperation through teamwork, transparency and fluidity of information as a fundamental basis as well problem-solving, critical thinking, communication, negotiation and analytical skills, creativity, and intercultural skills.

A competency includes knowledge, skills and attitudes(Council of the European Union, 2018; Rychen & Salganik, 2000). Knowledge is related to facts and figures, concepts, ideas and theories which are already established and support the understanding of a certain area or subject. Skills are the ability and capacity to carry out processes and use the existing knowledge to achieve results. Attitudes are the disposition and mind-sets to act or react to ideas, persons or situations (Council of the European Union, 2018, p. 14). Knowledge, skills and attitudes when integrated, is capable of generating high standard performance (Amorim & Barros, 2011).

Competencies have three main characteristics: they are linked to a particular work and organizational context; they are associated with superior performance; and can be described in terms of behavioural patterns or results that can be observed during the tasks executions (Hirsh & Strebler, 1994). On the other hand, Stokes and Oiry (2012) call attention to facts that are not forbidden to interpret and that can be replicated in a robotic way; otherwise, the competency model can become, in practice, a behavioral manual.

The competencies enable the user to handle new behavioral strategies to find solutions to complex problems. This is the reason to support LE learning system in competencies. According to the Council of the European Union(2018)competencies are acquired through active learning methodologies such as project and problem-based learning (PBL), experiential methods, serious games, hands-on activities, flipped classroom, among others. Such methodologies promote the participation of all the students, encouraging the self-critical feeling, the identity and the feeling of belonging, the teamwork, the problem-solving and critical thinking, among others. Through these methodologies, studentsbecame more active and adopting a protagonist role in their own education. This allows, not only skills related to the main theme of the studies to be performed, but also the ability to make decisions and toexecute actions in an entrepreneurial and autonomously way (competencies), addressing complex problems with results orientation.

Although adult education, e.g. companies professionals have a different way of learning, it is also based on a need to understand the meaning of their own experience. Such understanding should be facilitated by education, more concisely, transformative learning (Mezirow, 1997). Methods used in the transformative learning includes also an active process that help adults to develop their thoughts, feelings, and disposition, much as the Head-Heart-Hands (3H) taxonomy provides (Brühlmeier, 2010; Flumerfelt et al., 2014).Methods, similar to the ones referred above, includes action research projects because these promote reflective thought, imaginative problem posing, and discourse in a learner-centered, participatory, and interactive, group deliberation and problem solving.

This knowledge on adults learning demands, promote opportunities between academia and the professional industry that facilitate this knowledge transfer through LE (Alves et al., 2017; Alves et al., 2018; Flumerfelt et al., 2016). The companies that already follow Lean approaches leads to concern in the training and awareness process of its employees, as the impact of Lean learning on these changes is noticeable(Alves et al., 2016).Nevertheless, such competencies could be prevented from being learned in work environments if not well trained(Francis, 2016; Khatibi &Khormaei, 2016). This means if the learning methods used were not the correct, the meaning and motivation to learn is not practiced.

In this paper, it is discussed the serious games and hands-on activities in developing lean competencies in students/professionals. To achieve the conceptual review is undertaken, retrieving from scientific papers the lean competencies developed by such methods, according to their authors. Also, as the demand for different and new competencies emerges in the frame of the Industry 4.0 approach, a discussion about these alignments is initiated.

This paper is organized into five sections. The first presents an introduction and the objectives of the paper. The second section presents the research methodology. The section three presents the serious games and active learning approaches, followed by the fourth section where it is discussed the development of Lean competencies through serious games. Finally, the section five outlines concluding remarks.

2 Research methodology

The research discussed in this paper was, mainly, based on a conceptual review. According to (Sangwa & Sangwan, 2018) a conceptual review examines conceptual knowledge and synthesizes different theories, concepts, and phenomena, providing interrelationship among them. Lately, could be used to propose new conceptual framework, model, roadmap or instrument based on existing literature of the specific topic. In this research, lean serious games and hands-on activities are collected from literature review andanalyzed to find elements that evidence the importance of such educational activities to promote lean competences in the apprentices. Provides a theoretical literature review of existing theories and interrelationship among them.

3 Serious games and other active learning approaches

Learning is the process where the knowledge is created through the transformation of experience (Kolb, 1984). In Kolb's experiential model of learning, individuals are encouraged to reflect on the actions and consequences, then to create an understanding and reapplying it to future actions. Kolb defines four possible learning styles: (i) Divergent (feel and watch), (ii) Assimilative (watch and think), (iii) Convergent (do and think) and (iv) Accommodative (do and feel). These Kolb's styles are possibly interrelated depending on individual preferences, and may result in four different outcomes: Concrete Experience (to feel), Reflective Observation (to watch), Abstract Conceptualization (to think) and Active Experimentation (to do).

Piaget (1973) argues that the stages of learning are involved in a constant process of adapting man to the world. In the active learning process,through which learners build new ideas or concepts based on their old or current knowledge, the student selects and transforms constructive hypotheses as information and makes decisions based on his own cognitive structure(Wood et al., 1976).

The serious games approach gained impulse as a positive perspective of learning published in business reviews, as opportunities to apply games in large companies, to allow innovation and motivation of the employees (Erdős & Kallós, 2014).Wouters et al. (2007)mentioned that serious game aims to educate, put learners in situations in which they are responsible for decisions made, reflected and evaluated (Geithner & Menzel, 2016).During the game, apprentices can learn based on their own experience (Lopes et al., 2013).A result of the serious games is impulse a more interactive, participatory, inductive, reflective and exploratory learning environment (Tao et al., 2015).Furthermore, games based in problems, appear to be promising instructional approaches in different areas, including production and engineering education (Pourabdollahian et al., 2012).

The virtual serious games, in a simulation platform can be used as a virtual laboratory to perform experiments. According with Gadre et al. (2011) the virtual simulation assignments can give students an overview of how to apply lean tools to an existing production line, while also bolster students' learning through problem solving. Once that students would immediately see the effects of their suggested changes in the production line. Thus, the virtual platform would help students in lean and related courses to learn through their work, improve retention, and visualize the otherwise costly effects of commonly made mistakes in real-time(Gadre et al., 2011).

Additionally, some authors considered that the game-based learning (GLB) promote a hands-on qualification of the learners(Alves, Sousa, et al., 2017; de Vin et al., 2018; Flumerfelt et al., 2015, 2016). Another function of environmental learning, especially in the academic area is the usage as a test area for new technologies and processes (Municio et al., 2018; Schallock et al., 2018). The authors Kuriger et al. (2010)and Badurdeen et al.(2010)confirm that serious games are useful tools for teaching Lean concepts, as participants can see and experience what they learn in regular lecture sessions and other teaching techniques.

Although it is not possible to learn Lean exclusively through games, Bicheno(2014) stated thatthis is a quick experimental learning that no one cannot, reading or watching in an expository class. Additionally, this author claimed that the games can interact and promote discussion, participation and the decision to decide what the essential requirements for a successful Lean implementation are.

Also, Flumerfelt et al. (2015; 2016b), Alves et al. (2016; 2017b), Bicheno (2014), Sousa et al. (2014) among others, argued that Lean learning should follow active learning methods such as Project Based Learning (PBL) and also in the context of a final course project as identified in Alves et al. (2014). Only by this approach the benefits of learning Lean can reflect on concrete actions with quantitative and qualitative values for companies (Alves et al., 2017; Alves, Flumerfelt, et al., 2017; Kahlen et al., 2011).

4 Development of Lean competencies through serious games

Lean Education should be focused on the values of the Toyota Production Systems (Ohno, 1988), following the five principles defined by Womack and Jones (1996): 1) Value; 2) Value Stream; 3) Flow; 4) Pull Production and 5) Pursuit Perfection. According to Bauer et al. (2018), these could also be supplemented by the principle: 6) Respect for People - which the founders of the Toyota Way (Liker, 2004)regard as a fundamental basis for a trusting cooperation of all employees.Therefore, these principles refer to knowing the customer well and how her/his needs are, the point of view that increases the value of the product and what she/he is willing to pay, as a result of eliminating everything that may be in the way of a delivery on time, quality and right amount. This requires learning from everyone, employees, internal and external customers, and through a culture where is permanent the need to improve, making them aware of all errors, when identified, always being solved. According to Powell & Reke(2019), it could be no lean without learning.

Among educators, there is a consensus that Lean education approaches should contain the practical experience (De Vin et al., 2018; Flumerfelt et al., 2015; Flumerfelt et al. 2016; Alves et al., 2017). The objective should be to promote and develop as learners' skills and competencies to think lean and to act in the long term. Partly due to human and social capital being key factors for the functioning of society and economy, competencies are increasingly valued by companies and, for that same reason, they must be present in what they are and what those skills are necessary for successful of job tasks. Attending to this, many authors have been developing actives approaches for teaching Lean, in the academic and even in the industrial environments. The Table 1 presents some of these authors and relates the three main Lean competencies discussed, highlighting some evidence elements from these that match the competencies and/or skills embed in these competencies. Due to the paper dimension limitation, just a few publications were collected and presented in the Table 1.

Moreover, with the digital transformation as Industry 4.0 leads to changed competence requirements in different topics, also in technologies(Dombrowski et al., 2019; Enke et al., 2018).After the changes coming with Industry 4.0, as smart factories are the main resources, where "humans, machines and resources communicate with each other so naturally in a social network".

In this aspect, the current concept of “learning factories”, which denotes thereinforcing and construction of “factories that learn”, offers potential for the development of skills in the areas of human performance (cognitive, affective and psychomotor), and also for all classes of competencies. The concept “learning factories” mainly aims at people's cognitive performance, professional skills. The development of competencies in these areas does not occur automatically if students do not learn much more in a situation corresponding to daily adversities (Abele et al., 2015, 2017, 2019; Municio et al., 2018; Pascual et al., 2020; Tisch et al., 2016).

Consequently, new forms of Lean teaching and learning are needed in order to keep up with the developments described. In particular, research institutes that collaborate strongly with industry have a responsibility to develop innovative learning approaches that help prepare the current and future workforce to work in the company of the future (Dombrowski et al., 2019). Such approaches go through the learning factories already mentioned and are being implemented in several countries in partnership with companies (Adam et al., 2020; Municio et al., 2018; Pascual et al., 2020). Also, important is to measure how effectiveness this learning is (Adam et al., 2020; Leal et al., 2017; Pourabdollahian et al., 2012).

Table 1. Some publications and Lean competences

Publications/ game type	System-thinking	Sustainability	Ethics
(McManus et al., 2007) Lego airplane	Lean improvement on the "bottom line" even when improvement costs are taken into account; Redesign a fairly complex system.	Eliminate paperwork, eliminate stocks.	Work habits and relationships must change interpersonal effort; working together; team bonds; no cheating; bending several rules; communication; responsibilities; motivation; the importance of being organized and clean; following rules.
(Fang et al., 2007) Lego cars	See the whole picture of how products flow throughout the value stream; lessons learned.	Reduce inventory; eliminate wastes; reduce scrap.	Importance of the "people"; improved communication and worker motivation; importance of teams and appropriate teamwork; interdisciplinary collaboration; importance of the people side; experienced team frustration.
(Alves & van Hattum-Janssen, 2011) Torch assembly	Critical thinking of the production system initial state; see the entire process for the torch assembly; deep learning of all members of the team	Reduce transports and motion; reduce overproduction	Importance of being organized and clean; initiative; being responsible; motivation; respect for the others opinion; help each other.
(Pourabdollahian et al., 2012) Airplane	Make decisions and choose options; task accomplishment	Reduce defects, time.	Motivation; challenge; engagement; interest; team collaboration
(Silva et al., 2013) Electrical plug	Seeing the whole value stream of a product	Eliminate stocks and unnecessary movement.	Necessary that the participants are aware of the rules; seek perfection.
(Sousa et al., 2014) Machine set-up; 5S game; electrical plug	Critical-thinking; Problem-solving; Global learning; Reflexive learners.	Less stocks; reduction of the time.	Teamwork; engagement and motivation; importance of being organized and clean.
(Leal et al., 2017) Lego bricks	Students reflect on the results; theoryvs. practice	Eliminate waste; Less human work in process inventory.	Motivation; teamwork; team discussions and alignments; following rules; importance of being organized and clean; express opinions; confidence.
(Alves, 2018) Operating modes in U-shaped cells	Making-decisions about products to assembly; design the production system; organize people	Reduce transports and overproduction	Motivation; collaboration; engagement; respects for others opinion; be patient; importance of being organized and clean
(Sousa & Dinis-Carvalho, 2020) Mapping	Global understanding of the whole process as well as its interactions; Increase the process performance. Effective to represent the entire process as well as to identify improvement opportunities.	Reduce waste, mainly paperwork.	Conflict management; motivation and engagement; promote the coordination and communication between team participants.

5 Conclusion

This paper researched the use of serious games as a form of active learning methodologies, aiming to developing Lean competencies of System-thinking, Sustainability and Ethics. These are crucial competencies for theFourth Industrial Revolution. Such learning methodology is expected to deliver an oriented way to prepare students and worker's community equipped with competencies required for a complex market, considering that challenges occurred in the future will be adapted appropriately and in correctly time, in a Lean way.

Along with some examples from the literature, which reports good results while students flow on the games experience, some skills are evolved, like: critical-thinking; teamwork;communication; responsibility; motivation; global learning and concern with wastes elimination actions. Such skills are embedding in the three competencies referred above. Nevertheless, the sustainability competency does not seem deeply explored. This mind-set is a valuable differential for students and professionals.Once Respect-For-People and continuous improvement are the foundations of LT, it is succeeded that some well-developed serious games can be used to achieve the competencies required in Lean Education.

Nowadays, the COVID-19 pandemic, which imposes new patterns of behaviour and changes in habits, the expectations about the future are still uncertain. Therefore, to face this moment, the effects of virtual serious games understanding is relevant in the area of Lean education and in the relationship students and worker's community with digital educational technologies and their virtual nature.

Future plans are to perform systematic literature review of active learning methodologies to develop a model to measure the value-added created by the serious games and other active approaches for students learning and companies sustainability.

Acknowledgments

This work has been supported by FCT – Fundação para a Ciência e Tecnologia within the R&D Units Project Scope: UIDB/00319/2020.

6 References

Abele, E., Chryssolouris, G., Sihn, W., Metternich, J., ElMaraghy, H., Seliger, G., Sivard, G., ElMaraghy, W., Hummel, V., Tisch, M., & Seifermann, S. (2017). Learning factories for future oriented research and education in manufacturing. CIRP Annals, 66(2), 803–826. https://doi.org/10.1016/j.cirp.2017.05.005

Abele, E., Metternich, J., & Tisch, M. (2019). Learning Factories. Springer International Publishing. https://doi.org/10.1007/978-3-319-92261-4

Abele, E., Metternich, J., Tisch, M., Chryssolouris, G., Sihn, W., ElMaraghy, H., Hummel, V., & Ranz, F. (2015). Learning Factories for Research, Education, and Training. Procedia CIRP, 32, 1–6. https://doi.org/10.1016/j.procir.2015.02.187

Abreu, M. F., Alves, A. C., & Moreira, F. (2017). Lean-Green models for eco-efficient and sustainable production. Energy, 137, 846–853. https://doi.org/10.1016/j.energy.2017.04.016

Adam, M., Hofbauer, M., & Stehling, M. (2020). Effectiveness of a lean simulation training: challenges, measures and recommendations. Production Planning & Control, 1–11. https://doi.org/10.1080/09537287.2020.1742375

Alves, A. C. (2018). Lean Education: provider of system-thinking, ethics and sustainability competencies. 4th Edition 2018 - 11th EPIEM Conference on Innovation and Sustainability 2018. http://innovation.pub.ro/archive/2018.pdf

Alves, A. C., Flumerfelt, S., Moreira, F., & Leão, C. P. (2017). Effective Tools to Learn Lean Thinking and Gather Together Academic and Practice Communities. Volume 5: Education and Globalization, V005T06A009. https://doi.org/10.1115/IMECE2017-71339

Alves, A. C., Sousa, R. M., Dinis-Carvalho, J., Lima, R. M., Moreira, F., Leão, C. P., Maia, L. C., Mesquita, D., & Fernandes, S. (2014). Final year Lean projects: advantages for companies, students and academia. Project Approaches in Engineering Education, 1–10. http://hdl.handle.net/1822/30172

Alves, A.C. (2018). U-shaped cells operating modes: A review and a hands-on simulation comparison. International Journal of Industrial Engineering and Management, 9(2), 87–97. https://doi.org/658.5:004.94

Alves, A.C. (2019). Competencies driven by Lean Education: System-thinking, sustainability and ethics. International Symposium on Project Approaches in Engineering Education, 9, 710–713.

Alves, A.C., Leão, C. P., & Sousa, R. M. (2018). Lean education as a platform to close the academic and professional gap. International Symposium on Project Approaches in Engineering Education, 8, 17–19.

Alves, Anabela C., Leão, C. P., C. Maia, L., & Amaro, P. A. (2016). Lean Education Impact in Professional Life of Engineers. Volume 5: Education and Globalization, 5, V005T06A044. https://doi.org/10.1115/IMECE2016-67034

Alves, Anabela C., Leão, C. P., Uebe-Mansur, A. F., & Kury, M. I. R. A. (2020). The knowledge and importance of Lean Education based on academics' perspectives: an exploratory study. Production Planning & Control, 1–14. https://doi.org/10.1080/09537287.2020.1742371

Alves, Anabela Carvalho, Flumerfelt, S., & Kahlen, F.-J. (2017). Lean Education: An Overview of Current Issues (Anabela Carvalho Alves, S. Flumerfelt, & F.-J. Kahlen (eds.)). Springer International Publishing. https://doi.org/10.1007/978-3-319-45830-4

Alves, Anabela Carvalho, Kahlen, F.-J., Flumerfelt, S., & Siriban-Manalang, A. B. (2019). Lean Engineering for Global Development (Anabela Carvalho Alves, F.-J. Kahlen, S. Flumerfelt, & A. B. Siriban-Manalang (eds.)). Springer International Publishing. https://doi.org/10.1007/978-3-030-13515-7

Alves, Anabela Carvalho, Sousa, R., Dinis-Carvalho, J., & Moreira, F. (2017). Lean Education at University of Minho: Aligning and Pulling the Right Requirements Geared on Competitive Industries. In Lean Education: An Overview of Current Issues (pp. 149–175). Springer International Publishing. https://doi.org/10.1007/978-3-319-45830-4_10

Alves, Anabela Carvalho, & van Hattum-Janssen, N. (2011). Hands-on simulation in the classroom to teach new concepts and to prepare future industrial engineers as operator ´ s instructors. Proceedings of the 2011 Project Approaches in Engineering Education, 259–265.

Amorim, T. N. G. F., & Barros, S. L. (2011). Gestão por competências: nuances e peculiaridades. Revista Reuna, 16(1).

Badurdeen, F., Marksberry, P., Hall, A., & Gregory, B. (2010). Teaching Lean Manufacturing With Simulations and Games: A Survey and Future Directions. Simulation & Gaming, 41(4), 465–486.

Bauer, H., Brandl, F., Lock, C., & Reinhart, G. (2018). Integration of Industrie 4.0 in Lean Manufacturing Learning Factories. Procedia Manufacturing, 23, 147–152. https://doi.org/10.1016/j.promfg.2018.04.008

Bicheno, J. (2014). The Lean Games and Simulations (2nd editio). PICSIE books.

Brühlmeier, A. (2010). Head, Heart and Hand: Education in the Spirit of Pestalozzi. Sophia Books.

Council of the European Union. (2018). Proposal for a Council Recommendation on Key Competences for Lifelong Learning.

de Vin, L. J., Jacobsson, L., & Odhe, J. (2018). Game-based Lean Production training of university students and industrial employees. Procedia Manufacturing, 25, 578–585. https://doi.org/10.1016/j.promfg.2018.06.098

Dombrowski, U., Wullbrandt, J., & Fochler, S. (2019). Center of Excellence for Lean Enterprise 4.0. Procedia Manufacturing, 31. https://doi.org/10.1016/j.promfg.2019.03.011

Enke, J., Glass, R., Kreß, A., Hambach, J., Tisch, M., & Metternich, J. (2018). Industrie 4.0 – Competencies for a modern production system. Procedia Manufacturing, 23, 267–272. https://doi.org/10.1016/j.promfg.2018.04.028

Erdős, F., & Kallós, G. (2014). Benefit evaluation model for gamified add-ons in business software. Acta Polytechnica Hungarica, 11(5), 109–124.

Fang, N., Cook, R., & Hauser, K. (2007). Integrating Lean Systems Education into Manufacturing Course Curriculum via Interdisciplinary Collaboration. Proceedings of the 2007 American Society for Engineering Education Annual Conference & Exposition.

Flumerfelt, S., Alves, A., Calvo-Amodio, J., Hoyle, C., & Kahlen, F. J. (2016). Managing systems complexity through congruence. In Transdisciplinary Perspectives on Complex Systems: New Findings and Approaches. https://doi.org/10.1007/978-3-319-38756-7_5

Flumerfelt, S, Kahlen, F.-J., Alves, A., Calvo-Amodio, J., & Hoyle, C. (2014). Systems competency for engineering practice. ASME International Mechanical Engineering Congress and Exposition, Proceedings (IMECE). https://doi.org/10.1115/IMECE2014-40142

Flumerfelt, Shannon, Alves, A. C., & Kahlen, F.-J. (2013). What Lean Teaches Us About Ethics in Engineering. Volume 5: Education and Globalization, 5, V005T05A041. https://doi.org/10.1115/IMECE2013-62393

Flumerfelt, Shannon, Alves, A. C., Kahlen, F.-J., & Siriban Manalang, A. B. (2012). Why Require Ethics in Engineering? Volume 5: Education and Globalization; General Topics, 5, 495. https://doi.org/10.1115/IMECE2012-89392

Flumerfelt, Shannon, Alves, A. C., & Khalen, F.-J. (2014). Lean Engineering Education: The DNA of Content and Competency. Proceedings of the 2014 IIE Engineering Lean and Six Sigma Conference, 2014 Lean Educators Conference.

Flumerfelt, Shannon, Alves, A. C., Leão, C. P., & Wade, D. L. (2016). What do organizational leaders need from lean graduate programming. European Journal of Training and Development, 40(5), 302–320. https://doi.org/10.1108/EJTD-01-2015-0005

Flumerfelt, Shannon, Kahlen, F.-J., Alves, A. C., & Siriban-Manalang, A. B. (2015). Lean Engineering Education: Driving Content and Competency Mastery. ASME Press.

Francis, R. (2016). Learning styles: key to enhance learning among student teachers of the B. International Education and Research Journal, 2(12), 54–55.

Gadre, A., Cudney, E., & Corns, S. (2011). Model Development of a Virtual Learning Environment to Enhance Lean Education. Procedia Computer Science, 6, 100–105. https://doi.org/10.1016/j.procs.2011.08.020

Geithner, S., & Menzel, D. (2016). Effectiveness of Learning Through Experience and Reflection in a Project Management Simulation. Simulation & Gaming, 47(2), 228–256. https://doi.org/10.1177/1046878115624312

Hirsh, W., & Strebler, M. (1994). Defining managerial skills and competences. In Gower Handbook of management development (Vol. 4).

Kahlen, F.-J., Flumerfelt, S., Alves, A. C., & Siriban Manalang, A. B. (2013). The möbius strip of lean engineering and systems engineering. ASME International Mechanical Engineering Congress and Exposition, Proceedings (IMECE), 12. https://doi.org/10.1115/IMECE2013-62354

Kahlen, F.-J., Flumerfelt, S., Sinban-Manalang, A. B., & Alves, A. (2011). Benefits of lean teaching. ASME 2011 International Mechanical Engineering Congress and Exposition, IMECE 2011, 5, 351–358.

Khatibi, M., & Khormaei, F. (2016). Learning and personality: a review. Journal of Educational and Management Studies, 6(4), 89–97.

Kolb, D. A. (1984). Experiential Learning: Experience as the Source of Learning and Development (First edit). Pearson Education, Incorporated.

Krafcik, J. F. (1988). Triumph of the Lean Production System. Sloan Management Review, 30(1), 41–52.

Kuriger, G. W., Wan, H., Mirehei, S. M., Tamma, S., & Chen, F. F. (2010). A Web-Based Lean Simulation Game for Office Operations: Training the Other Side of a Lean Enterprise. Simulation & Gaming, 41(4), 487–510. https://doi.org/10.1177/1046878109334945

Leal, F., Martins, P. C., Torres, A. F., Queiroz, J. A. de, & Montevechi, J. A. B. (2017). Learning lean with lego: developing and evaluating the efficacy of a serious game. Production, 27(spe). https://doi.org/10.1590/0103-6513.222716

Liker, J. . (2004). The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer. McGraw-Hill.

Lopes, M. C., Fialho, F. A. P., Cunha, C. J. C. A., & Niveiros, S. I. (2013). Business Games for Leadership Development. Simulation & Gaming, 44(4), 523–543. https://doi.org/10.1177/1046878112471509

McManus, H. L., Rebentisch, E., Murman, E. M., & Stanke, A. (2007). Teaching Lean Thinking principles through hands-on simulations. Proceedings of the 3rd International CDIO Conference.

Mezirow, J. (1997). Transformative Learning: Theory to Practice. In New directions for Adult and Continuing Education (pp. 5–12). Jossey-Bass Publishers.

Monden, Y. (1998). Toyota Production System: An Integrated Approach to Just-In-Time (Third). Engineering and Management Press.
Moreira, F., Alves, A. C., & Sousa, R. M. (2010). Towards Eco-efficient Lean Production Systems. In IFIP Advances in Information and Communication Technology, Volume 322, Balanced Automation Systems for Future Manufacturing Networks (pp. 100–108). https://doi.org/10.1007/978-3-642-14341-0_12
Municio, A. G., Pimentel, C., & Ruano, J. P. (2018). Lean School: an example of industry-university collaboration. In R. M. Dinis-Carvalho, J., Alves, A. C., Costa, N., Lima, R. M. and Sousa (Ed.), Proceedings of the Fifth European Lean Educator Conference (ELEC2018) "Lean Educator's Role in Lean Development" (p. 10).
Ohno, T. (1988). Toyota Production System: Beyond Large-Scale Production. CRC Press.
Ohno, Taichii. (1988). Toyota Production System: beyond large-scale production. Productivity Press.
Pascual, J. A., Pimentel, C., Mateo, M., Hoyuelos, I., Matias, J., & Gento, A. M. (2020). A Learning Factory for Remanufacturing: A New Configuration at Valladolid Lean School. In Proceedings of 6th European Lean Educator Conference (ELEC2019). Springer International Publishing.
Piaget, J. (1973). Estudos Sociológicos. Forense.
Pourabdollahian, B., Taisch, M., & Kerga, E. (2012). Serious Games in Manufacturing Education: Evaluation of Learners´Engagement. Procedia Computer Science, 15, 256–265. https://doi.org/10.1016/j.procs.2012.10.077
Powell, D., & Reke, E. (2019). No Lean Without Learning: Rethinking Lean Production as a Learning System. In K. D. (eds) Ameri F., Stecke K., von Cieminski G. (Ed.), Advances in Production Management Systems. Production Management for the Factory of the Future. APMS 2019. IFIP Advances in Information and Communication Technology (pp. 62–68). https://doi.org/10.1007/978-3-030-30000-5_8
Rychen, D. S., & Salganik, L. H. (2000). Definition and selection of Key competencies. https://www.oecd.org/edu/skills-beyond-school/41529556.pdf
S. Shingo. (1989). A study of Toyota Production System from an Industrial Engineering.
Samuel, D., Found, P., & Williams, S. J. (2015). How did the publication of the book The Machine That Changed The World change management thinking? Exploring 25 years of lean literature. International Journal of Operations & Production Management, 35(10), 1386–1407. https://doi.org/10.1108/IJOPM-12-2013-0555
Sangwa, N. R., & Sangwan, K. S. (2018). Leanness assessment of organizational performance: a systematic literature review. In Journal of Manufacturing Technology Management (Vol. 29, Issue 5). https://doi.org/10.1108/JMTM-09-2017-0196
Schallock, B., Rybski, C., Jochem, R., & Kohl, H. (2018). Learning Factory for Industry 4.0 to provide future skills beyond technical training. Procedia Manufacturing, 23, 27–32.
Schonberger, R. J. (2019). The disintegration of lean manufacturing and lean management. Business Horizons, 62(3). https://doi.org/10.1016/j.bushor.2019.01.004
Silva, I., Xambre, A. R., & Lopes, R. B. (2013). A simulation game framework for teaching lean production. International Journal of Industrial Engineering and Management, 4(2), 81–86.
Sousa, R. M., Alves, A. C., Moreira, F., & Dinis-Carvalho, J. (2014). Lean games and hands-on approaches as learning tools for students and professionals. 7th International Conference on Production Research - Americas.
Sousa, R. M., & Dinis-Carvalho, J. (2020). A game for process mapping in office and knowledge work. Production Planning & Control, 1–10.
Stokes, P., & Oiry, E. (2012). An evaluation of the use of competencies in human resource development–a historical and contemporary recontextualisation. EuroMed Journal of Business.
Tao, Y. H., Yeh, C. R., & Hung, K. C. (2015). Validating the learning cycle models of business simulation games via student perceived gains in skills and knowledge. Journal of Educational Technology & Society, 18(1), 77–90.
Tisch, M., Hertle, C., Abele, E., Metternich, J., & Tenberg, R. (2016). Learning factory design: a competency-oriented approach integrating three design levels. International Journal of Computer Integrated Manufacturing, 29(12), 1355–1375. https://doi.org/10.1080/0951192X.2015.1033017
Toyota Motor Corporation. (2018). Annual report 2018. https://www.toyota-global.com/pages/contents/investors/ir_library/annual/pdf/2018/annual_report_2018_fie.pdf
Womack, J., & Jones, D. T. (1996). Lean Thinking: Banish Waste And Create Wealth In Your Corporation. Siman & Schuster, New York, USA.
Womack, J. P., Jones, D. T., & Roos, D. (1990). The Machine That Changed the World: The Story of Lean Production. Rawson Associates.
Wood, D., Bruner, J. S., & Ross, G. (1976). The role of tutoring in problem solving. Journal of Child Psychology and Psychiatry, 17(2), 89–100.
Wouters, P., Tabbers, H. K., & Paas, F. (2007). Interactivity in Video-based Models. Educational Psychology Review, 19(3), 327–342. https://doi.org/10.1007/s10648-007-9045-4

A-Cube Way for Research Learning Experience: View of Students

B. Naduni Hansika Abeywardena[1], Chatura Lavanga Mendis[1], Duangthida Hussadintorn Na Ayutthaya[1], Ei Ei Lwin[1], Yasiru Shikshitha Benaragama[1], Shih-Hsuan Wei[1,2], Chih-Fan Tan[1,2]

[1] A-Cube Research Group, Department of Industrial Systems Engineering, Asian Institute of Technology, Pathumthani, Thailand
[2] Department of Industrial Engineering and Enterprise Information, Tunghai University, Taichung, Taiwan

Email: nhabey93@gmail.com, lavanga.mendis@gmail.com, duangthidaHNA@gmail.com, eieilwin26@gmail.com, fluxes94@gmail.com, michellewei30@gmail.com, victoria841211@gmail.com

Abstract

Conducting research and presenting the findings are typically compulsory for engineering graduate students to fulfill the requirements for graduation. It is a means of preparing the students for a successful career before they leave the schools. It is no longer about transferring knowledge, but instead about building their competence. Once the students enter the industrial environment and face different kinds of problems, they should be confident enough to analyze the situation and find the solution by themselves. Presented in this paper is the view on their learning experiences of students in the A-Cube research environment in the Industrial Engineering Program at Asian Institute of Technology, Thailand, where the students are required to achieve creative solutions for challenging tasks on a strict schedule constructively and collaboratively. The students' perspective on their reported research learning experience journeys were classified into four different personas – considering different levels of education and areas of research – and described based on the LOVE learning experience model developed by the group. The results unfold a set of similar and different research learning activities and experiences between the four personas designing to support the students' research competent development in the group.

Keywords: Research Learning Experience; Engineering Education; Building Competence; A-Cube, LOVE.

1 Introduction

Different teaching approaches are used around the world to achieve one simple goal; to prepare the students to have a successful career once they leave the learning environment. According to the world economic forum, it's a requirement for employees of 2020, to have the following skills namely, complex problem solving, critical thinking, creativity, people management, coordinating with others, emotional intelligence, judgement and decision making, service orientation, negotiation and cognitive flexibility (Gray, 2016). In higher education, especially in the master's degree program, besides taking coursework, conducting research is mandatory. Conducting research will transform a person from being a consumer of knowledge to a producer of knowledge (Lovitts, 2005; Gardener, 2008). Scientists and faculty members have revealed that their research experiences were vital for the success in their respective fields. It is, therefore, of interest to investigate on their research learning journeys that transform them to be the producers of knowledge.

A-Cube Research Group – formed more than a decade ago in the Department of Industrial Systems Engineering, Asian Institute of Technology – has produced more than seventy graduates to support academic institutions and industry. Five of them are now faculty members in engineering. A few are operating their own business. Most of the research works produced by the group have been presented in international conferences and published in international journals (Koomsap, 2017). At A-Cube, students work in various areas of research, from Adaptive Layered Manufacturing to Customer Oriented Manufacturing. The team leader guides the students through a set of phases involving activities that help to stimulate their thinking while improving their skills and helping them discover their true potential.

This paper discusses the student's perspective of the effectiveness of active learning, the techniques involved in providing the students with a great research learning experience at A-Cube. The students' perspective on their reported journeys were classified into four different personas – considering different levels of education and areas of research – and described based on the LOVE learning experience model (Hussadintorn Na Ayutthaya and Koomsap, 2017) developed by the group.

The next section gives a brief understanding of the LOVE model and the types of learning experiences, followed by the third section which explains about the A-Cube research group. The fourth section describes the methodology followed and the results obtained. The paper is concluded by discussing the phases in the life of a student of A-Cube and their experiences throughout their journey at A-Cube. Future work is provided in the last section.

2 LOVE Model

Varieties of teaching approaches are applied and offered in different universities and thus students perceive different learning experiences throughout their academic journey. In some teaching approaches such as visual and virtual laboratory activities, students will have to actively involve and are immersed in them to understand the subject. However, in lectures and seminars, they just pay attention and absorb the knowledge and information provided by the lecturer or speaker. Students will have to interact with different teaching approaches offered until they successfully complete their learning journey. Therefore, the LOVE model (Figure 1) has been developed with the aim of assessing the students learning experience. It has been applied in assessing master's student research experience and its application suggests the supervisors adjust and improve their supervisory styles for the students to possess better research experiences (Hussadintorn Na Ayutthaya and Koomsap, 2018).

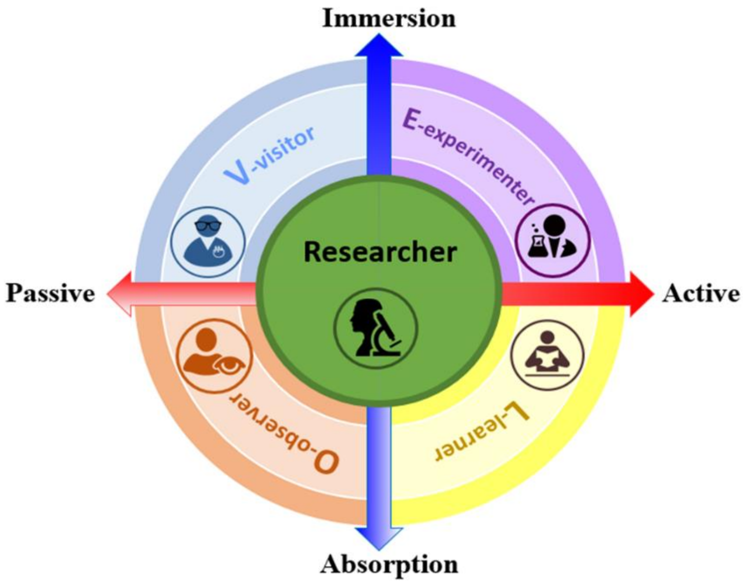


Figure 1. LOVE model (Hussadintorn Na Ayutthaya and Koomsap, 2017)

In the LOVE model, student learning experiences are classified into four types as learner (L), observer (O), visitor (V) and experimenter (E) regarding two dimensions: student involvement (passive and active involvement), and the nature of learning (absorption and immersion). The students will have the richest learning experience when they meet the four types of learning experiences in their learning journey. The definitions of the four types of learning experiences are explained as follows.

Learner: When a student actively participates in the learning activities and absorbs knowledge and information given by the lecturer or instructor, he/she is experiencing as a learner. Examples are class discussion and individual presentation.

Observer: When a student passively participates in the learning activities and absorbs the knowledge and information delivered by the lecturer or instructor, he/she is experiencing as an observer. Examples are lecture and seminar.

Visitor: When a student passively participates and immerses in the learning activities to gain knowledge and information, he/she is experiencing as a visitor. Examples are field trip and conference.

Experimenter: When a student actively participates and immerses in the learning activities to take action to gain knowledge and information, he/she is experiencing as an experimenter. An example is experimenting in a laboratory.

3 A-Cube Research Group

Formed over a decade ago, the research focus of A-Cube, founded by the team leader Dr. Pisut Koomsap, has evolved from its initial three "A"s namely, Adaptive Layered Manufacturing, Abrasive Waterjet Technology, and Automotive Technology, towards more trending areas like Customer Oriented Manufacturing including design for customer experience, co-created product design, image-based additive manufacturing from 3D computer-aided design (CAD) models, reverse engineering and sketch-based modeling, and flexible automation for rapid personalized production. "Make it simple" being no longer viable with the rapid development in engineering fields, future engineers will have to provide creative solutions, be resourceful and have critical thinking in order to succeed, thereby introducing the current motto "Thinking Beyond Engineering".

At A-cube, the team leader stimulates the members thinking while improving their skills and helping them discover their true potential. Working to a strict schedule, collaboration, constructive criticism, challenging tasks, and creative solutions are key features of our group. Progress presentation sessions held every two weeks helps improve the presentation skills of all group members, while making them think on their feet. Different areas of research are discussed in these meeting sessions, giving the students a broader view of the challenges ahead. The room allocated for the A-Cube research group is arranged in such a way that students from the same area of research are grouped together in a cluster. This enables the students to develop their research idea based on constructive criticism of other group members. Continuous interaction with different people from different nationalities helps improve communication skills as well as the ability to work in multicultural environments.

4 A-Cube Research Learning Experience

4.1 Methodology

During the postgraduate program, some students who completed their research at A-Cube within the last five years were requested to submit an individual report describing their research experience. The report consisted of the students' individual experiences, from the day that they joined the research group until the day they completed their postgraduate degree, and the types of their gained research experience classified by the LOVE model. Before forming the report, articles on the LOVE model, and some concise explanations were provided to them to aid their understanding. The students spent about a week to form their concise report.

Submitted reports were reviewed. The first round of review aimed to separate between different personas concerning their level of education (master student, doctoral student) and areas of research. The master students who submitted the reports spent one year on their journey. A few of them spent one or two more semesters to complete the research journey. The following are the four personas according to the reported research experiences.

Persona 1: The doctoral student who has completed the master's degree in A-Cube and then re-joined for the doctoral program. The student has spent a minimum of four years (one year as a Master student and three years as a doctoral student) at A-Cube. Considering the last five years, one student falls into this category.

Persona 2: The master student who works on the theoretical aspect of engineering, namely customer experience and service failure prevention. Considering the last five years, ten students fall into this category.

Persona 3: The master student who works on manufacturing – designing and developing prototypes to verify their concepts related to machining. Some key areas of interest of this persona are current research trends like smart manufacturing and additive manufacturing. Considering the last five years, twelve students fall into this category.

Persona 4: The master student who works on simulation. The student was in the dual master's degree program and was involved in simulation-based projects like developing intelligent warehouses for customized production and developing flexible assembly management systems for customized products. Considering the last five years, two students fall into this category.

Next, the second round of review was conducted. Following the guideline given by Hussadintorn Na Ayutthaya and Koomsap in 2018, the journeys described in the reports of each persona were carefully looked into details to itemize their research activities and assess their research experience. Collected activities could be separated into five phases in accordance with the LOVE learning experience model. During this process, some students were contacted or interviewed to retrieve additional information on their reported journeys – for example, when their reported types of experience were unclear.

4.2 Results and Discussion

Figure 2 represents the five phases of the research learning activities of the four personas as mentioned in relation to the LOVE model. The journey of all students at A-Cube starts with the proposal phase which is after the completion of coursework. Before working on their own research, the students are required to attend weekly group meetings at which the seniors will update the progress of their individual research areas. They will observe all the presented research work and select an area of interest by exchanging ideas with the seniors and discussing it with the advisor. "When I started the research, initially I discussed my interested research area with the supervisor. During the discussion, I had to actively generate ideas such as the interesting points of my research area and what I would like to do next and also gained helpful insights from the supervisor" was one view expressed by a student from persona four. Through discussions and the exchanging of ideas, they will move from the "Observer" experience towards the "Learner" experience. The "Experimenter" experience begins once they accomplish the literature review and identify the thesis objective. In the proposal phase of figure 2, it can be seen that persona 4 lacks the third activity; exchanging ideas with the seniors about their research since they are involved in a dual degree program thereby reducing the opportunity to interact with seniors. The experience type of each persona remains constant throughout the activities of this phase.

During the research phase, the group leader will stimulate the students thinking by sharing research papers in their respective fields of interest. Each persona makes the effort to explore their selected area of interest and present their findings at the group gatherings. At these gatherings, all personas will be visitors to each other's fields of interest in the sense that they will eventually try to grab some knowledge about each other's areas of interest, and passively immerse into the situation. But in the case of a persona attending a seminar of another research group, they will passively absorb the knowledge, but they will not have the capacity to be immersed in the situation entirely, thereby making them an observer. An example of this would be persona two whose area of interest is about customer experience attending a seminar related to nanotechnology. One such student had mentioned in their report that "When I listened to the progress presentations made by my colleagues since it was explained section-wise every week, I gradually got to know about their areas of interest. When attending seminars, even though I tried to grab as much information as possible during the seminar which usually lasted for two hours, I was unable to do so". Another scenario of the observer experience was seen in the situation where persona four was attending online lectures (activity 15) since they were involved in a dual degree program. The activities where all personas act as experimenters in this phase will differ according to their fields of interest.

Phase	Activity	Persona 1				Persona 2				Persona 3				Persona 4			
		L	O	V	E	L	O	V	E	L	O	V	E	L	O	V	E
Proposal	1 Observing seniors' research		●				●				●				●		
	2 Observing the feedback given by the advisor to the seniors		●				●				●				●		
	3 Exchanging ideas with the seniors about their research	●				●				●							
	4 Identifying area of interest	●				●				●				●			
	5 Discussing the area of interest with the advisor	●				●				●				●			
	6 Accomplishing literature review				●				●				●				●
	7 Identifying thesis title			●				●				●				●	
	8 Identifying thesis objective				●				●				●				●
Research	9 Updating research progress				●				●				●				●
	10 Discussing research with colleagues and others				●				●				●				●
	11 Listening to collegues presentations and gathering information			●				●				●					
	12 Sharing knowledge among advisor and students via research papers	●				●				●				●			
	13 Visiting laboratories and research centers			●				●								●	
	14 Attending seminars of other research groups		●				●				●						
	15 Participating in online lectures														●		
	16 Preparing for research presentation				●				●				●				●
	17 Identifying research concept				●				●				●				●
	18 Doing a case study				●				●								
	19 Simulating and testing on technical aspects related to area of interest												●				●
	20 Developing the prototype												●				
	21 Testing the precision and accuracy of the prototype												●				
	22 Identifying execution plan				●				●				●				●
	23 Analyzing research result				●				●				●				●
	24 Drawing research conclusion and recommendation				●				●				●				●
	25 Rehearsal				●				●				●				●
	26 Dissertation defense				●				●				●				●
Publication	27 Preparing manuscripts for publications				●				●				●				●
	28 Publishing the dissertation as journals				●												
	29 Attending international conferences		●				●				●				●		
	30 Presenting research papers in international conference				●				●				●				●
	31 Participating in a PhD students session in a conference	●															
	32 Participating in workshops	●															
	33 Social networking in conferences		●				●				●				●		
	34 Collaborating with other researchers				●				●				●				●
Assistant	35 Assisting in organizing a student conference							●					●				
	36 Developing a smart factory												●				
	37 Attending technical workshops									●							
Doctoral Training	38 Participating in an Erasmus Plus project on curriculum development				●												
	39 Taking meeting minutes reports				●												
	40 Co-developing teaching and learning materials for a newly developed course				●												
	41 Assisting an instructor in classes				●												
	42 Assisting in organizing a student conference				●												
	43 Assisting in organizing an international conference				●												
	44 Reviewing abstracts as a reviewer for an international conference				●												
		6	5	3	23	4	5	4	15	5	5	2	19	3	5	2	15

Figure 2. Classification of activities with respect to phases and the journey of personas

Activities like preparing manuscripts (activity 27), presenting research papers (activity 30), and collaborating with other researchers (activity 34) in the publication phase require the students to actively immerse to gain knowledge and information, thereby giving them the experience of an Experimenter. As students, the four personas had the opportunity of observing the activity of social networking between the team leader and other personnel who were participating in the conference. Differing from the other three personas, persona one being a doctoral student, has had the opportunity of participating in PhD student sessions and workshops where she had played the role of a learner.

The assistant phase is undergone mainly by persona three. While being involved in a project for smart manufacturing, one student had mentioned in their report that "By being involved in this smart factory project, I had to investigate countless methods of approaching the problem of building an efficient AGV fleet management system before finally settling down on the implemented system, which I found out to be the best possible way to approach to the problem". This statement clearly shows the active immersive experience of the student in their assistant phase. Another major point to note in this phase is that the same activity can have different experiences for different personas. For example, for persona three, the activity of assisting in organizing a student conference is an experimenter experience because they were actively involved in the organizing of the event whereas persona 2 has had the experience of a visitor since they had attended the event but haven't been involved actively in organizing the event. After the research phase, persona one had directly transferred to the doctoral program and had to actively participate in organizing the event as part of her doctoral training. This is one example where it's clear that the activities are independent of the phases. Even though the type of experience is the same (experimenter) for both persona one and persona three in the case of organizing the student conference, the level of effort put and understanding are different.

The doctoral training phase is present only for persona one. In this phase, all the activities that she had gone through fall under the category of experimenter hence suggesting that in comparison to other phases, the doctoral training phase had transformed the students to be more independent.

5 Conclusion and Future Work

From the results, it is clearly seen that students at A-Cube gain all types of the LOVE experience during their research journey regardless of their field of research interest. They undergo many phases throughout their journey in which through different activities, they gain different experiences. These experiences are varied according to the personas, their field of research, the research activities, and how they engage in these activities. At the beginning, the activities are more focused on Learning and Observing; whereas, in the latter phases, they are shifted towards Visitor and Experimenter. Each phase holds a set of common and unique activities that molds the students to become their own unique confident personalities – how a student evolves from a dependent state more towards a confident, independent individual with a unique personality.

However, there is still room for improvement. To enrich A-Cube research experience, more research activities should be designed to provide stronger experience on the dimension of visiting experience. Technology-supported teaching methods such as virtual lab tour may be brought in to explode the students into other fields of research and expand their vision. Collaboration between other research groups can also be considered to create the stronger research learning environment and enhance their research competence.

6 References

Gardner, S. K. (2008). "What's too much and what's too little?": The process of becoming an independent researcher in doctoral education. *The Journal of Higher Education, 79*(3), 326-350.

Gray, A. (2016, January 19). The 10 skills you need to thrive in the Fourth Industrial Revolution. Retrieved June 10, 2020, from https://www.weforum.org/agenda/2016/01/the-10-skills-you-need-to-thrive-in-the-fourth-industrial-revolution/

Hussadintorn Na Ayutthaya, D., & Koomsap, P. (2017). Assessment of student learning experience with 'LOVE', In: *11th International Technology, Education and Development Conference, Valencia*, pp.1973-1982.

Hussadintorn Na Ayutthaya, D., & Koomsap, P. (2018). An Application of 'LOVE' Model for Assessing Research Experience, In *M. Peruzzini (Ed.), Trandisciplinary Engineering Methods for Social Innovation of Industry 4.0* (pp. 712-720). doi: 10.3233/978-1-61499-898-3-712

Koomsap, P. (2017). Publication. Retrieved July 10, 2020, from http://faculty.ait.ac.th/pisut/publications/

Lovitts, B. E. (2005). Being a good course-taker is not enough: a theoretical perspective on the transition to independent research. *Studies in higher education*, *30*(2), 137-154.

International Dual-Degree Programs: Learning Experience in Student's Perspective

Shih-Hsuan Wei[1,2], Chih-Fan Tan[1,2], Pisut Koomsap[1], Chin-Yin Huang[2]

[1] Department of Industrial Systems Engineering, Asian Institute of Technology, Pathumthani, Thailand
[2] Department of Industrial Engineering and Enterprise Information, Tunghai University, Taichung, Taiwan

Email: michellewei30@gmail.com, victoria841211@gmail.com, pisut@ait.asia, huangcy@thu.edu.tw

Abstract

International dual-degree programs have been attractive and well accepted by students and parents, as earning an additional degree from another country is perceived as having better job opportunities. The program developers have tried their best to collaborate to put together attractive and useful content for the programs to meet the expectation. However, what the students experience is far beyond fulfill the program credits at both universities to graduate. They encounter and may have to adjust themselves back and forth for different styles of teaching, different learning environment, and unavoidable cultural difference. Presented in this paper are the viewpoints of the students who have graduated from an International dual- master's degree program in Industrial Engineering. The students' perspective on their two-year dual degree learning journey is described based on the two different educational environments and the process of self-recognition experiences.

Keywords: International dual-degree programs, dual- master's degree program, master of industrial engineering, learning experience

1 Introduction

In recent years, the issue of internationalization is getting more and more attention from people. Many students have planned to broaden their international horizons by studying aboard. A lot of universities have cooperated with overseas schools to establish a dual degree or triple degree courses. The key motivations for launching dual degree programs appear to revolve largely around advancing the internationalization of the campus and raising the institution's international visibility and prestige (Kuder & Obst, 2009). Therefore, the construction of a cooperative relationship through dual degree programs can be strategic with a long-term vision, which is not only beneficial to students and participating institutions, but also local economic development and social prosperity.

Taking the example of Taiwan, the latest data shows that the number of Taiwanese students studying in the dual degree system in the 2018 school year has reached 1541, which is an increase of more than 40% compared with 1092 in the previous year. Taiwan's Ministry of Education's "Public School Information Open Platform" statistics show that in 2018, the number of dual-education partnerships between Taiwanese colleges and universities and overseas schools reached 3583, which is an increase of more than 500 compared with 3080 in 2017. There are also more and more students intending to study abroad for multinational degrees, which is one of the important indicators of university internationalization. Therefore, we can learn that to cope with the impact of the globalization of the higher education market and enhance competitiveness, the dual degree program is one of the international academic exchange strategies.

This paper discusses the viewpoints of the students who have graduated from an International dual- master's degree program in Industrial Engineering between Tunghai University and the Asian Institute of Technology. Forth for different styles of teaching, different learning environment, and unavoidable cultural difference. The students' perspective on their two-year dual degree learning journey is described based on the two different educational environments and the process of self-recognition experiences.

1.1 Tunghai University

Tunghai University is the first comprehensive university with a Christian background in Taiwan. As a student majoring in industrial engineering, the Department of Industrial Engineering and Enterprise Information at

Tunghai University has been cultivating educational cooperation and exchanges with overseas partner universities for many years. In particular, the department and its partner universities Asian Institute of Technology (AIT) signed a dual degree program of master's degree in 2016. According to the contract, after completing the required credits for graduation from the two schools and completing the thesis, students could obtain two master's degrees from Tunghai University and AIT.

1.2 Asian Institute of Technology

Asian Institute of Technology is an international institute of higher learning located in Bangkok, Thailand. It is Asia's pioneer institution established in 1959 to help meet the region's growing needs for advanced learning in engineering, science, technology and management, research and capacity building. AIT's mission is to develop highly qualified and committed professionals who will play a leading role in the sustainable development of the region and its integration into the global economy. A medium of instruction is English.

2 Dual degree program

2.1 Comparisons of current way of overseas study

At present, there are three most common ways to study abroad, which are a direct application, a dual degree program, or an exchange program. Students, after completion of the program, will receive their degree certificates for the direct application and the dual degree program. For the dual degree program, the students will earn degrees from both the home university and the partner university. Compared with the duration of the other two options which is usually one to two years, the duration of the exchange program is mostly one to two semesters, but the students will not receive a degree from the universities they go for exchange.

The common thing between these three options is that most foreign schools are full English-spoken courses, and students must have an English proficiency test certificate when applying. For study fees, students enrolling in the direct program or exchange program only need to pay the tuition of their home school, but for the dual degree program, the students need to pay both tuition fees. Since exchange students do not have graduation thesis requirements, it is conceivable that the pressure is much lower than the other two. By consolidating the above-mentioned information is shown in Table 1. By allowing the students to obtain two degrees at the same time makes the program attractive and it is the reason why more and more people have chosen this way as studying aboard in recent years.

Table 1. Comparisons of current way of overseas study

	Exchange Program	Dual Degree	Independent application
Degree	X	O	O
Courses	High degree of freedom	*	*
Time limitation	1~2 semester	1~2 year	1~2 year
Number of applicants	Many (Competition with students from the same school)	Many (Competition with students from the same school)	Many (Competition with students from multiple countries)
Verification in English (2nd language)	O	O	O
Scholarship	Less opportunities	*	*
GRE/GMAT	X	X	*
Interview from the partner universities	X	*	*
Tuition of the partner universities	X	O	O
Thesis requirement	X	O	O
Pressure	Low	High	High
Advantage	1. Cost savings: less expensive than the dual degree. 2. Broaden horizons.	1. Save time: get two degrees at once. 2. Increase self-competitiveness.	1. Focus on one academic system.

* = According to school regulations

2.2 The pros and cons of dual degree programs

Although there are many claimed benefits for the dual degree program, but the initial implementation has faced a wide range of major challenges, ranging from national policies and regulations to institutional differences and extra administrative work at a personal level. Li (2010) concisely presented these points as follows:

(1) Different education systems/regulations and accreditation requirements.

(2) Difficulty in coordinating academic requirements, credits, and quality assurance.

(3) Different tuition and cost structures between participating universities.

(4) Difficulties related to the legal review, approval process, and administrative supports.

(5) Heavy workload during preparation and set-up that often produces very few students.

Since the amount of the student who is interested in joining the dual degree program has increased, the problems mentioned by Li (2010) have been solved and keep on improving. The pros and cons in three different aspects of being a student of dual degree program is shown as follows:

- **Broaden one's knowledge and skillsets.** The biggest benefit is that students get to learn more knowledge from different sites or even more than one field of study. On the other hand, students must spend more time researching without a chance to have work experience.
- **Choices in terms of potential career paths**. Studying further gains one's experience and knowledge from both places. Students may have a better selection of relevant jobs after graduating from school. On the other hand, it does not mean there is a guarantee that it would necessarily increase your income potential.
- **Time and Money on a graduate degree.** As a student of a dual master degree program, we saved time on what we would have spent if we pursued both masters separately. On the other hand, students still have to spend a lot of money upfront for things such as tuition and dormitory fees.

2.3 Recent dual degree program

The dual degree of international university cooperation allows Taiwan students to waive the certification requirements of TOEFL, TOEIC, GRE, or other admission tests after at least two semesters of study at the original school, and continue directly to the foreign university with the cooperation agreement to take the remaining credits. As long as the graduation conditions of the two schools are met, the degrees awarded by the two schools can be obtained. At present, in addition to the bachelor, master, and doctor of the same level, there are also a multi-level master's degree and master's doctorate. The length of the study depends on the content of the contract with the partner university. In the contract for the first year of enrollment, the calculation method of the credits of both parties, how to conduct a thesis and graduation oral exam, and the use of language are clearly defined. For the different types of dual degree programs for master degrees, the respective descriptions are presented in tables 2.

Table 2. Recent dual degree programs (Da Xue Wen,2019)

Degree	Program	Description
Bachelor + Master	3+2	Freshmen to juniors attended the original school. Senior year to partner universities. After completing the graduation credits, continue to study for a year of graduate courses.
	3+1+1	Freshmen to juniors attended the original school. Senior started to study the graduate course. After graduating from partner universities, continue to study for a year of postgraduate courses.
	4+1	Freshmen to seniors attend their original school. After graduation, go-to partner universities to take a one-year postgraduate course.
Dual master	1+1	The first year of graduate school was in the original school. The second year of the graduate school goes to the partner universities.
Master + PhD	1+N	The first year of graduate school was in the original school. By the doctoral studies, graduation conditions and contract provisions of the two universities.

Taking our own example, the contract of the dual degree program signed between Tunghai University and AIT is different from the situation described above, and it takes one semester as the cycle unit. In other words, during these two-year master's studies journey, I flighted back and forth between Taiwan and Thailand every six months.

3 Our learning experience with multi-culture

3.1 Education system experience

The education system of AIT follows the US educational system. The first semester is from August to December, and the second semester is from January to May; the education system of Tunghai University is based on Taiwan's education system. The first semester is from September to January, and the second semester is from February to June. Under this dual degree program, there will be a semester overlap half of the time in January. Therefore, we must prepare to complete the final reports and exams of Tunghai University's courses in advance and must acquire information on the courses registered at AIT whether there are any assignments during the overlapping period.

At Tunghai University, students work more individually than in groups. AIT provides students with two-way interaction between teachers and students. Students are asked to think independently and encouraged to raise questions. Besides, although there are fewer compulsory credits in AIT, each course focuses more on group cooperation and brainstorming during classes and group discussion after the class. Therefore, we spent a lot of time on the team working, conceivable that self-learning time was therefore compressed, so the management of time allocation was something we learned.

3.2 School life experience

In terms of class size, there are about twenty students in each class at Tunghai University. Because of the various choices of the course, we do not have the same group of classmates in every course. Also, even if there are still group reports in the course, most of the assignments can be completed independently by the students. So there is less connection between the students. Therefore, we will normally have a party at the end of each semester for teachers and students to get together. We call it "Final Examination Supplementation". Besides, the main student body of Tunghai University is college students. Therefore, even if there are many extracurricular activities organized by the student union, most of the activities are within the college students. There are fewer opportunities for master students to know friends from other departments.

In the course of the international dual degree program, an ability to communicate in English plays an important role, especially when there are many group reports that require a lot of discussions. In addition to acquiring technical knowledge, improving English ability is also one of the goals pursued by students of an international twin degree. For us, we encouraged ourselves to change our minds and tried to express ideas. Our classmates and friends at AIT were also very compassionate and willing to give us help. Also, we actively participated in extracurricular sports activities organized by the Student Union, including basketball games, chair ball games, and pétanque games. Many of these sports were new to us. Take the game of pétanque as an example, the other players were all from the same country and had already been familiar with the game. We were welcomed to join and they patiently taught us the rules. We met new friends and practice our English through sports. We realized that our English has also improved greatly.

Having roommates from other countries also played an important role in our AIT learning journey. We have different cultures and living habits. Diets are also very different. Having meals together allowed us to learn about their foods and cultures. This is a memorable experience.

3.3 Self-retrospect

We would like to use GREAT, which represents grow, revise, earn, accumulate and transform to describe our learning journey. In the study journey, various emotions were also an important part of my growth, we can better understand how we have grown up in this experience every time we face difficulties in the future.

3.3.1 How have we Grown up during the journey of the international dual degree program?

After experiencing as students of international dual degree programs, we start to look at things differently. Through good time and bad time we went through, we have learned not to be rigid to our initial thoughts but to open our minds to accept things as our new experience. We have learned to live beyond a comfort zone. We have learned to overcome the fear of change. These days when we encounter problems, rather than being panic, we begin to analyze the situation and seek available solutions prior to action. The change in our mindset has been the most important growth in this experience.

We are also aware of the importance of self-responsibility. We live alone far from our hometowns. Especially in the face of academic pressure and the frustration of research bottlenecks, self-regulation is a breakthrough in our internal growth. This must be a rare and commendable opportunity to improve ourselves.

3.3.2 What have we Revised ourselves, including study method and mood?

English was a major barrier in our communication with foreigners. We were reluctant to speak in English. We were afraid that they could not understand. Instead of focusing on the contents of our messages, we paid too much attention to the structure of the language. With much more opportunity to use daily, we have been able to express our opinions with confidence. The lack of language ability is no longer the biggest obstacle to the communication process, and learning has become more effective.

In the past, we learned to complete our work independently, but through teaching and learning methods, we have been encouraged to work as a team. Now we learn to manage our time, work in a team, and spare time for individual activities. We have accumulated a lot of experience in many teamwork and also confident to share our opinions. We know how to help each other in groups, play our role well, and become a member of the team that contributes to teamwork.

3.3.3 What do we Earn from the experience of an international dual degree program?

Through the experience of the international dual degree program, the most direct thing we have earned is that we have obtained two master degrees as we planned for. Besides, we have gained many transversal skills in multiple grouping and personal reporting experiences, especially the ability of thinking and learning, also the ability to read, interact and express. Now we can more effectively capture what the literature mainly focused while doing research, and arranged it in an organized way to present to the listener. These abilities can only be earned through real experience and contact with practical problems.

3.3.4 What would the experience Accumulate in our life?

As an international dual degree student, the experience we have is different from studying abroad, but to master the pros and cons of both places at the same time. This is undoubtedly the accumulation of another experience in our life stage. Besides, we also know many friends from various countries. By communicating with classmates and friends from different countries, we have a deeper understanding of things in different cultures. In addition to knowing new knowledge with a broader mind, we have also accumulated many experiences in making friends with different cultural backgrounds. As a result, our international outlook has developed a lot, and accumulating our international competitiveness will definitely help us in our job application in the future.

3.3.5 What do we Transform after study with a dual degree?

With this commendable experience, both of us know ourselves better. The growth and achievements also bring to ourselves after we overcome the problems that have made a big difference in our views and personalities. One of us has changed from a shy personality who was not good at expressing our thought in the past to someone who can confidently express our ideas with others and even give opinions.

In addition, we never had enough courage to easily try unknown things in the past, and now we know clearly that the experience accumulated after trying will be the best way to promote our growth. As a student of the international dual degree program, there must be some hardships during the study journey, but the growth and accomplishment that the experience gives us have made us great progress in all aspects. We would say that this must be one of the most worthwhile experiences for us.

4 Conclusion

Through the international dual degree program, we experienced several new things that required us to make adjustments. Such as the improvement of English ability and changing the mind of accepting new things, etc. Transversal skills make us confident to show our opinions to others and manage a team. In today's society, more and more people emphasize one's international competitiveness, many people seek to have experience of studying abroad or working abroad. The friends we have known from many other countries during this study journey also plays an important part in the way we improve our self-competitiveness. Apart from this, we not only gain professional knowledge, but also experienced a lot of different cultures by visiting some famous local attractions after classes.

Overall, studying for a dual degree program can not only reduce the amount of money spent in the past to study abroad and the time required to study a second degree, but also graduate early and enter the workplace as early as possible. We had gained international learning experience, enhance our international competitiveness, and make ourselves a sought-after talent for multinational companies at the same time. Although there are good times and bad times in this experience, we still believe no matters the internal or external growth we earned would be worthwhile in our life.

5 References

Da Xue Wen (2019), Education Information Platform: https://www.unews.com.tw/News/Info/2983

Kuder, M., & Obst, D. (2009). Joint and double degree programs in the transatlantic context: A survey report. New York: Institute of International Education.

Li, B. L. (2010). Practices and challenges of international dual degrees: The perspective of state universities. Paper presented at the 2010 AIEA Conference, Washington, DC.

Ministry of Education, College Affairs Information Open Platform：https://udb.moe.edu.tw/ReportCategories

How to Create Sustainable Future through Curriculum in Higher Education

Tatiana Salimova[1], Elena Soldatova[1]

[1] Economics Department, National Research Mordovia State University, Saransk, Russian Federation

Email: tasalimova@yandex.ru, elensold@mail.ru

Abstract

Sustainable Development has been the core concept of society development for the last decades. The 2030 Agenda for Sustainable Development has become the turning point in new global Sustainable Development framework. Education as a key instrument plays one of the important roles in promoting Sustainable Development philosophy including 17 Sustainable Development Goals among society to empower everyone to contribute to achieving the ambitious and crucial global Agenda. Integration of Sustainable Development Goals in educational and research programs allows to involve education representatives, policy makers, civil society actors and other stakeholders in raising awareness, generating knowledge and making decisions focused on three Sustainable Development dimensions – economic, social and environmental ones at different levels. The objective of this paper is to define inclusion of Sustainable Development aspects in curriculum in Higher Education Institutions and identify teaching tools and methods to motivate students to get new knowledge in Sustainable Development Goals, transform their behaviour for sustainable future and disseminate Sustainable Development values among wide range of stakeholders – business society, local and regional authorities and communities, etc. This paper presents a review of five year-experience in integrating Sustainable Development values and principles in curriculum accumulated by National Research Mordovia State University. The study is based on content analysis of Master's programs curriculum, qualitative analysis of perceived values and challenges relating to Sustainable Development Goals in the view of Master students and their inputs to the goals achievements. The findings illustrate some measures that may be adopted in order to enhance methodology and develop teaching tools to integrate Sustainable Development philosophy in Higher Education Institutions' curriculum. It also should be reinforced at different levels of University programs in different subject fields.

Keywords: sustainable development goals; higher education for sustainable development; curriculum; interdisciplinarity; values; behaviour.

1 Introduction

Sustainable development (SD) is considered as a holistic and integrative concept that combines different dimensions and values from the perspective of economic, social and environmental aspects and their impact on future generations. Discussions about the term 'sustainability' in the academic circles and society continue despite its definition mentioned in the Brundtland Report as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987). A common ground for different definitions of SD does exist and is summarised by Leal Filho *et al* (2009):

(a) refers to long-term prospects with ecological, political, economic and societal implications, (b) is a dynamic process, whose implementation depends on due consideration of social processes of which individual engagement and participation are essential elements and (c) depends on concerted efforts and cannot be based on action by a few countries or local actors if it is to be implemented on a global level.

The 2030 Agenda for SD (United Nations, 2015) has become the turning point in new global SD framework. The 17 Sustainable Development Goals (SDGs) are global in nature, universally applicable and interlinked.

Education plays one of the important roles in promoting the SD philosophy including SDGs among society to empower everyone to contribute to achieving the ambitious and crucial global Agenda. Engaging society in sustainable-related issues and making individuals sustainability change-makers require the knowledge, skills, values and attitudes that will empower them to take informed decisions and responsible actions for environmental integrity, economic viability and just society for present and future generations.

Education is considered both as "a goal in itself and a means for achieving all the other SDGs. It is not only an integral part of sustainable development, but also a key enabler for it" (UNESCO, 2017). Many HEIs worldwide are implementing strategies for attaining 17 SDGs through a whole institutional approach. The approach involves rethinking the curriculum, campus operations, organizational culture, student participation, leadership and management, community, relationships and research. Applying the whole institutional approach to implement the new philosophy at University may require even reframing HEI's vision, mission and values and restructuring it according to the priorities. Reorganization and reframing will necessitate extensive resources in certain cases but outputs be worth it (Maykova et al, 2017).

First of all, mainstreaming SD in education requires integrating SD issues into curriculum. Development of sustainable curriculum allows to improve the capacity of Higher Education Institutions (HEIs) to prepare people to pursue SD through changing their values and motivation, upgrading their knowledge, transforming their behaviour (Salimova et al, 2015). Young people will play a crucial role in achieving the SDGs since they have more to offer the challenge of SD; they have the skills and energy to deliver impact now. In 2025 the global student population in Further and Higher Education will reach more than 260 million (Goddard, 2011). Therefore students are becoming active agents in achieving SDGs that requires development of specific competences relevant to all goals.

Competences cannot be taught but have to be developed by the learners themselves. They are acquired during action on the basis of experience and reflection (UNESCO, 2015a). According to the UNESCO Competences Framework (UNESCO, 2017) the cross-cutting competences are crucial to be developed: systems thinking, anticipatory, normative and strategic competencies, collaboration, critical thinking, self-awareness and integrated problem-solving.

The competences are essential for applying available knowledge and expertise to address particular sustainability issues at a systemic level (in the social sphere and in policy-making), but they also work at a personal level guiding individual choices and lifestyle formation (Stoof *et al*, 2002; Dlouhá *et al*, 2019; Wamsler, 2020). It is for this reason that one of the key principles of the study is moving from a teacher-centred to a student-oriented approach. So, in other words, the teacher and the student collaborate in learning through the following "domains": "Learning to know"→"Learning to do"→"Learning to live together"→"Learning to be". Therefore, the importance of active learning strategies as a device to enhance meaningful learning and provide evidence from students that it helps to increase their engagement in learning are increasing (Fernandes *et al*, 2014).

This paper provides a reflexive case study of Master students' consciousness about SD priorities and their opportunities to achieve the SDGs. Therefore, the purpose of the study is to define inclusion of SD aspects in HEI curriculum and identify teaching tools and methods to transform students behavior for sustainable future and disseminate SD values among wide range of stakeholders – business society, local and regional authorities and communities, etc.

2 Materials and Methods

The study draws on different types of methods, such as content analysis of Master's programs curriculum, qualitative analysis of perceived values and challenges relating to SDGs from views of Master students in 2016-2020 academic years and mind mapping of the students inputs on the SDGs achievement. It should be noted that the study of student reflections is a part of the course "Sustainable Development Management".

2.1 Data collection

Data collection during the study included 2 stages. In the opening stage of the study Master's programs curricula implemented at National Research Mordovia State University were collected. It was revealed that 10 out 83 Master's programs curricula implemented in 2016-2020 academic years included different SD aspects. The second stage included the study of Master students' viewpoints as to SDGs' achievement. Participants for this study comprised 156 students enrolled for the course "Sustainable Development Management", represented two different Master's programs: "Entrepreneurship for Sustainable Development" and "Integrated Management Systems" in 2016-2020 academic years. The reflective thinking tasks were developed with regard to a SDGs perspective, aiming to explore students' perceived values and challenges related to SDGs. For ethical reasons, some of the background information on the students – such as age and the country of origin – was not accounted in the study. It was suggested to use the following framework to complete the task:

– Specify the SDGs that you consider to be priority and most important for development of mankind future.
– Make a critical reflection about your contribution to achieve each of 17 SDGs.

The students uploaded their responses to the reflective thinking tasks to the University eLearning environment system. These responses were extracted from the system and compiled in an excel file. The excel file was used for the value analysis and mind-mapping that showed reflection on inclusion of the students in achieving SDGs.

2.2 Data analysis

For the purposes of the study a set of methods were formed following the UNESCO Competences Framework and taking into account the necessity to develop cross-cutting competences of students both at the systemic and the individual levels. Therefore, content analysis of Master's programs curriculum refers to the systemic level and allows to identify the capacity of HEIs to upgrade students' knowledge in SD. Qualitative analysis of Master students' values provides with evaluation of students' behaviour transformation and their readiness to be involved in communities and joint activities. Analysis of results received from critical reflection about students' contribution to the SDGs achievement enables to identify their values and motivation to act as active agents in achieving SDGs and disseminate SD values among wide range of stakeholders – business society, local and regional authorities and communities.

At the first stage content analysis of Master's programs curricula were carried out. As a result of collecting Master programs implemented at the University 10 programs were selected. The criterion for selection of the programs was their Sustainable Development orientation.

Holsti (1968) defined content analysis as "any technique for making inferences by systematically and objectively identifying special characteristics of messages". Content analysis is a research tool used to determine the presence of certain issues, aspects, themes, or concepts within some given qualitative data (i.e. text). Using content analysis, it is possible to quantify and analyze the presence and, meanings of such certain points. In relation to our study the content analysis of Master programs curricula allowed to identify the programs focused on different SD dimensions. To meet the requirement, the methodology offered by Colombo & Alves (2017) studying sustainability in engineering programs, was applied. The curriculum of each Master program implemented at the University was analyzed and the courses with a title related to the SD dimensions – Environmental, Social and Economic were counted and registered in an excel file. After the courses were identified their objectives and learning outcomes were interpreted and analyzed.

The next stage of the study was supposed to include analysis of qualitative data received by the students' reflection on priority and most important SDGs for development of mankind future and their contribution to achieve each of them.

Bhattacherjee (2012) defined qualitative analysis as the analysis of qualitative data such as text data from interview transcript. The emphasis in qualitative analysis is "sense making" or understanding a phenomena. A creative and investigative mindset is needed for qualitative analysis, based on an ethically enlightened and participant-in-context attitude, and a set of analytic strategies.

At the final stage of carrying out the analysis mind mapping as a tool of structuration and visualisation of students inputs to the SDGs achievement was applied. The mind map allowed to represent a variety of students' views and main patterns of their potential contribution to attaining SDGs and evaluate importance of the goals from the perspective of students' perception.

3 Results and Discussion

Results of the content analysis of 10 Master's programs curricula carried out from the perspective of SD dimensions are showed in Table 1.

Table 1. Sustainable Development Dimensions of Master's programs.

Master programs	Sustainable Development Dimensions		
	Environmental	Social	Economic
Green Building	√	√	
Ecology and materials, products, structures saving in Construction	√		√
Geoecology	√		
Environmental management	√		√
Ecology	√		
Fundamental biotechnology	√		
Cultural heritage preservation		√	
Social protection and social services for families and children		√	
Integrated Management System	√	√	√
Entrepreneurship for Sustainable Development	√	√	√

The analysis revealed that only 2 out of 10 Master's programs curricula contained all three SD dimensions – environmental, social and economic ones: Integrated Management System and Entrepreneurship for Sustainable Development. 3 Master's programs curricula include two aspects: Ecology and materials, products, structures saving in Construction and Environmental management were focused on environmental and economic dimensions, Green Building – environmental and social ones. 5 Master's programs curricula were targeted at separate SD issues – environmental or social one. Environmental dimension dominated in 8 out of 10 Master's programs curricula.

For further analysis purposes 156 students enrolled for two Master's programs in 2016-2020 academic years - Integrated Management System and Entrepreneurship for Sustainable Development which contained all three SD dimensions (30-40 students per year at average) were involved in the study.

Answering a question about the priority of SDGs for development of mankind future, students ranked each goal by significance from 0 – "lack of significance" to 1 – "the key priority". Thus, each goal could score a maximum value of 1. The total value of all SDGs could be 17 based on the number of the goals. The criterion (quantitative) of the goals priority by year was identified at more than 0.5. The main results of the students' reflections are summarized below in Table 2 (average evaluation for each year and SDG).

Table 2. SDGs in perception of Master students (value analysis).

Year	1 NO POVERTY	2 ZERO HUNGER	3 GOOD HEALTH AND WELL-BEING	4 QUALITY EDUCATION	5 GENDER EQUALITY	6 CLEAN WATER AND SANITATION	7 AFFORDABLE AND CLEAN ENERGY	8 DECENT WORK AND ECONOMIC GROWTH	9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	10 REDUCED INEQUALITIES	11 SUSTAINABLE CITIES AND COMMUNITIES	12 RESPONSIBLE CONSUMPTION AND PRODUCTION	13 CLIMATE ACTION	14 LIFE BELOW WATER	15 LIFE ON LAND	16 PEACE, JUSTICE AND STRONG INSTITUTIONS	17 PARTNERSHIPS FOR THE GOALS
2020	**0,83**	**0,94**	**0,88**	**0,94**	**0,88**	**0,94**	**0,88**	**0,88**	**0,82**	**0,67**	**0,79**	**0,83**	**0,94**	**0,71**	**0,94**	**0,82**	**0,76**
2019	**0,87**	**0,81**	**0,91**	**0,96**	**0,91**	**0,90**	**0,91**	**0,87**	**0,78**	**0,71**	**0,63**	**0,87**	**0,83**	**0,67**	**0,96**	**0,96**	**0,83**
2018	**0,73**	**0,76**	**0,95**	**0,85**	0,48	**0,96**	**0,80**	**0,65**	0,49	**0,53**	0,49	**0,75**	**0,80**	**0,56**	**0,89**	**0,75**	**0,55**
2017	**0,79**	0,49	**0,93**	**0,58**	0,29	**0,82**	**0,89**	**0,56**	0,27	0,34	0,24	**0,69**	**0,82**	0,27	**0,79**	0,49	0,43
2016	**0,82**	0,36	**0,87**	0,45	0,18	**0,73**	**0,91**	0,36	0,18	0,19	0,17	0,50	**0,64**	0,20	0,82	0,36	0,18

Firstly, in 2016 only five SDGs (SDG1 – No poverty; SDG3 – Good health and well-being; SDG6 – Clean water and sanitation; SDG7 – Affordable and clean energy; SDG13 – Climate action) were marked as priority. Secondly, in 2017 the number of priority goals increased to 9. To the above mentioned goals SDG4 – Quality education; SDG8 – Decent work and economic growth; SDG 12 – Responsible consumption and production; SDG15 – Life on land were added. Thirdly, in 2018 other 5 goals were included in the students' priorities: SDG2 – Zero hunger; SDG10 – Reduced inequalities; SDG14 – Life below water; SDG16 – Peace, justice and strong institutions and SDG17 – Partnerships. Finally, in 2019 – 2020 academic years all 17 SDGs were identified by students as having priority for SD.

From the students' perspective, the highest priority goals, which value increased during the study period and in 2020 amounted to more than 0.9, have been SDG2 – Zero hunger, SDG3 – Good health and well-being, SDG6 – Clean water and sanitation, SDG13 – Climate action and SDG 15 – Life on land. At the same time, the greatest increase (more than 3 times) in value for the students is observed in relation to the following goals: SDG5 – Gender equality (4,8 times); SDG9 – Industry, innovation, and infrastructure (4,5 times); SDG10 – Reduced inequalities (3,5 times); SDG11 – Sustainable cities and communities (4,6 times); SDG14 – Life below water (3,5 times); SDG17 – Partnerships (3,3 times).

Therefore, qualitative analysis of students' reflections allowed to identify the increase in value of all 17 SDGs confirmed by the growth of the total evaluation – doubling in 5 years, from 7,92 in 2016 to 14,45 in 2020 (maximum estimation of the all SDGs' total value could be 17 as mentioned above).

As it was mentioned earlier mind mapping was used to visualise results of the students' reflections and their replies on the SDGs that reflected their values and motivation to contribute valuable input on achieving the SDGs. The students answered the question: "Please make a critical reflection about your contribution to achieve each of 17 SDGs". Segments of the students' most common reflections linked to each of 17 SDGs are presented in Figure 1. Most of their responses match the results of the qualitative analysis described above. The SDGs marked by the students as priority revealed more reflections and replies on their input to achieving the goals both now and in the future. They are SDG1 – No poverty; SDG2 – Zero hunger; SDG3 – Good health and well-being; SDG4 – Quality education; SDG13 – Climate action; SDG 15 – Life on land.

Their replies also reflect the use of knowledge and expertise to address particular sustainability issues both at the systemic and the personal levels. For instance, for SDG 15 – Life on land "use USB drive instead of paper" or "no buying a real New Year Tree" are an individual choice and "support National Parks and Nature Reserves" or "saving biodiversity ecosystems" are the decisions at the systemic level respectively. "Educate children and grandchildren saving seas and oceans" (for SDG 14 – Life below Water) highlights the students' views to attach much impotence to SD issues not only now but in the future.

4 Conclusion

This paper presents the experience of National Research Mordovia State University in the roll-out of its approach to promoting the Sustainable Development oriented course as a means of embedding SDGs, research-based teaching and learning in the Master' programs curricula. The study shows the need for changes at both the systemic and the individual levels in the context of SD knowledge.

Regarding the systemic level the study shows the importance of expanding the number of programs that include all three SD dimensions – environmental, social and economic ones, as well as introduction of these programs with regard to their interdisciplinary approach. It also should be reinforced at different levels of the University programs in different subject fields.

For the individual level, the findings illustrate an approach that may be adopted to enhance the methodology and develop teaching tools to integrate the SD philosophy in HEI curriculum. Special attention should be paid to applying active learning strategies (Research based learning, Project and Problem based learning) to increase the level of students' awareness and consciousness regarding the importance of SDGs for current and future generations, and their inputs in achieving the goals. Emphasizing learning domains with regard to SD competences thus shows not only the needs for balanced development of the systemic and the individual levels, it also may help to identify desirable learning processes that may be initiated through appropriate active learning strategies.

To conclude, our findings suggests that linking students' values and perceptions regarding SDGs with their promoted actions will require to motivate them for getting new knowledge in SDGs, transform their behavior for sustainable future and create an environment for the activity ("Learning to be") of new agents promoting the SD ideas in their daily lives.
Actively considering existing critiques and challenges, systemic and individual transformations could be a pulsion for improvement of Education for Sustainable Development and SDGs achievement.

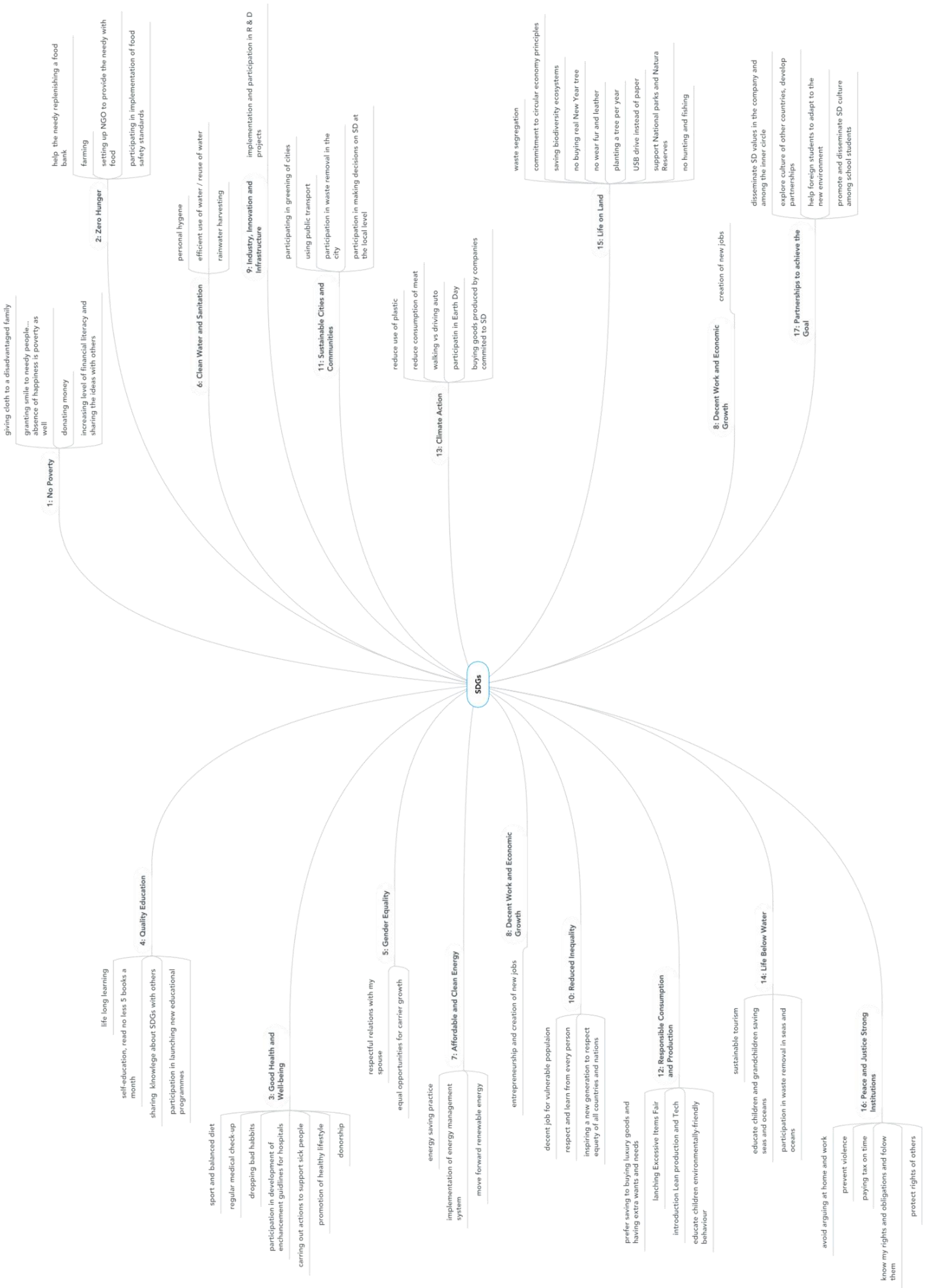


Figure 1. Mind mapping of students inputs on the SDGs achievement.

5 References

Bhattacherjee A. (2012). Social Science Research: Principles, Methods, and Practices. Available at: http://scholarcommons.usf.edu/oa_textbooks/3/ 2012 Global Text Project

Colombo, C. R., & Alves, A. C. (2017). Sustainability in engineering programs at a Portuguese Public University. Production, 27. https://doi.org/10.1590/0103-6513.221416

Dlouhá, J.; Heras, R.; Mulà, I.; Salgado, F.P.; Henderson, L. (2019). Competences to Address SDGs in Higher Education—A Reflection on the Equilibrium between Systemic and Personal Approaches to Achieve Transformative Action. Sustainability, 11, 3664.

Fernandes S., Mesquita D., Flores M. A. & Lima R. M. (2014) Engaging students in learning: findings from a study of project-led education, *European Journal of Engineering Education*, 39:1, 55-67, DOI: 10.1080/03043797.2013.833170

Goddard, B. (2011). Making a Difference: Australian International Education, University of New South Wales Press, Sydney.

Holsti O. R. Content analysis. The Handbook of Social Psychology, G. Lindzey, E. Aronson. Addison-Wesley, Reading, MA 1968; Vol. 2

Leal Filho, W., Manolas E., Pace P. (2009). Education for sustainable development: current discourses and practices and their relevance to technology education // Int J Technol Des Educ 19:149–165 DOI 10.1007/s10798-008-9079-z.

Maykova S.E., Okunev D.V., Salimova T.A., Soldatova E.V. (2017). Modeling organisational management structure of the united university. *Integratsiya obrazovaniya = Integration of Education*.; 21(3): 421-440. DOI: 10.15507/1991-9468.088.021.201703.421-440

Salimova T., Guskova N., Neretina E. (2015). Education for sustainable development in Russia: problems and challenges. *International Journal of Innovation and Sustainable Development*. Vol.9 No.3/4, pp.246 - 261 DOI: 10.1504/IJISD.2015.071855

Stoof, A.; Martens, R.L.; van Merriënboer, J.J.; Bastiaens, T.J. (2002). The boundary approach of competence: A constructivist aid for understanding and using the concept of competence. Hum. Resour. Dev. Rev., 1, 345–365

UNESCO. 2015a. Rethinking Education. Towards a global common good? http://unesdoc.unesco.org/images/0023/002325/232555e. pdf (Accessed 16 October 2016)

UNESCO (2017). Education for Sustainable Development Goals: Learning Objectives. Paris, UNESCO.

United Nations (2015). Transforming our world: the 2030 Agenda for Sustainable Development. Resolution adopted by the General Assembly on 25 September 2015. http://www.un.org/ga/

Wamsler C. (2020). Education for sustainability. Fostering a more conscious society and transformation towards sustainability. *International Journal of Sustainability in Higher Education*. Vol. 21 No. 1, pp. 112-130. DOI 10.1108/IJSHE-04-2019-0152

World Commission on Environment and Development (1987). The Report of the World Commission on Environment and Development 'Our Common Future, Available at: http://www.undocuments.net/our-common-future.pdf (accessed on 13 February, 2014).

Active Learning Workshops Production: Impacts and Benefits for Engineering Students

Arthur R. Costa[1], Emily M. B. Cornelio[2], Fernanda R. Silva[3], Filipe A. Batista[1], Larissa P. C. Santos[1], Marcus J. A. Oliveira[1], Carla M. C. C. Koike[4], Dianne M. Viana[1]

[1]Faculty of Technology, University of Brasília, Brasília, Brazil
[2]Gama Faculty, University of Brasília, Brasilia, Brazil
[3]Department of Education, Faculty of Education, University of Brasília, Brasília, Brazil
[4]Department of Computer Science, University of Brasília, Brasília, Brazil

Email: arreico@gmail.com, emilly.mbcornelio@gmail.com, fernandarose27@gmail.com, filipe.aziz@gmail.com, larissapsanntos@gmail.com, marcus.jesse1@gmail.com, ckoike@unb.br, diannemv@unb.br

Abstract

This article presents an account of the authors' experience on the preparation, implementation, and follow-up of active learning workshops for motivating the learning in robotics. The active learning strategies used range from “flipped classroom” and “guided practice” to “hands-on" and collaborative learning. The target audience of the workshops are undergraduate students that are going to replicate these workshops, under professor's supervision, to high school students, intending to introduce projects in robotics as tools for studies in math and physics. The workshops format is similar to the final desired structure: three days with two of these days committed to learning concepts and skills that will be employed on the third day dedicated to building a robotic car toy. The theme of the first day is "3D Modelling and Printing", with an introduction to modelling using CAD software to prototype a piece. On the second day, the theme approached is "Arduino Programming Workshop". Finally, on the last day, the students consolidate the knowledge gathering the information obtained during the previous workshops to build, program, and test the robotic car toy. The third workshop was applied for testing in two small groups of undergraduate students and the results were obtained for further improvements. In this article, the impact of the workshops on engineering student's education is described. The technical and not technical knowledge and skills reported by the authors include learn how to prepare lesson plans, additional experience in the workshop themes, communication skills improvement, in other words, the author’s self-development process is discussed and related to the results of the workshop.

Keywords: Engineering Education; PBL; Hands on activities.

1 Introduction

Educational robotics has been highlighted among Science, Technology, Engineering, and Mathematics (STEM) teaching-learning techniques. As a multidisciplinary area, robotics requires an organization of tasks ranging from planning to the assembly of the robot and its programming, and therefore, it is necessary for the full construction of a functional robot that amount of knowledge related to mechanical, programming, electronics and electrical engineering be combined to understand how robotics work (Cambruzzi & Souza, 2015). For this reason, when used as a teaching method, robotics can help in the understanding of physical and mathematical concepts and also bring pieces of knowledge about programming and electronics.

Furthermore, because they are attractive, robots instigate the curiosity of students, making them feel motivated to solve problems related to the assembly and programming of the robot. Moreover, depending on the robot used for classes, a robot can hold many electronic components that require different types of codes to work, which makes the use of robots in STEM teaching-learning complex, depending on what the teacher wants to teach, and fun, by allowing the creativity of students decide what the robot can do.

In this context, for even more effective learning, active methodologies can be used in classes. The active learning, differently from traditional teaching methodologies aims to imbue more knowledge in a more dynamic and interactive way, in the form of games, research, debates, among others. According to Felder & Brent (2009, p. 2) “Active learning is anything course-related that all students in a class session are called upon to do other than simply watching, listening and taking notes”. The authors reiterate that active learning happens, for example, when students ask a question, propose and discuss a problem, work individually or in small groups to solve problems and call for other groups to share responses. Felder & Brent (2009) also points out that a teacher is not doing active learning when lectures, asks questions that the same few students always answer, or conduct debates that only a few students show efforts to discuss.

However, implementing a teaching-learning method so different from what both tutors and students are already used to presents a great challenge. Given this, it is evident the importance of the tutor's role in the implementation of active methodologies. Several studies show that the tutor is a fundamental link concerning knowledge management, therefore, the training of tutors must involve several dimensions of learning: interaction, cooperation, cognition, metacognition, and affection (Medeiros & Faria, 2003).

This article discusses the benefits obtained by students involved in the production of three robotics workshops, and the impacts of these benefits on their academic life and future professional life. This study is divided into six sections. In the introduction, we addressed the relevance of the topic to society. In the second section, it is defined as the type of methodology used for this research, and in the third section, there is a literature review of the topic divided into two subtopics about Active Learning and PBL. In the fourth section, we discussed the results of the research explaining the three workshops and also analyze questionnaires sent to all students present in the workshops. In the antepenultimate section, we present conclusions and implications of the workshops for the students in question, and finally, in the last section, we list the bibliography about the topic developed.

2 Research Methodology

This study provides an analysis of the benefits obtained by undergraduate engineering students in the production of three workshops related to robotics that were applied in three days and tested on undergraduate students to train them to gain sufficient knowledge to later act as tutors in the workshops that will be later applied in high schools.

The three workshops are linked, since, the first and second ones are essential to the understanding of the third one. The first workshop, 3D Modelling and Printing, had as it is the main goal to use CAD software to model a wheel, later used in a robotic car that was assembled in the third workshop. In this first workshop, different manufacturing techniques were approached and finally, the wheel drawing made by the present students in the workshop was printed on a 3D printer. The second workshop, Arduino Programming Workshop, addressed basic questions about programming and electronics using the prototyping board Arduino. Ultimately, the third and last workshop gathered the knowledge obtained in previous workshops for the mounting of a robotic car. In this workshop, the Problem-Based Learning methodology was used, where the students received parts of the robotic car, an Arduino with electronic components and had, in groups of 3 or 4 people, to assemble and program the robotic car themselves so that it could work.

About the production, five students participated in the elaboration of the workshops and acted as tutors, and of these five, two also participated as apprentices in different parts of the workshops. At the end of those, forms were sent to tutors and apprentices to analyze questions about the teaching-learning methodologies used and to get suggestions for improvements for future workshops.

3 Literature Review

In this section, we are going to present, a literature review about the active learning methodologies and their importance in the educational context.

3.1 Active Learning

As highlighted by Prince & Felder (2006), the traditional teaching methods in which the teacher lectures about a topic and then gives students homework is a demotivating and inefficient methodology, since it takes the students to focus only on activities and exams, and not properly on the reasons they must learn what is being taught or how to apply the knowledge acquired in class. Consequently, traditional teaching techniques may be a problem for engineering students who have to learn how to apply theoretical knowledge to solve problems.

According to Berbel (2011), active methodologies use real or simulated experiences to develop new ways of learning to successfully solve problems arising from social practice activities. In this way, the active methodologies aim to learn by practising, with more autonomy by the students and making them protagonists in their learning, using discussions, practical activities in group and examples that bring the subject close to the student's daily life.

Faust & Paulson (1998) while suggesting exercises to increase student's active participation in classes, affirm that active learning develops critical thinking and writing and analysis skills, besides as help hone argumentative skills. The author exposes the flexibility of the active methodologies, showing how to suit it to each student, adapting it to each learning style.

Srinath (2014) reaffirms the importance of using practical examples, as it helps students to understand introduced concepts and visualize their applications. Therefore, examples shall illustrate concepts – making the theory more accessible – and teach how to apply this knowledge in other situations. Demonstrations facilitate to connect theory and practice, not eliminating theory but complementing it.

But though students usually respond positively to the active methods, some of them can show resistance. According to Tharayil et al. (2018), it can be reduced by making simple actions, like walk around the room and talk with students individually or in groups. The instructor must create a comfortable environment for the students to ask and answer questions without feeling intimidated.

Felder & Brent (2009) suggest a variety of strategies in which students can actively learn. One of these strategies is what they call Thinking-aloud pair problem solving (TAPPS). In this case, one of the students must act as an explainer and explain concepts or texts step by step to other students, and these students must question the explainer student when they feel that something has not been well explained or until there are still doubts.

When acting as a tutor a student must study concepts, prepare a class, analyze ways to pass on knowledge and act as an explainer, making the student the protagonist of his learning. In the end, the student has to make the effort to learn very well to be capable to explain what they know and, when asked questions, the tutor must remember what studied and explain in the better way they can to clarify doubts. Therefore, when acting as a tutor a student learns in the preparation of the class and in the class itself, whereas when a student can explain a concept to another person, this student truly understands what studied (Srinath, 2014).

3.2 Project Based Learning – PBL

According to Barbalho (2017), studies related to teaching methodologies have shown that several universities understand that in the area of engineering there should be a concern to use traditional teaching methodologies. Traditional teaching methodologies lead students to focus on memorizing specific contents for tests, directing all their efforts to pass evaluations, which results in students who do not fully understand what they are studying and the possible ways in which this memorized knowledge can be applied.
Engineering students may have problems with traditional teaching methodologies given that one of the skills developed by an engineer must be the ability to apply physics and mathematics to solve problems. One of the active methodologies that can help with the problem described previously is problem-based learning (and also the project-based learning, with the same acronym PBL), that according to Berbel (2011), was introduced in Brazil in medical courses, but has now also been used in other courses.

According to Hmelo-Silve (2004), psychological research and theory suggest that PBL can help students to learn content and thinking strategies. The author affirms that in the PBL methodology the process of learning is student-centred. In it, a complex problem is given but this problem doesn't have a single answer, so the students must work with other students to think strategies to solve the problem. In PBL the teacher must act as a facilitator of the learning process rather than say all the strategies and knowledge needed for solving the problem. Hmelo-Silve (2004) reiterates that the goals of PBL are to help students to develop flexible knowledge, effective problem-solving skills, a self-directed learning (SDL), effective collaboration skills and intrinsic motivation.

Allen, Donham & Bernhardt (2011) also affirm that in PBL students work in groups to solve complex problems, and although this methodology is most of all used in medical education, problem-based learn can influence positively in the integration of new knowledge with an already existing one in the education of undergraduate students. The authors also point out that "faculty members frequently adopt PBL to help students develop lifelong learning skills" (p. 25) which is exercised along the undergraduate course and continues to be exercised along with professional life.

4 Results

In this section, we discuss, details of the workshops and also present a questionnaires analysis that were applicated to the tutors at the end of each workshop.

4.1 3D Modelling and Printing Workshop

The 3D Modelling and Printing workshop was the first one to be realized. In it, the main objective was to teach the students how to model simple parts using a CAD software called *Solidworks,* a computer graphics software that allows the modelling of numerous objects, and finally to present the required steps for 3D printing. To achieve these goals, it was decided that the design made by the students would be a wheel of a robotic car (Figure 2) that would be later assembled by them in the third workshop. Knowing that the workshop was divided into five stages:

1. A quiz with simple questions about simple machines and physical and mathematical concepts, subjects discussed in a material sent to the students the day before the workshop took place. The test was done and accessed by the students through the *Kahoot!* platform;
2. A theoretical exposition about simple machines, gear types, speed reduction, torque and power;
3. A practical activity where the students, with instructions from the tutor, designed in *Solidworks* a wheel of the robotic car;
4. An explanation on how to use the *Solidworks* Toolbox library to design a cylindrical spur gear;
5. A presentation about the different types of manufacturing, that are: subtractive manufacturing such as turning and milling, additive manufacturing and the main 3D printing technologies. In the end, the students could see the printing of the robotic car wheel they drew.

The technological evolution has allowed us today to print 3D objects. In some universities still, there are no specific subjects about 3D printing and therefore the opportunity to know the necessary steps to print an object, from modelling to the calibration of the printer, is important in the training of an engineer in a future where 3D printing will be much more used than it is today. On the figure 1, there is a picture of the car wheel being printed.

The competitiveness of the market requires that companies often seek improvements in product development processes. With this objective, commonly, physical prototypes are used to help in the communication of the teams responsible for these improvements and to minimize failures, and, because they are tested in their real use environment, something that is often not possible to do through digital simulations, physical prototypes are an irreplaceable step in the technological development (Volpato, 2018) (Wiltgen, 2019). For reasons like these, additive manufacturing methods, or commonly called 3D Printing, are processes that must be known by an engineer.

In our university, there are no subjects that approach directly the use of printers for additive manufacturing, and for this reason, the 3D Modelling and Printing workshop has brought benefits to tutors, bringing an additional experience to students who already knew how to handle a printer and knowledge to students who would not have this contact through subjects during their course.

About CAD modelling, besides *Solidworks,* there are many types of CAD software. This type of tool is extremely important for engineers, especially those responsible for creating projects because it allows the modelling of parts and elaborate drawings. In the early semesters of engineering, it is common to learn technical drawing norms with the help of software similar to *Solidworks* and as future engineers, the knowledge of tools of this type is essential for the creation of new projects.

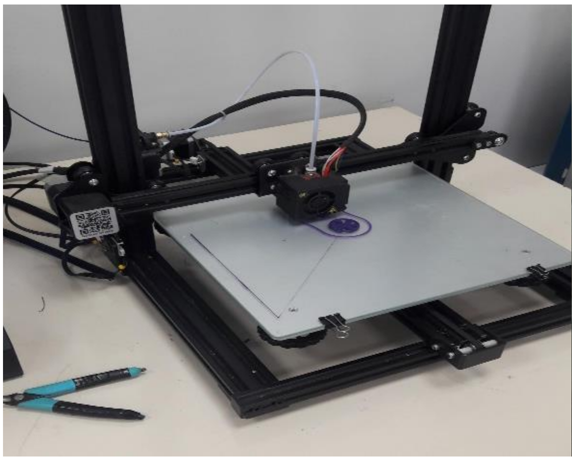


Figure 1. The car wheel being printed.

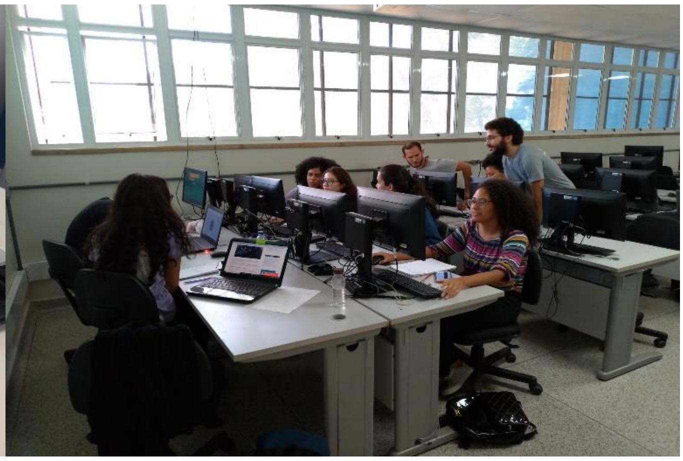


Figure 2. Students doing the car wheel using Solidworks software.

4.2 Arduino Programming Workshop

On the second day, the workshop consisted of teach Arduino Programming. The workshop started with theoretical explanations using images to help the understanding of the students (Figure 3), for which the projector was used for the slide show and the responsible tutor who developed the topics, explained the contents always bringing examples of real-life to help the understanding of the learners since that is substantial that the Education "contextualize the contents of the curriculum components, identify strategies to present them, represent them, exemplify them, connect and display the requirements, based on the reality of the place and the time in which the learning takes place are located." (BNCC, 2015, p. 16).

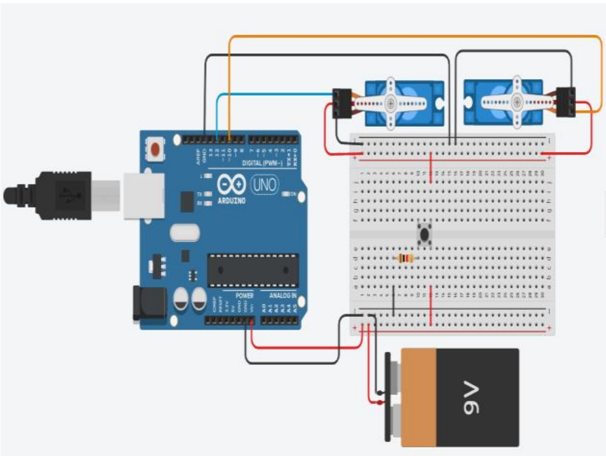


Figure 3. Arduino circuit

The explanations covered the basic concepts of electronics such as electric current, electric voltage, resistance and Ohm's Law, the operation of some electronic components, such as source, protoboard, resistor, potentiometer, LED, buttons and motors, was also explored computation and programming focusing on the basics of the C language and finally, there was the introduction to Arduino and its basic operation.

Although programming and electronics knowledge is important for engineers, some courses such as mechanical, civil and environmental engineering, do not address more than one or two subjects about these areas. According to the National Curricular Guidelines of the Engineering Undergraduate Course (2019) in force in the Brazilian territory, all engineering course qualifications must include basic Algorithms and Programming contents. However, such programming disciplines given for engineering courses that do not work directly with the construction of algorithms are not intended to train programmers, but only introduce basic concepts of programming logic and problem-solving through algorithms (Marcussi et al. 2016).

Programming and electronics are important knowledge that all engineers should have. During engineering graduation, students learn how to solve daily problems in different ways and the logic used to program would be of great help in this development. When programming, the problem is understood, a solution is found and a resolution strategy is drawn up, that is, the ability to solve problems is developed.

In the job market, even though it is not required, having knowledge of programming and electronics in the curriculum often helps in hiring and also in the execution of the profession. The technology is disseminated in practically all professions, consequently, the more knowledge related to electronics and programming, the easier it is to optimize the tasks to be done, to correct problems, among others. That way, all engineers would benefit from having at least a little knowledge of programming and electronics.

In this context, the programming workshop with Arduino serves as an incentive for engineering students to seek to understand more about the subject. For those who have not felt encouraged to dedicate time from their undergraduate studies to these topics, the programming workshop with Arduino serves as an introduction that can later help them understand simple programming and electronic problems.

4.3 Knowledge Integration: Car Toy Construction

Finally, the last workshop focused on the assembly and programming of a robotic car (Figure 4). The students were separated in groups of three or four and then they received kits with loose parts of the car, a battery, an Arduino and some electronic components. This workshop required from the students the knowledge already obtained in the two previous workshops, especially the programming and electronics knowledge obtained in the Programming with Arduino workshop. The steps of the workshop were:

1. Assembly of the robotic car;
2. Circuit assembly;
3. Programming the car so that it could move;
4. Try to go through a predetermined circuit.

All activities were conducted using the active PBL methodology. Under no circumstances did the responsible tutors explain what was to be done, but they were there in case there was any problem that needed intervention.

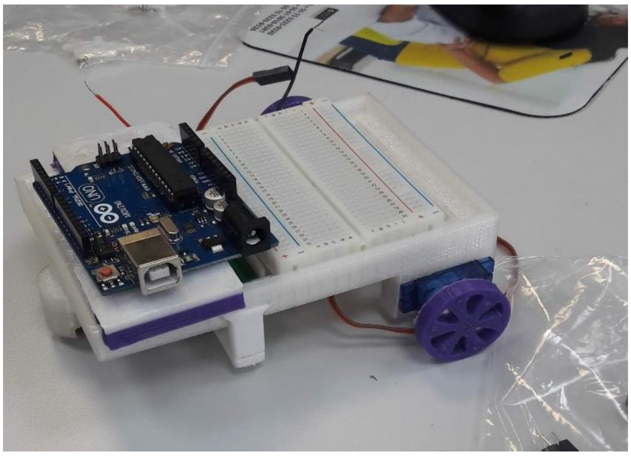


Figure 4. The robotic car assembled by students.

During the production of the workshops there were several modifications to the prototype of the robotic car, which exercised group work and the ability to transmit ideas, in addition to promoting experience in projects. The choice of components led to a better understanding of the characteristics of each actuator used in the prototype (attributes, advantages and disadvantages for each application).

4.4 Questionnaires analysis

After all the three workshops, the tutors had to respond a questionnaire about their impressions and thoughts over their practice to reflect on the strategies and methods adopted by tutors and their role in these practices based on active learning methodologies - flipped class, guided practice, hands-on and, mainly, the so-called PBL (Problem Based Learning).

Regarding the first day, when asked about the use of the active methodologies in the teaching-learning process, we had positive feedbacks emphasizing that such process becomes more efficient and interesting when the students are actively participating.

When comes about the difficulties faced in the class plan realization and the application of it, the didactic aspect and the capacity of adjusting the language were the ones elected, that is, of explaining complex things easily.

Finally, concerning what that experience add as an engineer's students and personally, the answers were: "I learned new things before even studying undergraduate"; " I realized that I have to improve my didactic ability, for the contents be understandable to everyone" and "Being tutor, I could observe details that are going to help me to prepare better workshops in the future". In contrast, aspects that have to be improved were; "Theoretical classes about Physics concepts"; "We need to develop our didactical skill", etc.

In the second workshop, the tutor pointed out that the students were very participative during the application of active methodologies, contemplating one of the active learning characteristics.

"Yes", was the answer when asked: Did you create opportunities to stimulate the autonomous and critic thought of the students? That answer reveals that when the student has autonomy, she/he becomes a proactive individual, able to solve problems more easily, inside and outside the educational context, and learns to be critical about what she/he thinks and produces.

Lastly, the experience added as an engineer's students and personally, become the realization that it is not easy to plan a class and neither put what was planned in practice, even more when the apprentices do not know the subject taught.

The last one workshop, when questioned about the importance of the robotic for education, was mentioned that the Educational Robotics allows that the students develop reasoning, promotes the interaction between student-student and student-tutor, and also motivate the high school's alumni to choose a STEM career. It is important to cite that, the Educational Robotics emerged around 1960, when its pioneer Seymour Paper developed his theory of constructionism and advocated the use of computers in schools as a resource that attracted children (Wildner, 2015) being a powerful tool that is changing the way of teaching.

It is relevant to say that in this specific workshop, the PBL methodology was used, so the tutor considered that did not have any difficulty on planning the class using this resource motivating the robotics learning since the apprentices were very participative and interested in assembling the car toy.

The last item was concerning the experience added and as in the others workshops, the conclusion was that the understanding some teaching methods can help to identify good study methods for tutors themselves who are also students and as future engineers should never stop learning.

5 Conclusion

Given the above, it can be concluded that the active learning workshops were quite productive and successful, even though there were some difficulties encountered during the planning and execution of the same, we managed to achieve our goals.

It is clear that such workshops, with their playful and practical nature, arouse the interest, curiosity and motivation of students in the teaching-learning process and that we, tutors, when we are teaching, we are learning at the same time that we interact with the apprentice, valuing autonomy, stimulating the exchange of knowledge, aspects these, essentials in active learning.

Finally, with the results obtained, the workshops will be improved for later application with high school students and new workshops will be created. It is hoped, therefore, that this work has contributed to the reflection of the theme.

6 References

Allen, D. E., Donham, R. S. & Bernhardt, S. A (2011). Problem-Based Learning. *New Directions For Teaching And Learning*. 21-29. doi: 10.1002/tl.465

Barbalho, S. C. M., Reis, A. C. B., Bitencourt, J. A., Leão, M. C. L. A. & da Silva, G. L. (2017). Project Based Learning approach for Production Planning and Control: analysis of 45 projects developed by students. *Production, São Paulo,* 27, 1-16. doi: 10.1590/0103-6513.225916.

Berbel, N. A. N. (2011). Active methodologies and the promotion of student autonomy. *Semina: Social Sciences and Humanities*, 32 *(1)*, 25-40. doi: 10.5433/1679-0359.2011v32n1p25.

BNCC, Ministry of Education (2015). National Common Curriculum Base. *Brasília, MEC. Available in:* <http://basenacionalcomum.mec.gov.br/images/BNCC_EI_EF_110518_versaofinal_site.pdf.>.

Brazilian Association of Higher Education Maintainers. National Curriculum Guidelines of the Engineering Undergraduate Course. *Available in*: https://abmes.org.br/arquivos/legislacoes/Resolucao-CNE-CES-002-2019-04-24.pdf.

Cambruzzi, E. & De Souza, R. M. (2015).Educational Robotics in the learning of Programming Logic: Application and Analysis. *IV BRAZILIAN CONGRESS OF INFORMATICS IN EDUCATION, 2015, Maceió. Brazilian Computer Society - SBC.* doi: 10.5753/cbie.wie.2015.21.

Faust, J. L. & Paulson, D. R. (1998). Active learning in the college classroom. *Journal on Excellence in College Teaching*, 9 (2), 3-24.

Felder, R. M. & Brent, R. (2009). Active Learning: An Introduction. *ASQ Higher Education Brief,* 2, 1-5.

Hmelo-Silver, C. E. (2004). Problem-Based Learning: What and How Do Students Learn?. *Educational Psychology Review*, 16(3), 235-266.

Marcussi, L. D., Guedes, C., Filho, R. G. D. M., Filho, R. M. S. & Junior, C. R. B. (2016). Pesquisa no Ensino de Algoritmos e Programação nas Engenharias: Estudos e Resultados Preliminares. *Simposium of Production Engineering.*

Medeiros, M. F & Faria, E. T. (2003). Educação a distância: cartografias pulsantes em movimento. *EDIPUCRS*, Porto Alegre.

Prince, M. J. & Felder, R. M (2006). Inductive Teaching and Learning Methods: Definitions, Comparisons, and Research Bases. Journal of Engineering Education. 123-138.

Srinath, A. (2014). Active Learning Strategies: An illustrative approach to bring out better learning outcomes from Science, Technology, Engineering and Mathematics (STEM) students. *International Journal of Emerging Technologies in Learning, 9 (9), 21-25. doi: 10.3991/ijet.v9i9.3979.*

Tharayil, S., Borrego, M., Prince, M., Nguyen, K. A., Shekhar, P., Finelli, C. J. & Waters, C. (2018). Strategies to mitigate student resistance to active learning. *IJ STEM, 5 (7), 1-16, doi:* 10.1186/s40594-018-0102-y.

Volpato, N. (2018). Manufatura aditiva: tecnologias e aplicações da impressão 3D. *Publisher Edgard Blucher, 1 ed, 401.*

Wildner, M. C. S. (2015). Robótica Educativa: Um Recurso Para o Estudo de Geometria Plana no 9º Ano do Ensino Fundamental. *Univates University Center, Rio Grande do Sul.*

Wiltgen, F. (2019). Protótipos e Prototipagem Rápida Aditiva - Sua Importância no Auxílio do Desenvolvimento Científico e Tecnológico. *doi:* 10.26678/ABCM.COBEF 2019.COF2019-0441.

Collaborative Manufacturing Systems: Active Learning from Its Name

Kunlapat Thongkeaw[1], Thanate Ratanawilai[1], Wanida Rattanamanee[1], Pisut Koomsap [2], Duangthida Hussadintorn Na Ayutthaya[2], Wasawat Nakkiew[3]

[1] Department of Industrial Engineering, Prince of Songkla University, Songkhla, Thailand
[2] Department of Industrial Systems Engineering, Asian Institute of Technology, Pathumthani, Thailand
[3] Department of Industrial Engineering, Chiang Mai University, Chiang Mai, Thailand

Email: tkunlapat@eng.psu.ac.th, thanate.r@psu.ac.th, wanida.r@psu.ac.th, pisut@ait.asia, duangthidahna@gmail.com, wasawat@eng.cmu.ac.th

Abstract

Collaboration among partners to form a value network has become necessary as sharing of information at all levels from among physical units on the shop floor to connect with external business processes is so critical for being competitive in a market. Therefore, a course on Collaborative Manufacturing Systems has been recently developed to build students' competence in this aspect. Presented in this paper is how this course has been developed according to the learning experience-focused course design and development process (LEF-CDD). Bloom's Taxonomy, Kolb's experiential learning cycle, and the LOVE learning experience have been utilized for identifying learning outcomes, for planning learning activities for ease of learning, and for the selection of teaching and learning methods for offering a diversified learning experience along their learning journey respectively. Based on the design, the students will actively learn from class discussion, laboratory works, and a term project.

Keywords: Collaborative manufacturing; Bloom's Taxonomy; Kolb's experiential learning cycle; LOVE model; Course Design and Development

1 Introduction

The manufacturing sector continues to have high competition due to product variations and complexity in production. This leads to increase cost of product as a primary driving factor. One solution to drive cost down is to improve efficiency, implement new technology and strengthen company growth. A collaboration between machines, manufacturing systems, or companies is also another way to decrease cost. Interaction with each other seamlessly and instantaneously, in some instances, a collaborative manufacturing systems is needed to adopt. The effective collaborative manufacturing systems would bring a better integration of their product and production processes, planning, and strategies.

Collaborative manufacturing systems can be defined as sharing information between business processes across internal or external partners in the value chain network (McClellan, 2003). In the similar sense, collaborative manufacturing management is defined as "the practice of managing by controlling the key business and manufacturing processes of a manufacturing enterprise in the context of its value networks (ARC Advisory Group, 2001). This capability requires the use, application, integration and synthesis of multiple standards and technologies within and between manufacturing enterprises. The sharing system of information communication, service, production processes, the produce progress of production line, or even the delivery scheduling would achieve to fully ensure the satisfaction of the customers.

The collaborative partners in the value chain networks should be able to share any information even sensitive information such as occasional performance, design of products and expense in manufacturing process. The collaboration also requires the relationship among plant and enterprise applications, markets, value chains, and manufacturing nodes. The objective of collaboration should be consistent and mutually aligned among all partners. In addition, the strategies of collaborative manufacturing are frequently focused on four main areas:

product life cycle management, inventory/production synchronization, distribution order fulfilment and manufacturing enterprise collaboration (McClellan, 2003).

However, the collaboration does not mean to putting every piece of data in a central database. More commonly, a few data sharing requirements were specified, and then make a point-to-point connection for data transformations. Many new systems became candidates for integration, for instance, a manufacturing execution system (MES) as the central integrating point or the Middleware or Enterprise Application Integration (EAI) solutions, which were built on standard messaging systems. When supply chain is included to the focus of manufacturers, the business process needs to included value chain partners to be well suited to business-to-business (B2B) integration (McClellan, 2003). This kind of platform uses plant level production management systems to plan, commit and manage production based on actual demand rather than usual forecast. The advantage of the web could be used for information sharing from variety systems of each enterprise. As a result, collaborative manufacturing systems focus on ways to gain benefits from the Internet and develop technologies to become more competitive.

Collaborative manufacturing system is therefore a connecting between the plant floor to external systems such as internal business processes and external business processes to share information throughout the enterprise. Collaborative manufacturing systems could be strengthening the enterprise to compete as a highly flexible and responsive operation to the flexible demands of customers by using value network partners (Mark Allen Engineering Ltd, 2002).

In general, the process begins with collaboration among value chain members to share information including rules and mechanisms of revenues, costs, marketing, the product and solution design, and business processes. The appropriate plant will receive the order through the value network. Then, the information on the progress of manufacturing process and the quality control will be electronically reported to the related partner. Finally, the product will be delivered with the satisfaction of the customer. It is clear to express that collaborative manufacturing system is not only connecting the Internet to the plant floor, but also including a fundamental change in the strategic value proposition for manufacturers. The collection of systems, processes, and technologies could support and enable manufacturers to have more effectively compete through collaboration with strategic partners (Mark Allen Engineering Ltd, 2002).

The objective of this paper is to create knowledge and develop technical competence for better understanding of future emerging sustainable smart manufacturing systems. The course is creating knowledge and is developing technical competence for better understanding of future emerging sustainable smart manufacturing systems. The course is structured around advanced approaches to manufacturing processes, including manufacturing strategies, high-speed machining, flexible tooling, tool-less assembly, generative numerical control, adaptive and predictive process control, embedded sensors, data and simulation, and nanotechnology.

2 Current Learning and Teaching on Collaborative Manufacturing System

As mentioned above, the knowledge of collaborative manufacturing system becomes important for the 21th century. The collaboration is not only sharing information, but also including well management in the value chain network. To achieve the management of collaboration manufacturing system, four main areas of product lifecycle, inventory/production integration, order distribution, and manufacturing enterprise collaboration are considered (McClellan, 2003). Managing collaboration is not easy to implement to be successful, it requires skills of complex problem solving, critical thinking, people management, etc. to cope with. Therefore, the preparation of knowledge on collaborative manufacturing system for student to be ready for work is necessary. From reviewing literature, rarely existing courses are related to collaborative manufacturing system, and the knowledge about collaboration is mostly presented in terms of subtopics inside the courses. For example, the knowledge of collaborative product development has been discussed in courses of Cloud Manufacturing (Production Engineering Department. 2014) or Concurrent Engineering and Product Life Cycle Management (Mechanical Engineering Department. 2015). Although some knowledge of collaboration in shop floor level, such as collaborative robot has been existed as a course (Carlisle and Sivadas, 2018), the understanding of value chain network in collaborative manufacturing system is insufficiency. Thus, the course design and development that includes multi-dimensional collaboration in manufacturing system is important.

Beside the knowledge presenting in the existing courses, most of them adopt a conventional teaching and learning approach of knowledge-focused teacher-centered learning that instructors will decide the content what the students should learn; develop teaching and evaluating methods according to the content; and then attempt to make connections between the learning outcomes and teaching and learning methods (Bowen,2017). As the result of this, students may not achieve to learning outcomes. Student-centered learning has been approved to be an effective approach for engineering education in the 21th century (Mohd-Yusof, 2017). According to this concept, students are imposed in an active role that improve their learning outcomes to be able to apply knowledge for problem solving, rather than remember and understand. Instructors should pay attention to select appropriated teaching and learning methods for students to gain good learning experience. Therefore, this study aims to the course design and development on collaborative manufacturing system, using Learning experience-focused concept. Bloom's Taxonomy theory is applied for identifying learning outcomes, while. Kolb's experiential learning theory and LOVE model are employed to design teaching and learning method activities. These will be introduced in the next section before the propose approach for course design and development on collaborative manufacturing system.

3 Learning Experience-Focused Course Design and Development

A study reports that more than half of existing teaching and learning methods provide the same type of learning experience (Hussadintorn Na Ayutthaya and Koomsap, 2019). A group of researchers in engineering education has then been paying attention to selecting appropriate teaching and learning methods for good learning journeys (Koomsap et al., 2019). They have recently developed a backward course design approach entitled 'Learning Experience-Focused Course Design and Development (LEF-CDD)' which put an emphasis on the utilization of Bloom's Taxonomy (Shabatura, 2018), Kolb's Experiential Learning Cycle (Kolb, 1984) and the LOVE learning experience model (Hussadintorn Na Ayutthaya and Koomsap, 2017). LEF-CDD aims to obtain a well-designed journey that offers a strong learning experience leading to competence development. Teaching and learning methods are well selected and arranged into the designed journey to foster student experiential learning cycle for every single topic of a course. Along the journey, the majority of students will be engaging with learning activities that assist them in achieving the expected learning outcomes of the course.

With LEF-CDD, a course developer begins by establishing the objective of a course, followed by applying Bloom's Taxonomy to set up the expected learning outcomes that the students, after completion of the course, should be able to perform. At this point, the developer will normally start designing course contents, but with LEF-CDD, the course developer is asked to think about how to assess the students regarding the set course learning outcomes. The course contents are next designed. Learning topics can be seen as touchpoints and are connected to establish a learning journey. A better understanding of the current topic eases the students learning on subsequent topics. Therefore, Kolb's model is applied to create an awareness of the course developer on how each of the topics should be taught such that a cycle can be closed for the topic. The LOVE model is applied along with Kolb's model for the proper selection of the teaching and learning methods to make the learning experience interesting and effective.

4 LEF-CDD for Collaborative Manufacturing System

This section shows the LEF-CDD application for the Collaborative Manufacturing System. The following contents are presented conforming to LEF-CDD process.

4.1 Collaborative Manufacturing System

The Collaborative Manufacturing System course is a 3-credit course consisting of 30 lecture hours and 45 laboratory hours. Students will learn and practice how to apply collaboration in manufacturing system and manage manufacturing collaboration in a teamwork environment. The course development concentrates on student-centered learning. Teaching and learning materials are included with various type, such as slides, videos, case study, games, computer simulation, etc. During lecture session, students are encouraged to participate actively in the discussion. To gain in-depth understanding of the course, some topics such as; plant simulations, collaborative machines, collaborative robots and collaborative material handling system are required to do laboratories. In addition, project based learning are assigned to students to develop and practice several skills; teamwork, decision making, communication, problem-solving, conflict resolution and critical thinking. Presentation are also defined in group projects and individual assignments for personal development and knowledge sharing. In sequence, the application of the LEF-CDD process for Collaborative Manufacturing System will be illustrated by presenting the course objective, the expected course learning outcomes (CLOs), the assessment scheme, the course outline and the planned learning experiences, classified according to the Kolb's and LOVE model.

Course Objective:

Collaboration among partners to form a value network has become necessary as up-to-date information is so critical in a competitive market. Sharing of information among a network of physical units on the shop floor and connecting internal manufacturing processes and business processes with external business processes allow a company to offer a core competence with flexible, responsive operations meeting the expectations of customers and the value network partners. This course aims to build students' competence in collaboration in manufacturing from the board picture of collaborative manufacturing management down to collaboration on a shop floor. The students will learn from concepts, applications, and hands-on experience.

Learning Outcomes:

The students on the completion of this course would be able to:

CLO1: Recognize a potential collaborative manufacturing in a factory (understand)

CLO2: Identify a value network for collaborative manufacturing for a business (apply)

CLO3: Apply collaborative manufacturing management in practice (apply)

CLO4: Manipulate collaborative robots for collaborative tasks (apply)

CLO5: Manage manufacturing collaboration on a shop floor (apply)

Assessment scheme:

Course assessment approaches are divided into two methods; formative assessment and summative assessment, as shown in Table 1. It can be seen that class discussion and participation will be the main methods to assess CLO1, while peer assessment in class activities predominantly involve CLO3-5. Presentation and group projects are defined in summative assessment as the activities are more suitable to evaluate at the end of learning.

Table 1. Assessment methods applied to achieve CLOs

Assessment Method/CLOs	CLO1	CLO2	CLO3	CLO4	CLO5
Formative Assessment Method					
Class discussion and participation (5%)	9	9	3	3	3
Peer assessment in class activities (5%)	3	3	9	9	9
Practical exercises (20%)		3	9	9	9
Assignments (10%)		9	9	3	3
Summative Assessment Method					
Presentation (10%)		3	3	9	9
Group project (50%)		3	9	9	9

Note 9: Strong; 3 Moderate; 1: weak)

Course Outline:

In this course, three modules are developed based on the learning outcomes. The module's contribution to CLOs is presented in Table 2. In addition, four main laboratories including; laboratories on plant simulation, collaborative machines, collaborative robots and collaborative material handling system are developed to increased students experiences. The topics covered in this course are illustrated in Table 3, and according to learning activities in the course, the sequence of learning stages is determined. Learning experiences based on are also analyzed from teaching and learning method used.

Table 2. Module's contribution to Course Learning Outcomes

Course Module/CLOs	**CLO1**	**CLO2**	**CLO3**	**CLO4**	**CLO5**
Module I: Collaborative Manufacturing Management	9	9	3	1	1
Module II: Machines Collaboration on a Shop Floor	3	1	3	9	9
Module III: Man-Machine Collaboration on a Shop Floor	3	1	9	9	9

Note 9: Strong; 3 Moderate; 1: weak

Table 3. Learning Experience Embedded Course Outline-Collaborative Manufacturing System

Module	Subtopic	Sequence of learning stages (Learning experience)			
		AC	AE	CE	RO
I. Collaborative Manufacturing Management	1. Evolution of Manufacturing Systems	1(LO)		12(LE)	13(L)
	2. Collaborative Manufacturing Management Model	2 (LO)	3(E)	12(LE)	13(L)
	3. Collaborative Manufacturing Management Fundamentals and Infrastructure	7(LO)	4(LE)	5(LO)	6(L)
	4. Ontology for Collaborative Manufacturing	10(O)	11(LE)	8(VL)	9(L)
II. Machines Collaboration on a Shop Floor	1. Distributed Manufacturing	17(LO)	18(O)	15(LO)	16(L)
	2. Distributed Arrival Time Control for Real-Time Scheduling	22(LO)	19(LE)	20(LO)	21(L)
	3. Collaborative Material Handling System	23(LO)	24 (LE)	25(LE)	26(L)
	4. Collaborative Manufacturing Processes	27(LO)	28 (LE)	29(LO)	30(L)
III. Man-Machine Collaboration on a Shop Floor	1. Evolution of Man-Machine Collaboration	31(LO)	32 (LE)	39 (LO)	40 (L)
	2. Industrial human augmentation systems	33(LO)	34 (LE)	39 (LO)	40 (L)
	3. Flexible Human-Robot Collaboration	35(LO)	36 (LE)	39 (LO)	40 (L)
	4. Cyber-Human System	37(LO)	38 (LE)	39 (LO)	40 (L)
	Entry stage				
	Fulfil during the group project				

4.2 Discussions

As shown in Table 3, a sequence of learning steps and leaning experience have been introduced into the topics. Based on Kolb's learning cycle (Kolb, 1984), learning has a cycle of four stages; abstract conceptualization (AC), active experiment (AE), concrete experience (CE) and reflective observation (RO). The sequence of learning is defined to be a cyclic order and the teaching and learning methods from LOVE model (i.e. L:Learning, O:Observing, V:Visiting and E:Experimenting) are selected for each learning stage. It can be noticed that AC is the common entry stage for most of the topics because of the modern topics. The abstract conceptualization can navigate student to understand the whole concept of each topic before learning in details. Most of learning cycles are completed in CE and RO stages with group project activities to ensure that students understand and can apply the knowledge for solving problems. The active teaching and learning methods of L and E are frequently seen in the learning experience. These results students have competence to achieve the CLOs. The combination of LEF-CDD, Kolb's learning cycle and LOVE model was employed for Product Design and Development course for teaching master's students at Asian Institute Technology and Thammasat University, Thailand (Koomsap et al., 2019). It was found that students' feedbacks were positive as they were encouraged to express their ideas and improve thinking in different ways. The participant-centered learning in a team environment and learning experiences with respected to Kolb's and LOVE models influence students to complete each learning topic effectively. The teaching and learning of Collaborative Manufacturing System course with the LEF-CDD concept has not conducted yet. Nevertheless, it can believe that students will gain more experiences, knowledge and skills to have their competences for future world.

5 Conclusion

Collaborative manufacturing has become necessary for businesses to compete in a market as it is sharing information across internal or external partners in the value chain network. The preparation of students' competence to be ready for this emerging knowledge is important. Therefore, a course design and development on Collaborative Manufacturing Systems is presented in this paper. The approaches of Bloom's Taxonomy, Kolb's experiential learning cycle, and LOVE learning experience have been applied through LEF-CDD process. The course objective, learning outcomes, assessment scheme and course outline and teaching and learning activities have been conducted. From the designed course, students are put in an active role from the activities of class discussion, laboratory works, and a term project. As the result of this, students will improve their competence to apply the knowledge and skills in other unseen problem.

6 References

McClellan M., 2003. Collaborative manufacturing: A strategy built on trust and cooperation, ‖ Control Solution International, vol. 12, pp. 27-31

ARC Advisory Group. 2001. Collaborative Manufacturing Management Strategies, ARC Strategies, ARCweb.com, pp. 1-28

Bowen, Ryan S. 2017. Understanding by Design. Vanderbit University Center for Teaching. Retrieved June 15, 2020 from https://cft.vanderbilt.edu/understanding-by-design/

Carlisle, B. and Sivadas, A. 2018. Collaborative Robot Safety: Design & Deployment, Coursera. Retrieved June 15, 2020 from https://www.coursera.org/learn/collaborative-robot-safety#syllabus

Hussadintorn Na Ayutthaya, D., and Koomsap, P. 2017. Assessment of Student Learning Experience with 'LOVE'. In: 11th International Technology, Education and Development Conference, INTED2017, INTED2017 Proceedings, pp.1973-1982, Valencia, Spain. doi: 10.21125/inted.2017.0588.

Hussadintorn Na Ayutthaya, D., and Koomsap, P. 2019. LOVE-Based Teaching and Learning Method Classification. In: 13th International Technology, Education and Development Conference, INTED2019, INTED2019 Proceedings, pp. 3521-3529, Valencia, Spain. doi: 10.21125/inted.2019.0914.

Kolb, D.A. 1984. Experiential Learning: Experience as the Source of Learning and Development. Englewood Cliffs., New Jersey: Prentice-Hall

Koomsap, P., Hussadintorn Na Ayutthaya, D., Nitkiewicz, T., Lima, R.M., and Luong, H. T. 2019. Course Design and Development: Focus on Student Learning Experience. In: 11th International Symposium on Project Approaches in Engineering Education (PAEE) and 16th Active Learning in Engineering Education Workshop (ALE), PAEE/ALE' 2019, PAEE/ALE'2019 Proceedings, pp. 144-153, Hammamet, Tunisia. Retrieved from https://paeeale.esprit.tn/wp-content/uploads/2019/06/PAEE_ALE_ 2019_PROCEEDINGS.pdf

Mark Allen Engineering Ltd/ The Engineer, 2002. A brief history of collaborative manufacturing. Retrieved June 15, 2020 from https://www.theengineer.co.uk/a-brief-history-of-collaborative-manufacturing/

Mechanical Engineering Department. 2015. 10ME7107 Concurrent Engineering and Product Life Cycle Management, M.Tech Manufacturing Systems Management (Mechanical Engineering), Kerala Technological University [PDF File]. Retrieved June 15, 2020 from https://ktu.edu.in/eu/att/attachments.htm?download=file&id=fv4Qc7J8OzbTmq7iTcawswzvjZqZU4lMa5GoIVQZE7U%3D

Mohd-Yusof, K. 2017. Sustaining Change for PBL at the course Level. In PBL in Engineering Education, SensePublishers, Rotterdam, pp. 13-32.

Production Engineering Department. 2014. 07PE7119 Cloud Manufacturing, M.Tech Manufacturing Systems Management (Production Engineering), Kerala Technological University [PDF File]. Retrieved June 15, 2020 from http://gectcr.ac.in/wp-content/uploads/2014/07/M07-12-Manufacturing-Systems-Management.pdf

Shabatura, J. 2018. Using Bloom's Taxonomy to Write Effective Learning Objectives. Accessed 10 February 2019. https://tips.uark.edu/using-blooms-taxonomy/

Double Degree M.Sc Program on Industrial Safety Engineering with Aerospace Application: A Case Study

O. Ivanova[1,2], M. Ivanov[1], M. Kuznetsov[1], A. Aleksandrov[1], R. Revetria[2]

[1] Bauman Moscow State Technical University, Moscow, Russia
[2] University of Genoa, Genoa, Italy

Email: olgaivanova@bmstu.ru

Abstract

The paper describes an experience of Bauman Moscow State Technical University (Russia) and University of Genoa (Italy) in design and implementation of a double degree M.Sc. program "Master in Industrial Safety Engineering" with its application to the aerospace industry. Preparatory phase, elaboration of the double curricula, students' enrolment and transfer of records and award of the diploma is presented in the paper. The application to the aerospace has been carried out by introducing research topics related to space exploration. An example of such topic is provided. Results of the double degree implementation have demonstrated its efficiency and usefulness. Students show high interest to the program and study hard in order to obtain two diplomas.

Keywords: Double degree, case study, curricula.

1 Introduction

Today in the era of globalization, internationalization and World-wide reforms universities, which often used to find themselves competing against one another in a struggle to attract students, donors, best talents and best research resources, are now seeking partnerships outside their country borders in order to meet the challenges and opportunities that internationalization and Europeanization of higher education offers. (van der Ploeg and Veugelers, 2008 and Lyapuntsova et al., 2020). Cooperation is always more fruitful than competition. However, the aerospace industry was traditionally considered one of the most conservative and classified. This resulted in additional difficulties in establishment of a collaboration of any kind between different countries (Levinzon, Suleyman, Tsarkova, 2019 and Briano, Catania, Revetria, 2008). Among different types of university partnerships one can distinguish participation in associations, academic mobility of students and staff. Of the most complicated and advanced form of such collaboration is students' education performed by two or more universities simultaneously.

Such partnership programs may be generally divided into two types: double degree programs and joint degree programs (Johnstone et al. 1998 and Lyapuntsova et al. 2019).

Joint degree program assumes study of the students at both universities simultaneously and ends up with awarding of a single diploma with signatures and stamps of all universities who were delivering studies (Carnoy, 2000). Although this is the most advanced type of study program it can't often be realized in many countries of the World including Russia as it requires changes in national higher education regulations (Tatarinov, 2019 and Drobyshev et al., 2019).

Double degree programs deliver studies by all participating universities in a consecutive way, students' study firstly in one university and then move to another. All records achieved in the partner universities have to be transferred to their home universities according to the regulations established between the universities. The studies end up with award of several diplomas: one per each partnering university. In this case study program in each university may slightly change and adapt to the local regulations. This makes it much simpler in many cases to award the degree and perform studies. Furthermore, after graduation students obtain several diplomas of higher education at once.

Thus, the double degree program was chosen as it was considered by us as more applicable and easily implemented.

2 Description of the Double Degree Program

The study program has been developed together by the department of Ecology and Industrial Safety of Bauman Moscow State Technical University (BMSTU) in Moscow, Russia and Department of Mechanical and Electronical Engineering at University of Genoa (UNIGE) in Genoa, Italy. Bauman Moscow State Technical University is well known for its aerospace developments and researches. University of Genoa also performs a lot of studies applied for aerospace. Furthermore, both universities have found that the topic of industrial safety may be considered as the most versatile and advanced. Also, a positive experience of invited lectures UNIGE professors at BMSTU was used as a good basement for double degree establishment.

In 2017 a cooperation agreement between BMSTU and UNIGE has been signed on development of a double degree program "Master in industrial Safety - MISE". This agreement has considered all the issues that may occur during program implementation. These are selection and enrolment of students, ensuring student mobility among both universities, ensuring teachers exchange, approval of the rights of the students in each university, preparation and defense of the master thesis, award of the certificates and diplomas, actions in case of students' academic failures, issues related to financial and general management of the activity and other minor issues. Last but not the least the cooperation agreement introduced the selection criteria admission and study program itself.

General flow of the students is presented at Figure 1.

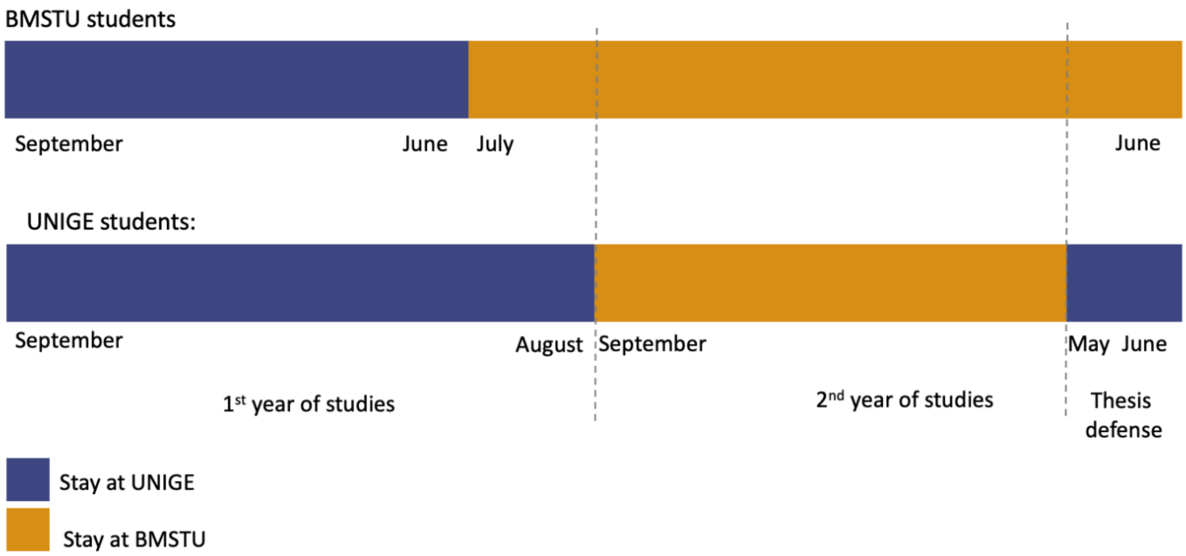


Figure 1. General student academic mobility at MISE program.

It fixes two mobility plans: from the students originally of BMSTU and originally of UNIGE. Both groups start studies in September (beginning of the term) and end in June (end of the term). The thesis defense always is done in the home institution. This means, that originally BMSTU students stay and study at UNIGE from September to June of the first year. In July they move to their home institution and end their studies there. UNIGE students, on the other hand, spend their first year at their home institution and move to BMSTU only in the beginning of September. They stay there until May-June and then come back to Italy to do the thesis defense.

It is important to mention that both participating universities have already had similar programs taught in their native languages: Master in Analysis and Management of Natural and Human-related risks (Area of Specialization 20.04.01 Safety in Technosphere) in BMSTU and Laurea Magistrale in Safety Engineering for Transport, Logistics, and Production classe LM26 in UNIGE. Therefore, contents for many courses has been already prepared. After comparison of the programs it was concluded that among courses that may be recognized equally by both universities, however, there are some courses that are delivered only in one of the participating universities (Table 1.).

Subjects in Table 1 are recognized by both universities if they are allocated in front of each other and not marked with any color. Otherwise, the subjects are delivered only by one university, i.e. Technologies for safety, security, and infomobility and Theory and Analysis of transport systems are delivered only in UNIGE and Methodology of scientific research and Dynamic risk analysis are delivered only in BMSTU. This means that two programs combined in any case would have a higher workload than individually. This would require more study time from students, higher motivation and exceptional skills.

In order to perform correct recognition of the studies a table of grades equivalence was elaborated. It is presented in Table 2. Subjects that considered to be equal are located in front of each other.

Table 1. Comparison of the study programs of UNIGE and BMSTU.

UNIGE		BMSTU	
№	**Subject**	**№**	**Subject**
5.1.	Technologies for safety, security, and infomobility		
3.1.	Theory and Analysis of transport systems		
3.2.	Planning and design of transport systems		
4.2.	European Union Law and Transport Policy		
5.2.	Telecommunications networks		
7.1.	Safety and security of transport systems		
7.2.	Integrated and sustainable transport systems		
		B3.	Methodology of scientific research
		10	Dynamic risk analysis
		12	Economics of environment safety
		E17	Applied methods of natural and man-made emergencies risk analysis
		Pr19	Pedogogical practicum
6.2.	Production quality and sustainability	9	Theory of risk analysis and management
9.	Industrial Logistics	E14	Risk and reliability of technical systems
		Pr23	Risk and reliability - Coursework
8.	Energy systems and environmental impact	11	Heat-mass exchange in biosphere
6.1.	Principles of industrial safety Engineering	B4.	Environment Safety Inspection
		Pr24	Environment safety inspection - Coursework
10.1.	Technologies for goods safety and security	6	Technosphere safety management
2.2.	Modelling and control of traffic systems	8	Mathematical modelling
E1.	Environmental mitigation strategies in coastal areas	E15	Risk analysis in case of emergencies in coastal areas

		B2.	Foreign language
E3.	Methods and models for decision support	B1.	System analysis and processes modelling in technosphere
		Pr25	Risk analysis and management - Courseproject
10.2.	Supply chain resiliency	7	GIS-technologies for risk analysis at hazardous objects
1.	Data analysis and mining	E13	Experimental planning and postprocessing
4.1.	Safety Engineering law	E16	State policy in risk management
2.1.	Optimisation and control methods	B5.	Control systems in technics
11.	Seminars and orientation	Pr21	Industrial practicum (4 weeks after 2 semester)
		Pr22	Prediploma practicum
		Pr18	Research
12.	Final exam	26	Final exam

Each successfully completed course is estimated in certain amount of ECTS credits. Students must acquire at least 30 ECTS credits in the home University and at least 30 ECTS credits of taught modules at the hosting University.

After all agreements have been made and all legal documents prepared the double degree program was initiated.

Table 2. Grades equivalence.

Grade	*Scale*		
	BMSTU	**UNIGE**	
Excellent cum laude	5+	30 cum laude	
Excellent	5	24-30	
Good	4	21-23	
Satisfactory	3	18-20	
Poor	2	0-17	
Pass	Pass	Pass	18-30
Fail	Fail	Fail	0-17
Did not attend	NA	Did not attend	DNA

3 Implementation of the Double Degree Program

After the study programme has been approved jointly by both institutions, a committee has been assigned to manage programme implementation. The committee consisted of members of both universities. The committee did selection of the students for first intake and managed their enrolment and further study process. First intake of the students was launched in September 2017. Three students from BMSTU and three students from UNIGE were enrolled to the program (Buldakova and Mikov, 2019 and Tatarinov et. al., 2019). First year of study was carried out in UNIGE according to the study plan. Russian students were allocated in UNIGE dormitories and provided with all relevant societal security.

All studies were done fully in English. To do this all study materials were translated into English and a series of study books were prepared. When possible, existing English literature was used.

After completion of the first-year students have moved to BMSTU, where they were also provided with the university dormitories and national social security.

Jointly by both universities it was decided that the MISE program will have an aerospace specialization. This was realized by introducing research topics related to ensuring human safety in space and space development projects. In example, one of the students' research projects was dedicated to safety design principles applied to a new manned reentry vehicle from space. This project reviews the study of the design and development of a Clipper landing vehicle.

This has been studied first in the last decade of the XX century as a new way to reach Space and to come back with a new technology which would have been reliable and reusable for at least forty years.

This analysis has been done to define the optimal characteristics with data and hypotheses found during the literature research with particular attention to the safety concepts and on the environmental impact of the facilities involved in the program.

After a theoretical analysis, with the support of programs such as Mathcad 15.0 ©, Autodesk® Inventor® Professional 2017 and SLAB, different considerations brought to the choice of which model of Clipper would be the best, among the configurations considered. Then how to develop the landing system and which rocket would be the most adapt in achieving a successful departure and return from Space.

In June-July 2019 all students have successfully completed and defended their theses in front of an academic board of their home institution. Partner institution was participating in the defense in person when the defense was in BMSTU or by means of remote internet connection when the defense was in UNIGE (Figure 2).

All students of the first intake obtained highest grades and were awarded with M.Sc diplomas cum laude of both universities.

The results of programme implementation were assessed by a committee consisting of members of both institutions. The committee agreed that project may be assessed as successful and should be repeated for the next intake. In September 2019 a second intake of students was launched. Three students from BMSTU have been sent for first year of studies to UNIGE.

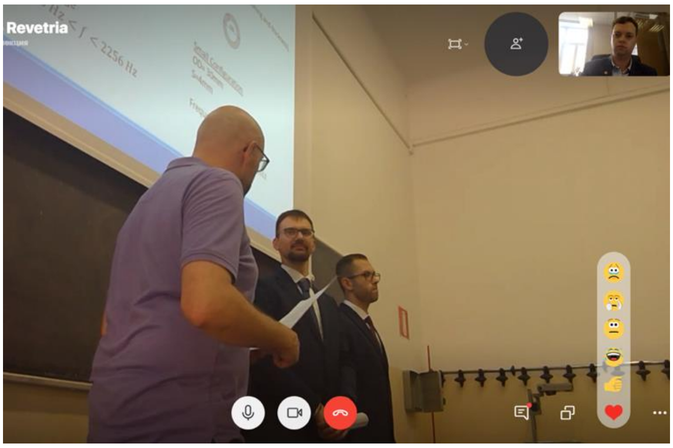


Figure 2. A remote connection for participation in final thesis defense at UNIGE.

4 Conclusion

As result it may be considered that MISE double degree program may be considered as a successful and useful experience. However, there were some difficulties in providing a scholarship to the students on the period of staying abroad; lack of free space in the dormitories; general decline of the teaching quality due to transition to non-native English language.

Nevertheless, students gain much broader knowledge that is provided by different universities in different countries; English language should not be considered as the main difficulty in teaching; 6 students in two years of studies have published 17 articles in Scopus journals.

5 References

van der Ploeg, Frederick, and Reinhilde Veugelers. "Towards evidence-based reform of European universities." CESifo Economic Studies 54.2 (2008): 99-120.

Lyapuntsova, E. V., Belozerova, I. M., Borkovskaya, V. G., Drozdova, I. I., & Baranova, Y. S. Organization and Management of Educational Work in Universities in the Light of National Strategic Guidelines for the Development of Education IOP Conference Series: Earth and Environmental Science, Volume 459, Chapter 5 (2020.

Levinzon, Suleyman V., and Natalia V. Tsarkova. "Criteria for evaluating the technical universities of the world using Forbes rating." 2019 54th International Universities Power Engineering Conference (UPEC). IEEE, 2019.

Briano, Enrico, Alessandro Catania, and Roberto Revetria. "e-learning: analysis development and opportunities of the new way of teaching in Italy." Proceedings of the Seventh IASTED International Conference. Vol. 610. 2008.

Johnstone, Donald Bruce, Alka Arora, and William Experton. The financing and management of higher education: A status report on worldwide reforms. World Bank, Human Development Network, Education, 1998.

L Lyapuntsova, E. V., Vdovichenko, M., Belozerova, Y., & Gorbatov, A. (2019, December). Application of modern modeling methods: virtual technologies in the era of digitalization and their role in modern companies. In Journal of Physics: Conference Series (Vol. 1425, No. 1, p. 012165). IOP Publishing..

Carnoy, Martin. "Globalization and educational reform." Globalization and education: Integration and contestation across cultures (2000): 43-61.

Tatarinov, V. V. "Methods of teaching fundamental disciplines to foreign students at Bauman Moscow State Technical University by the example of mathematics." AIP Conference Proceedings. Vol. 2195. No. 1. AIP Publishing LLC, 2019.

Drobyshev, D. V., K. A. Neusypin, and T. Yu Tsibizova. "Distance education in the training system of highly qualified personnel." AIP Conference Proceedings. Vol. 2195. No. 1. AIP Publishing LLC, 2019.

Buldakova, T. I., and D. A. Mikov. "Matlab application for information security risk analysis." AIP Conference Proceedings. Vol. 2195. No. 1. AIP Publishing LLC, 2019.

Tatarinov, V. V., U. V. Prus, and A. A. Kirsanov. "Decision support software for chemical accident elimination management." AIP Conference Proceedings. Vol. 2195. No. 1. AIP Publishing LLC, 2019. M., & de Graaff, E. (2017). The philosophical and pedagogical underpinnings of Active Learning in Engineering Education. *European Journal of Engineering Education, 42*(1), 5-16.

A Service Learning experience with engineering students

Sandra Fernandes[1,2], José Dinis-Carvalho[3]

[1]Portucalense Institute for Human Development – INPP, Portucalense University, Portugal
[2]Research Centre on Child Studies – CIEC, University of Minho, Portugal
[3]ALGORITMI Centre, Department of Production and Systems, School of Engineering, University of Minho, Guimarães, Portugal
University of Minho, Portugal

Email: sandraf@upt.pt, dinis@dps.uminho.pt

Abstract

Service learning is an educational approach that combines learning processes and community service in a single well-articulated project, in which all participants work on the real needs of the environment with the aim of improving it. The service learning experience presented in this paper aimed to provide students with the opportunity to develop technical and transversal skills in a real context of practice, taking also in consideration the social needs of the community and environment where the students are inserted. The participants in the study included seven teams of students, with 3 to 5 group members each, enrolled in the curricular unit called "Lean Enterprise", which took place from October to December 2019 at the University of Minho. Although following a Service Learning approach only two student teams were carrying out their project on social organizations (group A of students). The other 5 teams were carrying out their projects in university services and directories as well on campus research and development institutions (group B). Based on the Service Learning approach, students applied knowledge acquired in the course to help the host institutions to make their work more efficient and effective. At the end of the project, students' feedback about their project and service learning experience was collected through an online survey, following the work of Folgueiras et al. (2018). Findings from students' perceptions show, in general, that they had a positive view of the effects of their participation. Students from group A gave more relevance to social awareness and personal development while students from group B gave more relevance to technical and professional competences developed in the project.

Keywords: Higher Education; Service Learning; Lean Enterprise

1 Introduction

The most successful way of organizing and managing operations started to be established in the Toyota Motor Company in the 1950s under the designation of Toyota Production System (TPS). It became a major milestone in the history of the production organization and management. That way of organizing and managing work has been formalized in sets of principles and concepts in several forms. Probably the most important currents of thoughts representing it are: Lean Thinking (Womack & Jones, 1997), Shingo Model (Plenert, 2017) and Toyota Way (Liker, 2005). The principles that shape each one of the models can be divided in two main groups, the visible side and the invisible side as expressed by Mike Rother (Rother, 2010). The visible side includes principles such as value and pull production flow, as well the visible side of continuous improvement. The invisible side is more related to the human side, culture and behaviour, including principles such as: "Respect Every Individual", "Lead with Humility", "Embrace Scientific Thinking", "Think Systematically", and "Create Constancy of Purpose" from Shingo Model. Examples from the Toyota Way are (Liker, 2005): "Having a long-term philosophy that drives a long-term approach to building a learning organization", "Grow leaders who thoroughly understand the work, live the philosophy, and teach it to others", "Develop exceptional people and teams who follow your company's philosophy", "Respect your extended network of partners and suppliers by challenging them and helping them improve", "Make decisions slowly by consensus, thoroughly considering all options; implement decisions rapidly (Nemawashi), and "Become a learning organization through relentless reflection (hansei) and continuous improvement (Kaizen)".

The roots of Service based Learning (SbL) or also called Service Learning go back to the beginning of the 20th century when Arthur Dunn incorporated service project in the community as part of his social studies curriculum (Nieboer, 2000). The term "Service Learning" was introduced in the 1970s (Southern Regional Education Board, 1970) stating among other things that universities should encourage student to do community service, assist in assuring learning as part of this service as well as stating that students, college faculty and staff, cooperate in the administration of programs in which students both serve and learn. Service learning is an educational approach that combines learning processes and community service in a single well-articulated project in which all participants are working on real needs of the environment with the aim of improving it (Casares, 2013). Service learning programs are very similar to Project-based Learning on which our research group has long experience (PBL) (Lima et al., 2017). The main difference is that the real context in SL are social organizations instead of companies. Learning while developing projects in real context is recognized to be more effective than traditional classroom learning but SL is also believed to hold the potential to broaden and significantly enhance the learning climate for students (Levesque-Bristol, Knapp, & Fisher, 2011). The general learning goals of Service-Learning can be organized in three categories (Felten & Clayton, 2011): civic learning; academic learning and personal growth. Service Learning programs can be found in many universities in Europe (EOSLHE, 2020), in many universities in USA where we stand out Purdue University (EPICS program) (Purdue University, 2020), as well as in general across the world.

Service-learning projects imply challenges in the development of community actions that have a high educational component. Knowing the needs and realities of other groups and encouraging people to contribute with their input allows stereotypes to be changed and contributes to rebuilding social links. In service-learning projects, people in situations of exclusion are no longer beneficiaries of solidarity-based actions to become agents of change, and service actions are opportunities to incorporate their voices, input and contributions in the building of inclusive citizenship.

The implementation of lean principles and concepts in social organizations is not completely new. One example comes from Jefferson County (Murman & Bakst, 2017) and another one refer non-profit organizations discovering lean advantages (Murray & Ma, 2015). Attending to Lean Thinking principles, it is in this kind of organizations and services that lean makes even more sense, due to the scarce resources they have (Shafiq & Soratana, 2020). Some local communities have been benefiting of such services, namely, the local communities where the Lean Sigma Academy of the UTRGV-Texas Manufacturing Assistance Centre is integrated (UTRGV, 2020). One of the few examples about learning Lean Six Sigma with Service-Learning is provided by Braun (Braun, 2013). Higher education institutions have formal social responsibility expressed in many different ways. In Portugal one of these ways is expressed in the so called "Green book on Social responsibility of HEI" (*Livro Verde sobre Responsabilidade Social e Instituições de Ensino Superior*, 2018)**.** By strengthening the community - university partnerships, universities can contribute to bring solutions to the major challenges of the 21st century, such as increasing environmental and socio-economic crises, inequalities of income and wealth and political instabilities (von Hauff & Nguyen, 2014). These challenges are also at the heart of the 2030 Agenda for Sustainable Development, adopted by the all United Nations Member States in 2015 (Johnston, 2016). The 17 Sustainable Development Goals (SDGs) are an urgent call for action by all countries - developed and developing - in a global partnership. By integrating lean principles and practices into social organizations, through active engagement of engineering students in community projects, universities can lead by example. Furthermore, through curriculum innovation and active learning approaches, future decision makers can learn the competences needed to solve ecological, social, and economic problems in societies, along with the development of human competences and civic awareness (Cumbo & Vadeboncoeur, 1998; Folgueiras, Aramburuzabala, Opazo, Mugarra, & Ruiz, 2018). Service Learning plays a crucial role to support HEI to achieve these goals (*Livro Verde sobre Responsabilidade Social e Instituições de Ensino Superior*, 2018).

This study aims to describe a service learning experience carried out with fifth year students of an engineering programme at the University of Minho, Portugal. The learning approach followed the principles of SL, combined with PBL. Students worked in teams and applied knowledge acquired in the curricular unit of "Lean Enterprise" to help social and non-social organizations make their work more efficient and capable. As not all groups had the opportunity to develop their project in a social organization, this paper aims to analyse if there are any differences in terms of the participation, type of service, the competences developed and the general satisfaction, between students who developed their project in a social organization and students who did not. What conclusions can be drawn from this comparison? Which of these dimensions presented results that were most surprising? What are the implications for practice?

In the next sections, we will provide a description of the context of the study, followed by the methodology and results, which are organized and discussed according to the impact of the project on the social / non-social organizations and students' perceptions about the SL experience, based on the application of a survey (Folgueiras et al., 2018).

2 Context of the study

This study took place at the end of 2019 at the University of Minho in 2019 with students from the 5th year of the Integrated Masters in Engineering and Industrial Management. These students were enrolled in the curricular unit "Lean Enterprise" which includes every year a project in a real context to develop skills in the areas of Lean thinking applied in a non-industrial context. It is also the aim of the project that students develop important transversal skills for their future as professionals. Projects usually follow a Project Based Learning fashion and are carried out in internal services of the university such as administrative services, technical services, master's degrees directories, and departmental directories. In 2019 the responsible for the curricular unit decided to also include some projects outside the university walls in social organizations. Two social organizations agreed to join the project and for that reason the framework of this type of learning model became a kind of a mix of Project Based Learning (PBL) and Service Learning (SL). In fact the adopted system followed more the SL guidelines than the PBL. The 31 students organized themselves in 7 teams and each team selected the service or social organization of their preference to carry out the project.

Table 1 – Host institutions and project general objectives.

Host Institution	Team size	Project objectives
RB - Refood in Braga	5	Analyse and Improve processes
RG - Refood in Guimaraes	5	Analyse and Improve processes
TM - TecMinho	5	Introduce Lean Office Tools
PIEP – Innovation in polymers Institute	5	Introduce Continuous Improvement
DEP – Polymer department directory	3	Analyse and Improve processes
PSD – Technical Office at PSD	3	Implement Lean Green practices
DSI – Technical Office at ISD	5	Apply Lean practices

The list of host institutions and project objectives is shown in Table . Refood in Braga and Refood in Guimaraes are social organizations with the purpose of collecting free food supplied by local restaurants and delivering it to people in need in the same region. TecMinho is a private non-profit association founded in 1990, having as sponsors the University of Minho and the Association of Municipalities of Vale do Ave. PIEP (innovation in polymers) is also a non-profit organization created in 2001, at the initiative of the plastics and moulds sector, in close collaboration with the University of Minho, through the Department of Polymer Engineering and IAPMEI. The other three host institutions are services in the same building of our department (PSD - Production and Systems Department) being one of them the Directory of the Polymer Department, the other one the Technical office in our department, and the technical office of the Information and Systems Department (ISD).

Each host institution has assigned the responsibility of accompanying students during the project to someone from the institution with the responsibility of guiding the student team in the project. Students would have to spend some time every week in the host institution performing their project tasks and also meet weekly with project supervisor to show the project progress and obtain feedback. The teams had to present their work 3 times during the project to obtain feedback and had to perform a final presentation at the end of the semester with highest wait in terms of assessment. Each team also had to assess the other teams in their final public presentation and that assessment was only used by the curricular unit coordinator to help the fine tune the final grades. The project was assessed by the quality of team´s presentations in terms of communication effectiveness, the quality of the technical solutions proposed and implemented, the quality of the results.

According to Aramburuzabala, Cerrillo, & Tello (2015), the project results should be celebrated and disseminated with all the participants involved in the SL project. For this final celebration, students at University of Minho organized a final event, open to the academia and the local community. All the host institutions were invited, and the student teams performed brief public presentation, with the main results of their projects and the improvement suggestions implemented in each context. These presentations were not subject to any formal assessment of students. The people representing host institutions were asked to give specific feedback from the project in their institutions as well as general feedback for the initiative. A discussion was then promoted in terms of the initiative impact on students in terms of personal growth and social awareness as well as the projects role in the community. Finally everyone was invited to get together in a more informal way in a reserved area of the building cafeteria to share some snacks and drinks and socialize. Figure shows on the left side the flyer created by the students to formalize the event and invite institutions and on the right side one picture of the final informal socialization.

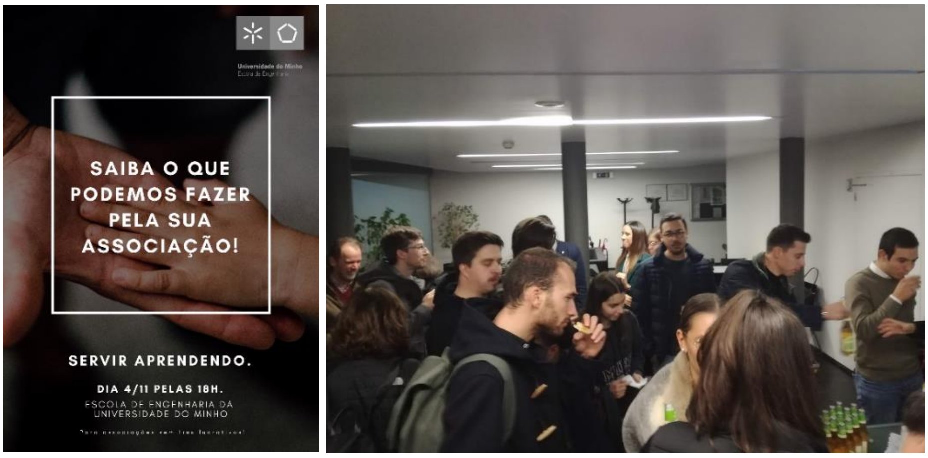


Figure 1 - Flyer of the Final Event (left) and celebration of SL results (right)

3 Methodology

At the end of the project, students' feedback about their project and service learning experience was collected through an online survey, following the work of a group of experts of service-learning in Spanish Higher Education (Folgueiras et al., 2018). These authors developed an instrument to analyse the impact of service learning on four main concepts or elements: Participation, Service, Competences and General Satisfaction. Figure 2 presents the dimensions included in the questionnaire, which included different type of questions (scale, closed, multiples responses, exclusive and non-exclusive responses). The questionnaire was kindly shared and authorised, by the original authors, to be applied at the context of the University of Minho.

To enrich the data collection, 4 open-ended questions were added to the online questionnaire aimed at identifying the most positive (strengths) and less positive (weakness) aspects and suggestions for improvements. So, for the analysis, both quantitative and qualitative data will be considered.

The participants in the project included 31 students, 20 male and 11 female. Students' ages ranged from 21 to 25 years old. The questionnaire was sent to all students, by email, after the conclusion of the project. The sample of this study includes 21 participants, who voluntarily answered the questionnaire.

Concepts/elements	Dimensions	Indicators	Items/scale measures
Participation	Levels of participation	Participation throughout the project Participation at some points Participation in needs analysis Participation in assessment New projects Decision to carry out one or other activity	10 and 11: closed, multiple responses, non-exclusive
	Factors conditioning participation	Personal motivation; liking for project type, putting course contents in practice etc. Organizational aspects: distance, timetable etc.	9, 12: scale
Service	Description of service	Field: health promotion, rights promotion etc. Type of service: direct/ indirect Beneficiaries: individuals/ groups/institutions	1, 2 and 3: closed, multiple responses, exclusive
	Opinion of project usefulness	Usefulness of the service for working on course contents, understanding needs etc.	4, 5, 6 and 7: scale
Competences	General and transversal	Instrumental: finding and managing information etc. Interpersonal: teamwork etc. Systemic: organizing and planning etc.	8: scale
Transversal	General satisfaction	Participation: organizational engagement etc. Service: service activities carried out etc. Competences: curriculum contents etc. Others: project impacts etc.	14 and 16: closed, multiple responses, non-exclusive 15: scale

Figure 2 - Relationships between concepts/dimensions/indicators/items and scale measurement of the SL Questionnaire (Folgueiras et al., 2018, p. 6)

4 Results

The results section is organized in three parts. The first part describes the impact of students' projects on the host institutions, showing the improvements developed by students in each host institution. The second part discusses students' feedback about the experience, based on the results from the application of the questionnaire developed by Folgueiras et al. (2018). The third part presents a comparison of students' perceptions, when divided into two groups, according to the context where their project took place: a social organization (group A) or another type of organization (group B). An attempt to identify differences in students' perceptions is explored in this last subsection.

4.1 Improvements in the host institutions

The type of improvements that were proposed and implemented in each host institution by each student team is shown in Table 2. The 5S technique and One-Point-Lessons/Standards were the most common implementation being applied in 5 of the 7 host institutions. The implementation of 5S was quite expected because it is probably the most common lean tool being implemented when organizations start a lean journey. One-Point-Lessons and Standards are also in line with 5S helping creating more discipline and organization in production or office areas. The second most proposed and implemented lean practice was material flow mechanisms. The material flow mechanisms were designed to keep the flow of materials, such as food or office material, avoiding stagnation or shortage. The teams implemented mechanisms such as Kanban and two bin systems to control the flow and stock of materials.

Table 2 – List of lean practices that were proposed and implemented.

Lean Practice	Host Institution						
	RB	RG	TM	PIEP	DEP	PSD	DSI
5S technique	I	I	I		I		I
One-Point-Lessons/Standardization	I		I		I	I	I
Flow mechanisms (Kanban/Two bin System)	I	P			I	I	
5S audits		P	P		P		
Improve information flow		I			P		P
Visual Management	I	I		I			
Improve Layout	I	P					
Poka-Yoke			I			I	
KPI development and monitoring				I			
Team boards				I			
Team meetings				I			
Reutilization and recycling mechanisms						I	
Energy savings						I	
"I" – Implemented; "P" – Proposed and not implemented until the end of the project							

Other implementations shared by tree teams were the 5S audits system, solutions to improve information flow and visual management solutions. Regarding the 5S audits systems the teams designed a check list appropriated to the context as well as the definition of the audit people and its periodicity. Visual management solutions were implemented by three teams in order to simplify management and monitor the work to be performed. The other lean practices were implemented only by two or one team.

4.2 Students' feedback about the Experience

In general, students' feedback about the project experience was considered positive. An overall analysis of the results from the questionnaire reveal a positive opinion of students in regard to the four main categories of questions included in the questionnaire: general satisfaction, type of service provided, level of participation and competences acquired by taking part in the project (Figure 3).

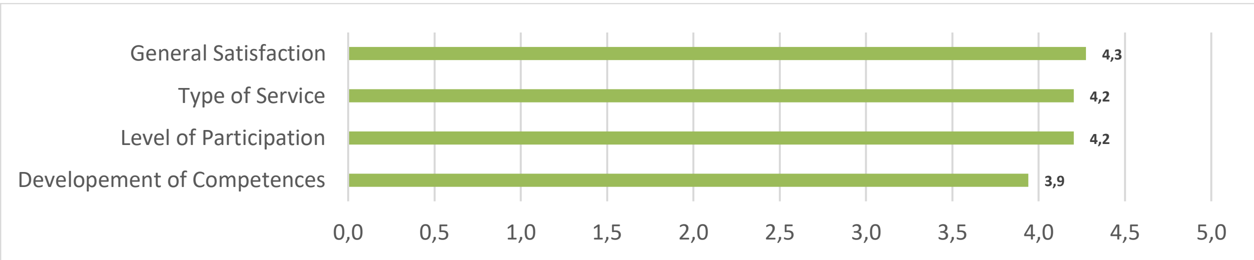


Figure 3 - Overall results of the survey, according to the four main categories of the questionnaire

As shown in Figure 3, students' general satisfaction with their projects shows the highest average (4.3), when compared with the other three categories, which also reveal positive results. Despite the host institution where the projects were carried out, all students showed a positive opinion about their project experience. Some of the qualitative data collected from the students, referring to what they liked most about the project, elucidate the aspects most valued by students. The following quotes from students confirm this: *to be able to apply what we learn in theory; having a positive impact on an organization; the power to have had a beneficial impact on the organization in which the project took place; real case in an organization; the people involved in the project; to see how it was actually possible to implement most of the suggestions in a timely manner and see the results; interaction with the organizations.*

The development of competences is also one of the most evident results of the impact of PBL and SL on student learning and personal development. Besides the technical competences that students are strongly encouraged to develop through the improvements implemented in the host institutions, as previously explored in section 4.1. of this result analysis, students clearly recognized a set of transversal competences that were effectively developed through the project. The competences that were most positively evaluated, as shown in Figure 4, were teamwork (4.63), adapting to new situations (4.4), problem-solving (4.4), ethical commitment (4.38) and communicating orally and in writing (4.38). These competences are both common to PBL and SL approaches, which is not a surprising result, as both approaches share the principle of "learning by doing" and teamwork is an important asset for the successful development of the project. The items from the questionnaire, regarding competences development, that were rated less positively were foreign language learning (2.0), knowledge of ICTs (3.13) and expressing feeling (3.13). This fact may be due to the nature of the projects developed and the specific objectives which they entailed. It is also important to refer that most of these students who participated in the project have already some experience in PBL, as this is one of the most favoured methodologies of the Integrated Masters in Engineering and Industrial Management (Lima et al., 2017). To conclude, the majority of the items were rated with an average above 3.5, which reveals a positive impact of the project on the development of students' competences.

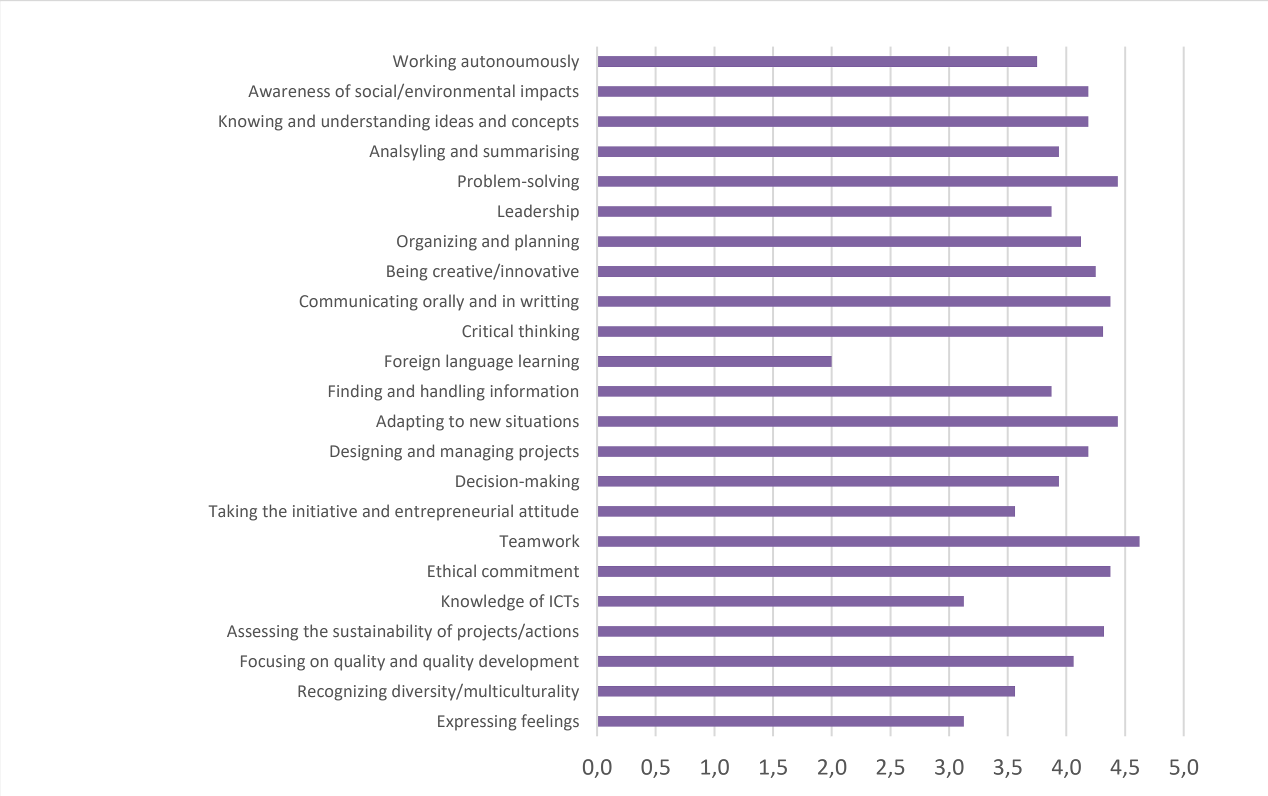


Figure 4 – Results of the questionnaire for the category "Development of Competences"

When questioned about the usefulness of the service, students mostly referred to the benefits in terms of the opportunity to put professional skills into practice (4.56), to be more consistent in their actions (4.44), to relate theory and practice (4.38), to know the professional field of their degree (4.31) and learning values (4.31). When asked about what they learned from the project, through an open-ended question, students' answers included several dimensions related to opportunity to contact with the organization where their project took place. Some examples that confirm this are the following quotes from students: *[I learned] to understand the needs of information of companies and organizations. The attitude and initiative that you need to have in order to obtain the essential information for the completion of the project. Listening and working in groups (it is a continuous learning process); [I learned] Lean Office tools; [I learned] to put in practice; [I learned] to identify problems, discuss possible solutions, reach an agreement, propose solutions and implement solutions, evaluating the results; [I learned] the relationship between tools and the environment.*

4.3 Comparing Students' perceptions

Since some students carried out their projects in social organizations, an attempt was made to identify differences in their perceptions. For this study, students were divided into two groups, group A and group B. Students in group A carried out their projects in social organizations, students in group B carried out their projects in other organizations. From the answers collected from the questionnaire there was a clear difference between the average assessments given by the two groups. Figure 5 shows the questions that group A assessed in a clearer positive way.

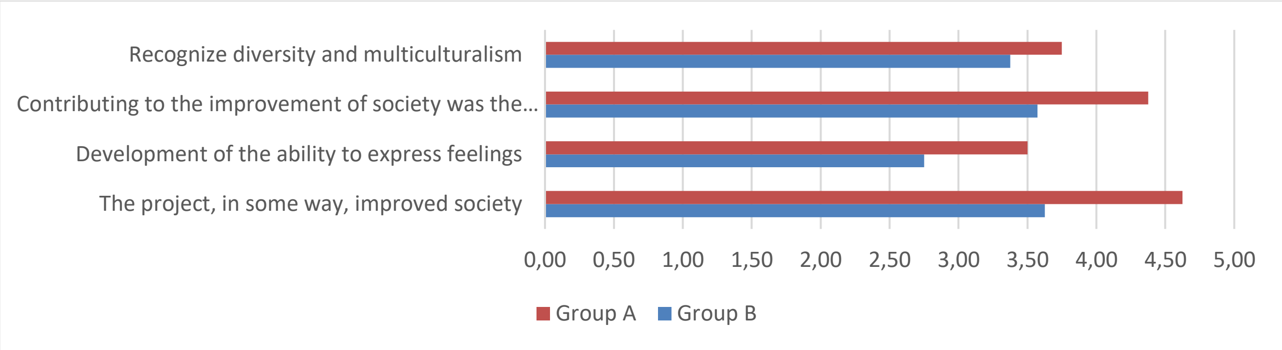


Figure 5 – Questions with more positive feedback given from group A than group B.

Students from group A (project in social organizations) recognized that their project allowed them to improve society more (22% more) than students from group B. The same perception was given to the development of the ability of expressing their feelings (also 22% more to group A). With more than 18% difference in assessment was the responses given by students from group A as contributing to improve societies being the reason why they chose the project. The competence to recognize diversity and multiculturalism was also identified as being developed more positively by group A by around 10%.

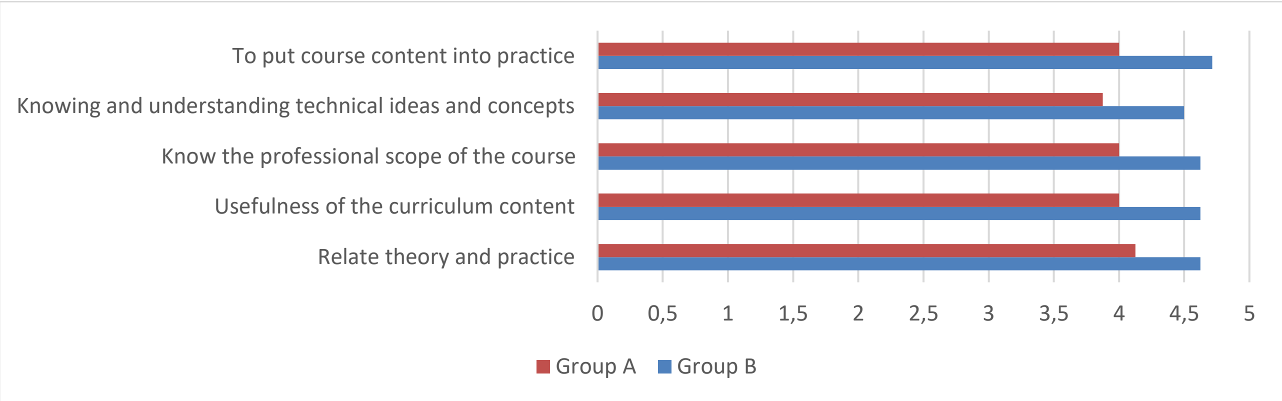


Figure 6 - Questions with more positive feedback given from group B than group A.

At the other extreme we have questions whose answers from group B were in average clearly more positive (Figure 6). Students from group B perceived in a more positive way that the project provided the development of competences in the technical side. The clearest examples are shown in Figure 6 and are the connection between theory and practice, usefulness of the curriculum content, knowing their professional scope, knowing and understanding technical ideas and concepts, and to put course content into practice.

5 Conclusions

A service learning approach was experienced in a course where traditionally a PBL approach was used. In order to identify the differences when social organizations act as host institution, the students were divided in two groups. Students from group A were assigned to a project carried out in a social organization while students from group B were assigned to a project carried out in other non-profit organizations. In both cases, students developed specific technical and professional skills as well as transversal skills. A survey was applied to collect students' perceptions. Regarding the technical and professional aspects, students highlighted that they "put professional skills into practice" (4.56 out of 5), "relate theory and practice" (4.38), and "to know the professional field of their degree" (4.31). Regarding the transversal skills students in general highlighted teamwork (with 4.63 out of 5), adapting to new situations (4.4), and problem-solving (4.4). A second part of this study was to identify possible differences between the perceptions of students from group A and students from group B. Students from group A recognized that that project allowed them to improve society much more than students from group B. Moreover, students from group A recognized much more the developed ability of expressing their feelings, as well as the competence to recognize diversity and multiculturalism. Students from group B, in general, gave more importance to the professional learnings. The overall learnings from this experience is that the advantages of Service Learning approach in improving the developing in students aspects such as social awareness and personal development is more than welcome. This is even more relevant in a course like the one referred in this study where "respect every individual" and "lead with humility" are their key principles (Plenert, 2017; Liker, 2005).

Acknowledgments

This work has been supported by FCT – Fundação para a Ciência e Tecnologia within the R&D Units Project Scope: UIDB/00319/2020.

6 References

Aramburuzabala, P., Cerrillo, R., & Tello, I. (2015). Service-learning: a methodological proposal for introducing sustainability curriculum in higher education. *Profesorado-Revista De Curriculum Y Formacion De Profesorado*.

Braun, J. M. (2013). Teaching Lean Six Sigma with Service-Learning. In *2013 ASQ Advancing the STEM Agenda Conference*. GRAND RAPIDS MI.

Casares, M. G. (2013). *SERVICE LEARNING AND SOCIAL INCLUSION*. aprenentatgeservei. Retrieved from https://www.incorpora.org/documents/20181/134822/SERVICE_LEARNING_AND_SOCIAL_INCLUSION/037583d2-bebc-45dc-a235-bf5bc75ac501

Cumbo, K. B., & Vadeboncoeur, J. A. (1998). What are Students Learning?: Assessing Service Learning and the Curriculum.

EOSLHE. (2020). European Observatory of Service-Learning in Higher Education. Retrieved April 27, 2020, from https://www.eoslhe.eu/

Felten, P., & Clayton, P. H. (2011). Service-learning. *New Directions for Teaching and Learning*, (128), 75–84. https://doi.org/10.1002/tl.470

Folgueiras, P., Aramburuzabala, P., Opazo, H., Mugarra, A., & Ruiz, A. (2018). Service-learning: A survey of experiences in Spain. *Education, Citizenship and Social Justice*. https://doi.org/10.1177/1746197918803857

Johnston, R. B. (2016). Arsenic and the 2030 Agenda for sustainable development. *Arsenic Research and Global Sustainability - Proceedings of the 6th International Congress on Arsenic in the Environment, AS 2016*, 12–14. https://doi.org/10.1201/b20466-7

Levesque-Bristol, C., Knapp, T., & Fisher, B. (2011). The Effectiveness of Service-Learning: It's Not Always what you Think. *Journal of Experiential Education*, *33*, 208–224. https://doi.org/10.1177/105382590113300302

Liker, J. (2005). *Toyota Way: 14 Management Principles from the World's Greatest Manufacturer*. McGraw-Hill Education.

Lima, R. M. M., Dinis-Carvalho, J., Sousa, R. M. M., Alves, A. C. C., Moreira, F., Fernandes, S., … Mesquita, D. (2017). Ten Years of Project-Based Learning (PBL) in Industrial Engineering and Management at the University of Minho. In & A. K. A. Guerra, R. Ulseth (Ed.), *PBL in Engineering Education: International Perspectives on Curriculum Change* (pp. 33–52). Rotterdam, The Netherlands: Sense Publishers. https://doi.org/10.1007/978-94-6300-905-8

Livro Verde sobre Responsabilidade Social e Instituições de Ensino Superior. (2018). ORSIES - Observatório sobre Responsabilidade Social e Instituições de Ensino Superior.

Murman, E., & Bakst, J. (2017). Growing a Lean Community: The Jefferson County WA Lean Journey. In *2017 Mid-Atlantic Lean Conference*.

Murray, P., & Ma, S. (2015). The promise of Lean Experimentation. *StanfordSocial Innovation Review*. Retrieved from https://ssir.org/articles/entry/the_promise_of_lean_experimentation

Nieboer, R. (2000). Arthur Dunn: Civic Visionary from the Heartland. *Annual Meeting of National Council for the Social Studies*. Retrieved from https://archive.org/details/ERIC_ED448090/page/n1/mode/2up

Plenert, G. J. (2017). *Discover excellence : an overview of the Shingo model and its guiding principles*. Productivity Press.

Purdue University. (2020). EPICS. Retrieved April 24, 2020, from https://engineering.purdue.edu/EPICS

Rother, M. (2010). *Toyota KATA*. McGraw-Hill Education - Europe.

Shafiq, M., & Soratana, K. (2020). Lean readiness assessment model – a tool for Humanitarian Organizations' social and economic sustainability. *Journal of Humanitarian Logistics and Supply Chain Management*, *ahead-of-p*(ahead-of-print). https://doi.org/10.1108/JHLSCM-01-2019-0002

Southern Regional Education Board. (1970). Atlanta Service-Learning Conference Report Southern Regional Education Board. In *Atlanta Service-Learning Conference Report*. Retrieved from https://digitalcommons.unomaha.edu/slceproceedings/10/

UTRGV. (2020). Lean Sigma Academy.

von Hauff, M., & Nguyen, T. (2014). Universities as potential actors for sustainable development. *Sustainability (Switzerland)*, *6*(5), 3043–3063. https://doi.org/10.3390/su6053043

Womack, J. P., & Jones, D. T. (1997). Lean Thinking—Banish Waste and Create Wealth in your Corporation. *Journal of the Operational Research Society*, *48*(11), 1148–1148. https://doi.org/10.1057/palgrave.jors.2600967

Learning Experiences from Digital Factory Subject and Communications and People Skills Development for Engineering Leaders Subject

Chawantorn Chanchittakarn[1], Karakade Buakaew[1], Athakorn Kengpol[1]

[1] Department of Industrial Engineering, Faculty of Engineering, King Mongkut's University of Technology North Bangkok, Bangkok, Thailand

Email: s6101091810018@email.kmutnb.ac.th, karakadeb@kmutnb.ac.th, athakorn@kmutnb.ac.th

Abstract

The Curriculum Development of Master's Degree Program in Industrial Engineering for Thailand Sustainable Smart Industry (MSIE 4.0) is a project that develops knowledge and skill necessary for the industrial 4.0, which consists of 16 courses. At present, the Department of Industrial Engineering, Faculty of Engineering, King Mongkut's University of Technology North Bangkok (KMUTNB) has already conducted 2 courses, which are Digital Factory subject and Communications and People Skills Development for Engineering Leaders subject. The main objective of this study is to present teaching and learning activities including feedbacks from the courses, which are attended by instructors and 14 students in Master's degree and international exchange students. It also presents experiences from student's perspective, by using indicators in the form of interviews and evaluations. The results are that students can satisfy with the subjects. In addition, they have developed knowledge and skills necessary for the industry 4.0 as intended.

Keywords: Digital Factory; Communications and People Skills Development for Engineering Leaders; Industry 4.0; Learning Experiences.

1 Introduction

Industry 4.0 creates new demands on the competencies in connection with the digitalization of future production. The requirements and opportunities, in the use of emerging technology, increase the pressure on the qualification and recruitment of employees with new cognitive skills (Helge, Kurt, & Ib, 2020). From this situation, The Curriculum Development of Master's Degree Program in Industrial Engineering for Thailand Sustainable Smart Industry (MSIE 4.0) (Co-funded by the Erasmus + Programme of the European Union) has created a course curriculum to develop learners according to the characteristics of industry 4.0. At present, the Department of Industrial Engineering, Faculty of Engineering, King Mongkut's University of Technology North Bangkok has a group of students, who have studied Digital Factory subject (MSIE-06) and Communications and People Skills Development for Engineering Leaders subject (MSIE-16). The learning courses are developed for preparing students to the industry 4.0 factories and for responding to current and future smart factory personal needs. In this paper, it summarizes the activities that occur during the pilot courses and the outcomes.

2 The Course Element

2.1 Course Background

Industry expectations of engineering graduates are increasingly expanding with modern times (Evert, 2017). Therefore, the curriculum structure is built on required skills and knowledge in Industry 4.0. The surveying is from the academicians and industrial entrepreneurs' perspectives. The curriculum Development of Master's degree Program in Industrial Engineering for Thailand Sustainable Smart Industry (MSIE 4.0) has improved the teaching and learning methods which have the structure of the curriculum in 16 courses according to the skills needed for industry 4.0.

2.2 Learning Method: Digital Factory subject

Industry 4.0 requirements can be summarized as flexibility, increased productivity, individual product manufacturing, knowledge and application of new technologies with manufacturing systems and robot collaboration. These requirements are essential for the future education system (Andrea, Martin, Frantisek, & Jiri, 2019). Therefore, the instructors must redesign their courses in active learning for balancing the learner experiences. The four main dimensions for assessment framework are learning (L), observing (O), visiting (V), and experimenting (E). These dimensions are grouped and named as LOVE model which can be classified for teaching and learning method to balancing the student learning experiences (Hussadintorn Na Ayutthaya, & Koomsap, 2019). The LOVE model is the important tool for learning experiences based on teaching and learning method (Kengpol, Koohathongsumrit, & Meethom, 2019).

During the teaching process, the students learn related case studies, for example the functional drink industry and the cosmetic packing industry. In the functional drink industry, the decision support system software is developed for assessing customer satisfaction on functional beverage flavor note (Ouansri, Kengpol, Tuamee & Tabkosai, 2020). In the cosmetic packing industry, the production process is improved for reducing the scrap (Mingsakul, Kengpol, Usadornsak & Tuntitippawa, 2020). In addition, there are more case studies for learning and practicing on how to improve the factories and industries.

2.3 Learning Method: Communications and People Skills Developments for Engineering Leaders subject

The evolution of communication relates to the use of linguistic process. Most institution will be likely preferred to embrace a more revolutionary attack by changing the underlying foundation of their educational approach to a new approach of learning utilizing a student-centered strategy (Halizah, & Zawawi, 2015). This subject is an activity-based course. During the lecture sessions, class discussion is conducted. During workshop session, the students are active learners for practicing the communication skills together with the related people skills, and for understanding of the general characteristics of engineering leaders. This course also creates awareness of obstacles to career success when the skills are not developed.

2.4 The Questionnaire and The Interview

Questionnaires can be effective tools for collecting the information, but only if they are properly designed and used. There are a number of factors that should be considered when designing the questionnaire (Tiina, 2006). The 5-level satisfaction questionnaire is commonly used to collect data, which consisted of the average score criteria and interpret the result as follows (Samakpol, 2014):

- The average score of 4.21-5.00 means that the appropriateness is at the highest level
- The average score of 3.41-4.20 means that the appropriateness is at high level
- The average score of 2.61-3.40 means that the appropriateness is at moderate level
- The average score of 1.81-2.60 means that the appropriateness is at low level
- The average score of 1.00-1.80 means that the appropriateness is at the lowest level

The interview is a conversation for gathering information. A research interview involves an interviewer, who coordinates the process of the conversation and asks questions. Interviews can be conducted face-to-face or over the internet/telephone.

3 Learning Activities

This section presents learning activities from the Digital Factory (MSIE-06) and the Communications and People Skills Development for Engineering Leaders (MSIE-16) course, which occurred at the Department of Industrial Engineering in King Mongkut's University of Technology North Bangkok. The students from master degree and exchange students from Indonesia and Jordan are shown in Figure 1 and Figure 2 respectively.

Figure 1. The students join the courses.

Figure 2. The exchange students from Indonesia and Jordan.

3.1 Digital Factory subject

In the first semester of 2019 between June and October, the students had taken the Digital Factory course (MSIE-06). In the first lesson, the lecturer described the course syllabus including objectives, contents and evaluations, causing the learner to know how to prepare to study. The LOVE model is applied in the course.

The Learning method (L) in the course, the students learn the digital factory by videos playing, and after that they have to express their opinion to exchange the ideas together. Moreover, they have to find information from the internet and have some discussion about the digital factory topics such as the future wind power from smart wind generator, the future farm and the smart assembly plant etc., which is presented in Figure 3.

Figure 3. The Learning (L) activities.

The Observing method, the students try to find interesting new technology from the internet. The cyber-physical system and another type of smart equipment systems such as robotic system, additive manufacturing, automated guided vehicle (AGV), virtual reality (VR) and augmented reality (AR) are discussed in the class and they talked about how to transform a traditional factory to a digital factory. The data flow diagram (DFD) is used to explain how the transformation can be done. The activities are presented in Figure 4.

Figure 4. The Observing (O) activities.

The Visiting method in the course, they have first factory visit at the furniture factory as show in Figure 5 for observing the five production lines and writing the Data Flow Diagram (DFD) for group works, and they have to use the knowledge from the learning method and observing method to design the new DFD in each production lines, which can transform to become a digital factory.

Figure 5. The Visiting (V) activities: ths first factory visit.

The second factory visit, the students present the ideas in form of DFD for improving each production line to achieve the goal of digital factory. There was a discussion of exchanged ideas between learners and production supervisors about the necessity and possibilities of the new DFD and the related smart equipments in presentation as presented in Figure 6.

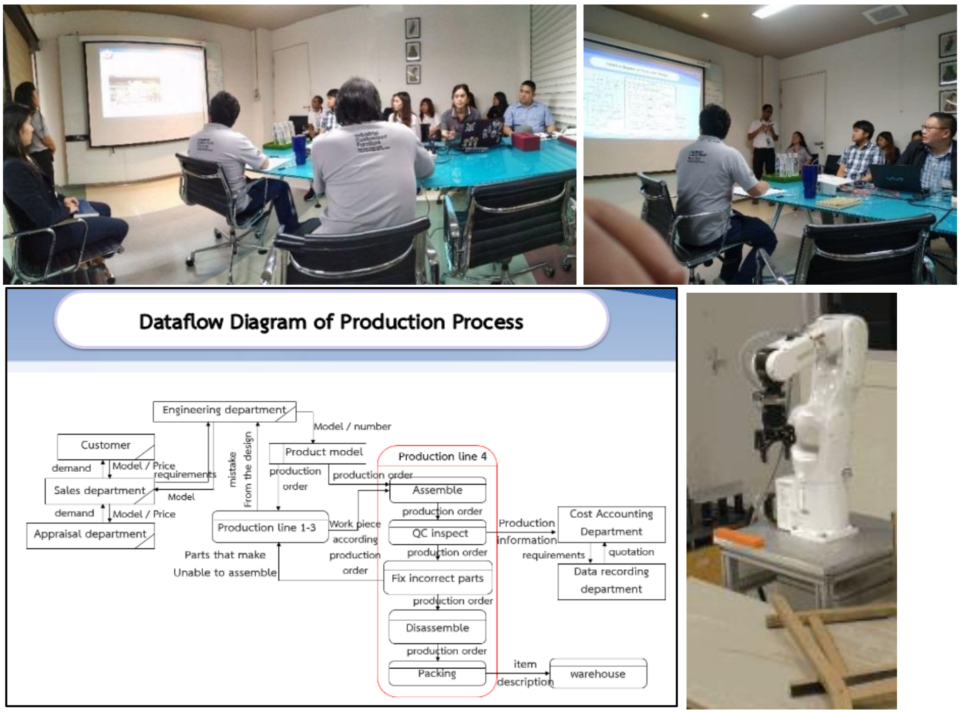


Figure 6. The Visiting (V) activities: the second factory visit.

The Experiment method (E) from the course, the students have joined the virtual reality (VR) laboratory at KMUTNB. They learn VR theory and learn how VR can be applied. The VR goggles are used by the students for grabbing and throwing objects in the virtual world in the laboratory and the students can also see their activities on the screen, as presented in Figure 7.

Figure 7. The Experiment (E) activities: using VR goggles.

3.2 Communications and People Skills Development for Engineering Leaders subject

In the second semester of 2019, the students had taken the Communications and People Skills Development for Engineering Leaders course (MSIE-16). The course objective is to build engineering competence in leadership communication skills and people skills. Thus, the training method is very important so that the students can communicate effectively at the end of the course.

The course has three modules. The module 1 is Essential Communication Skill Development for Self-Expression. The students are improved in oral communication and written communication skills. They practiced by plotting their ideas, filling up and polishing the story respectively. After that, they have to practice the story presenting by video recording themselves when they are presenting the story. The videos from the students are played in the class and the instructor advises to fix weaknesses and skills development guideline for each student. The activities are presented in Figure 8.

Figure 8. Student introductory skills.

The module 2 is Collaborative Communication Skills Development. The students practiced more communication skill such as emotional intelligence, strategic persuasive communication and effective managerial communication in a meeting. The topic of this session training is job application. Hypothetical, the students are finding the new job and try to introduce themselves for applying a job. The training activities is presented in Figure 9.

Figure 9. Student training in classes.

The module 3 is Leadership Communication Skill Development. The students are knowing the leadership style, and they could adapt their communication to different situations and audience.

3.3 Evaluation form

In this study, the evaluation is used to assess appropriateness in Digital Factory subject and the Communications and People Skills Development for Engineering Leaders subject. The students in these courses have to rate the class questionnaires using the appropriate evaluation forms, which the score 5 means strongly appropriate degree, score 1 means weak appropriate degree. The average scores are the result. In addition, the interviews are performed to assess students' experienced and what they gained from the courses.

4 Result

This session presents the student's experience after attending in the Digital Factory Course and Communications and People Skills Development for Engineering Leaders course according to interview result and evaluation average scores respectively.

4.1 Digital Factory Course

This subject is using the presentation and the interview to assess student's ability. From the furniture factory visiting in session 3.1, the student presented how to transform the tradition factory to the digital factory, in which the production supervisors attended the presentation. After that, the supervisor conducted additional interviews with the students to assess the knowledge and skill necessary for Industrial 4.0. The result show that, the students have knowledge and skills necessary to create concepts for transforming the tradition factory into the digital factory.

From the student's perspective to this subject, the satisfactory score is used, and the result is presented in Table 1.

Table 1. The assessment of satisfactory score for the Digital Factory subject

No.	Assessment:	Average
1	I learned a lot from this course.	4.42
2	You would recommend the course to other students.	4.58
3	Overall, I am satisfied with the course.	4.67
4	The grades issued were objective and fully reflected the learning outcomes.	4.33
5	The course was conducted in a way that was understandable, interesting, orderly, motivating to learn, and forcing to thinking.	4.50

The average score on all assessments is in the range 4.21-5.00, that means the satisfactory of every assessment is at the very high level.

4.2 Communications and People Skills Development for Engineering Leaders course

This subject estimate student's ability by assessing the quality of the speaking skill and the writing skill by the lecturer. The result show that, the students have the skills necessary to communicate on the various occasions, and they know how to improve their communication skills even better.

From the student's perspective to this subject, the satisfactory score is used, and the result is presented in Table 2.

Table 2. The assessment of satisfactory score for the Communications and People Skills Development for Engineering Leaders subject

No.	Assessment:	Average
1	I learned a lot from this course.	5.00
2	You would recommend the course to other students.	4.75
3	Overall, I am satisfied with the course.	5.00
4	The grades issued were objective and fully reflected the learning outcomes.	4.50
5	The course was conducted in a way that was understandable, interesting, orderly, motivating to learn, and forcing to thinking.	4.75

The average score on all assessments is in the range 4.21-5.00, that means the students satisfied with the courses.

From Table 1 and Table 2, the average scores can be shown as a comparison chart as in Figure 10.

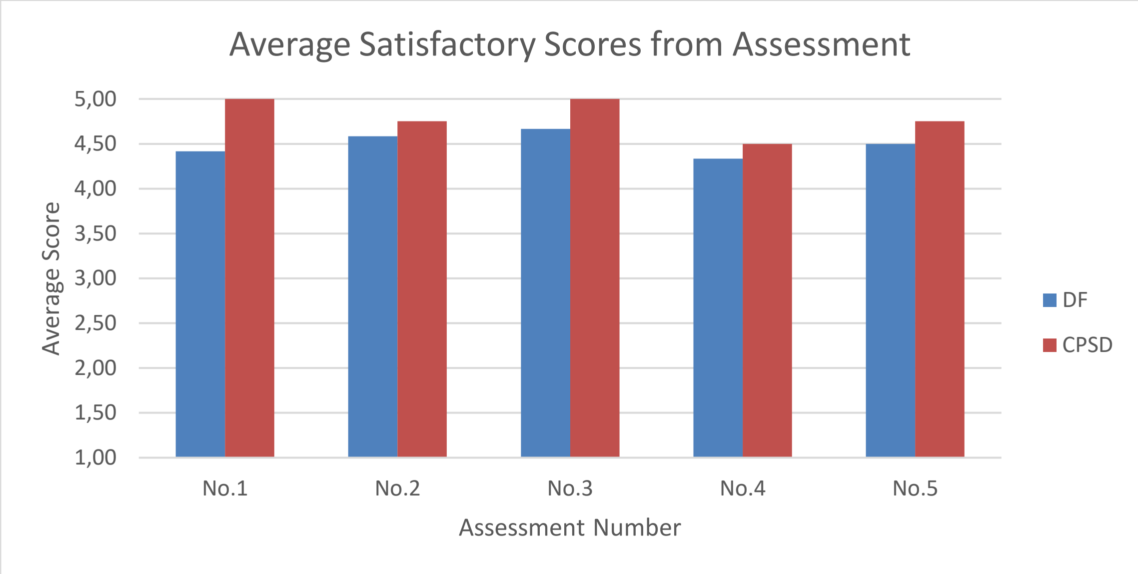


Figure 10. Average Satisfactory Scores from Assessment.

5 Conclusions

The students satisfied with both subjects and they have developed skills and knowledge necessary for the Industry 4.0. In which other opinions from the course are as following:

In the viewpoint of students in Digital Factory class, students gained experienced in the form of technology of smart factories in the Industry 4.0. The teaching and learning processes in the subject, the LOVE model has been used effectively. Each class discussions proceeded creatively. The ideas exchanging between the student's workgroups leads to develop the industry 4.0 concepts, that is following global industrial changed.

For the Communications and People Skills Development for Engineering Leaders subject, the students practiced communication skills in both speaking and gesture, which can increase communication effectively. The students in the class learned the weaknesses in their communication skills through their videos and practice over and over again to reduce those weaknesses and communicated properly. As for the development of writing skills is proceeded step by step, the students have learned to plot the story line from the milestones and practiced writing for using in various situations effectively.

6 References

Andrea, B., Martin, H., Frantisek, S., & Jiri, T. (2019). "Requirements for Education 4.0 and Study Programs within Industry 4.0." In *Proceeding of the International Conference on Industrial Engineering and Operations Management Pilsen*, Czech Republic, July 23-26, 1678-1686.

Evert, J., S. (2017). Essential Skills of Graduate Engineers: *The Case of Namibia*. Master Thesis, Industrial Engineering Program, Faculty of Engineering, Namibia University of Science and Technology.

Halizah, A., & Zawawi, D. (2015). "Improving a Communication Skill Through the Learning Approach Towards the Environment of Engineering Classroom." In *Word Conference on Technology*, Innovation and Entrepreneurship. Procedia - Social and Behavioral Science 195, 480-486.

Helge, G. G., Kurt, L., & Ib, H. N. (2020). "Presenting the UCN Industrial Playground for teaching and researching Industry 4.0." In *the 10th Conference on Learning Factories*, CLF2020. Procedia Manufactoring 45, 196-201.

Hussadintorn Na Ayutthaya, D., & Koomsap, P. (2019). "LOVE-Based Teaching and Learning Method Classification." In *the 13th International Technology, Education and Development Conference*. INTED2019 Proceeding, 3521-3529.

Kengpol, A., Koohathongsumrit, N., & Meethom, W. (2019). "Time analysis of teaching and learning method based on LOVE model." In *The 22nd International conference on Interactive Collaborative Learning*, Bangkok, Thailand.

Mingsakul, W., Kengpol, A., Usadornsak, C., Tuntitippawa, N. 2020. Reduction of scrap in anodization process: a case study in a cosmetic packaging industry, *Applied Science and Engineering Progress*, Vol. 13, No. 1, January-March**.**

Ouansri, A., Kengpol, A., Tuamee, S., Tabkosai, P. 2020. Design of a Decision Support System for Functional Beverage Flavoring, *Applied Science and Engineering Progress*, Vol. 13, No. 2, April-June**.**

Samakpol, S. (2014). Student's Satisfaction Toward Recreation Activities Management at The Institute of Physical Education. *Master Thesis*, Science Program in Sports Science, Facuty of Sports Science Chulalongkorn University, 83. (in Thai).

Tiina, I. (2006). mCreate Care Satisfaction Survey: Case Nokia Oyj. *Thesis Report.* Tampere Polytechnic Bussiness School.

Fully 3D Printed Spring Powered Car: A Project-Based Learning Experience

Nyan Linn Htet, Siraphat Sukhobol, Shune Lae Sandar, Pisut Koomsap

Department of Industrial Systems Engineering, Asian Institute of Technology, Pathumthani, Thailand

Email: st120969@ait.asia, st120798@ait.asia, st120805@ait.asia, pisut@ait.asia

Abstract

Since its introduction more than three decades ago, additive manufacturing (AM) has gained popularity and has become one important technology in supporting the revolution of the new industrial era. Being familiar with AM, therefore, opens up more opportunities for graduates as the technology will be available more and more in all types of businesses. Consequently, a course on AM has become a regular part of engineering curricula, including the Additive Manufacturing and Reverse Engineering course offered in the Industrial and Manufacturing Engineering Program at the Asian Institute of Technology. This course contains several activities that require student engagement, and as a part of competence development, the students are always assigned a group project. All groups are usually encouraged to explore their interests under a given common theme. Presented in this paper is our project-based learning experience from this group project activity. For our class, we were asked to design and build an interesting artefact that is required physical assembly of printed components. Our group decided to make a movable toy car that all parts, such as gears, wheels, and body frames, were printed from Polylactic Acid (PLA) filaments. It is worth mentioning that printing a functional spring was quite a challenge. This paper will share our journey from brainstorming to design, to parameter identification until testing the final product. Challenges encountered along the journey and our way of overcoming these challenges are also discussed.

Keywords: Additive Manufacturing, 3D printing, PBL, Project.

1 Introduction

Additive manufacturing (AM) technology has become integral to modern prototyping and manufacturing. AM technology is the term used for the technology that builds three-dimensional objects by adding layers of materials such as plastic, wood, concrete, or metal. It includes subsets such as rapid prototyping, 3D printing, direct digital manufacturing, layered manufacturing, and additive fabrication. AM provides cost and time-saving ways to produce low-volume and customized products with complicated geometries and advanced material properties and functionality (Huang, Y., Leu, M. C., Mazumder, J., & Donmez, A, 2015).

There are different categories that comprise additive manufacturing technology. All AM systems can be easily categorized into liquid-based, solid-based, and powder-based. In a Liquid-based RP system, a liquid state is the initial form of the material. Through a curing process, the liquid is transformed into a solid-state. For example, 3D Systems' Stereolithography Apparatus (SLA), Cubital's Solid Ground Curing (SGC). Solid-based RP systems are meant to encompass all forms of material in the solid-state except for powder. In this condition, the solid form can include the shape in the form of a wire, a roll, laminates, and pellets. For instance, Cubic Technologies' Laminated Object Manufacturing (LOM), Stratasys' Fused Deposition Modelling (FDM). In a strict sense, the powder is somehow created to be in a solid-state. However, it is intentionally made as a category outside the solid-based RP systems to mean powder in grain-like form. For example, 3D System's Selective Laser Sintering (SLS), Z Corporation's Three-Dimensional Printing (3DP) (Chua, C. K., Leong, K. F., & Lim, C. S, 2010).

A course on AM has become a regular part of engineering curricula, including the Additive Manufacturing and Reverse Engineering course offered in the Industrial and Manufacturing Engineering Program at the Asian Institute of Technology. Based on project-based learning, this course contains several activities that require student engagement, and as a part of competence development, the students are always assigned a group project. Problem-based learning (PBL) is a team-based teaching and learning approach that uses "real life" problems to help students gain technical knowledge and develop important skill sets in problem-solving, collaborative engagements, effective communication, and research. In PBL, students are presented with an example of a real-life situation and are expected to analyse and/or propose solutions or courses of action which they can then optimize (Tang, Y. M., & Mo, J. P, 2015).

PBL develops cognitive skills associated with problem-solving, group processing skills, and reflective and evaluative skills as well as developing theoretical understanding. As students reflect on the problem-based experience, they acquire transferable skills and knowledge which equip them with the ability to approach a range of novel situations likely to be encountered in their professional careers. Student satisfaction indicators and industry engagement indicators are high. Problem-based learning approaches are commonly applied in science subjects. The analysis of the effect of the Problem based Learning Method in the success degree and motivation of students showed that the problem-based learning method made a positive contribution to the students' success (Ergül, N. R., & Kargın, E. K, 2014).

In this paper, we propose a problem-based learning approach to teach the Additive Manufacturing and Reverse Engineering course. The learning process is designed to conform to well-known principles in the Additive Manufacturing course as well as taking full advantage of the latest 3D printing. This paper will share our journey from brainstorming to design, to parameter identification until testing the final product. Challenges encountered along the journey and our way of overcoming these challenges are also discussed.

2 The process of Additive Manufacturing

The generic AM process includes the following steps.

Step 1: Computer-aided design (CAD); Products developed through AM are created beginning with a software model containing the exterior geometry. Another viable option is to reverse engineer an item or part using a laser or scanning device.

Step 2: Conversion to STL; This step requires converting files to STL, which is the current standard and can be produced by a majority of CAD systems. The STL file is required because it contains the dimensions of the closed exterior surface and is necessary to calculate the layers.

Step 3: STL File Manipulation and Upload to AM Machines; The generated STL file is uploaded to the AM machine. Necessary manipulation of the file may be performed at this time to ensure details such as size, position, and angle.

Step 4: 3D Printer/Machine Setup; Configure the AM machine setting to ensure it accounts for restrictions, power source, layer width, precision degrees, timing, and other configurations.

Step 5: Build; The AM machine builds the object via an automated process similar to paper printers. Limited oversight needs are required to make sure the printer has adequate material and to address possible software malfunctions.

Step 6: Removal; The printed object must be removed upon completion of build. Aside from simply removing it, safety interlocks in place to prevent the printer from overheating or from moving parts.

Step 7: Post Processing; Depending on the removal of the printed object from the printer, it may need to be cleaned, subjected, or unbraced to final manual touch-ups.

Step 8: Application; The 3D-printed object may now be functional. In some cases, it may require additional manipulation such as priming, painting, texturing, or finishing necessary to realize the final intended end-use state. At this point, it can be used or assembled into the component of which it is a part for complete functionality.

3 Our Learning Environment

For the first time that we started learning this course, we felt that the teaching method is different from other courses because the instructor gave the lecture for only one-third of the section and the remainder included the group assignments and activities. Sometimes, the instructor made us into three groups and gave different titles related to the AM course and let us access the knowledge and we had to share and explain what we had learned and known. At that time, it was difficult to get this learning flow, but later we got used to it. Figure 1 is our learning environment called AM Space.

Figure 1. Our AM Space

The first time, we got to the AM Space, we were surprised because there were a lot of 3D printers and we were having access to use them. We got a chance to explore innovative ideas to design functions of the 3D printing products. 3D printers in our laboratory are "Flashforge Adventure 3", fused decomposition modeling (FDM). We were very excited to collaborate on lectures and practical activities. Since there was enough equipment for all of us, every student had access to use freely.

4 Our Group's Project

Since this AM course is project-based learning, we were asked to perform as a group and to make a project related to 3D printing. Therefore, our class members were separated into three groups, each group containing three members. Each group had to come out with their own ideas and discuss their activities related to their ideas. Initially, our group wanted to make a movable car with some electronic components, motors, and battery until we started to questioning ourselves why we cannot make a fully 3D printed movable car without any electronic components. On the other hand, making a 3D model and printing a solid object without any characteristics were too simple and easy. So, our group decided to make something special that has some features with elasticity and flexibility using only PLA filament. Based on the FDM printing process, our group was keen on making a movable car with components that were all printed with PLA filaments. In order to make a movable car, spring plays an essential part and at the same time, it was difficult to print with a normal 3D printer. Thus, making a fully 3D printed movable car became our group's challenge. It is worth mentioning that printing a functional spring was quite a challenge. Finally, our group decided to set the following goals.

- To analyse the capabilities of the 3D printers that we got from the lab.
- To design the elastic print parts with the PLA filament.
- To discuss and design on the CAD Design of the fully 3D printed movable car.

In this AM course, the instructor also gave the guidelines of how to handle 3D printers. Moreover, we learned some important factors of 3D printers' manufacturing capabilities. They are as follows.

4.1 Materials

In FDM printing process, we learned some common materials used in the 3D printers like thermoplastic materials, Polylactic acid (PLA), Acrylonitrile butadiene styrene (ABS), polycarbonate (PC) and Polyamides (nylon). At that time, we could use only thermoplastics (PLA) materials for our group project.

4.2 Size and accuracy

The size of the designed parts depends on the dimension of 3D printers. The maximum print volume of the 3D printers was 150 mm on both X, Y, and Z axes. On the other hand, the manufacturing time is affected by the size of the product. As a result, printing time has also needed to be taken into consideration during the design of the parts.

4.3 Feature design

The printer's nozzle tip was 0.4 mm. The resolution of the printing part can be affected by the nozzle size. The printing time also depends on the diameter of the nozzle. For example, if the nozzle diameter is large, the extrusion width becomes larger and it will decrease the printing time. On the other hand, normally large nozzles cannot print the small parts that are smaller than the nozzle. Printing with support is required when plastic must be deposited on a layer where there is insufficient plastic on the previous layer. Support printing and removal processes are usually time-consuming. The use of support is also wasteful and increases unnecessary costs.

Figure 2. 3D scanning and exporting STL files

Furthermore, in our class, we got a chance to learn 3D scanning as shown in Figure 2 thoroughly which is a process of analysing an object from the real world, to collect all the data in order to recreate its shapes and appearance, digitally. It is useful for the 3D printing process because 3D printers need STL format files which 3D scanning generates.

5 Our Group Project Experiences

For our group, all members were keen on making a movable car with components that were all printed using PLA filament. A lot of discussions and plans were conducted to achieve the goals and challenges. In order to make a movable car, spring plays an essential part, and at the same time, it was difficult to print with a normal 3D printer. Moreover, as our car needed to combine serial parts such as gears, wheels and body frames, the CAD designs of the car came to play an important issue to consider. For the slicing software, we used the "Flash Print" slicing software. Printing parameters like shell parameters, scale, infill density, and layer height affected significantly on assembly components.

5.1 Printing and testing the elastic and flexible objects

In order to make the printing parts flexible and elastic, our group discussed and designed three parts; band, compression spring, and conical spring. Also, PLA material was used in the FDM printing process. Figure 3 shows the 3D Printed band, compression spring, and conical spring.

5.1.1 Band

The first design of the band was simple but the parameter of the shell and extrusion width should be in the correct ratio in order to generate an efficient printing process that is the ratio of the thickness of the print part and the extrusion width. We faced some problems in the printing process that were the poor resolution of the print parts because the printing path was not a single line and continuous. Instead, it should be a single line in each layer and we decided to make the printing path continuous to get a good resolution product and the printed part elastic and flexible.

5.1.2 Compression spring

The second one was a compression spring. It was difficult to print with our 3D printers. Normally, the design of the print part needs a support structure. On the other hand, if we added support structures or placed another position, the spring would not be elastic and flexible. So, our group discussed and made the tests by changing the parameters of the printing setting. Finally, we got the correct setting and a compression spring. This proved that our printers have some limitations but are still powerful.

5.1.3 Conical spring

The conical spring played a key role in making the car movable. In the printing process, there was almost no error however we found many Spidey strings in the printed part. This effect was caused because the retraction parameter was small. The retraction parameter is the length of the recoil movement of the filament necessary to prevent dripping of material during movements and displacements that the extruder performs during printing. To solve this problem, we could set the retraction parameter from the slicing software.

Figure 3. 3D Printed band, compression spring and conical spring

5.2 Testing shrinkage effect

There were many things that go on during the 3D printing process. There were times where shrinkage was not generally an issue and other times when it could be a big deal. When the size of the object was crucial, material shrinkage could become more of a problem and must be taken more seriously. In order to do assembly, we needed to consider the shrinkage effect of the PLA material. This shrinkage was a direct result of the transition from a liquid to a solid-state during the curing process. Depending on the material, there could also be an increase in shrinkage based on the temperature of the environment. First, we designed two cylindrical shapes as shown in figure (4) and we put a gap between them to get a smooth rotation between the body frame and gears. So, we had to check the gap which is appropriate for fitting and smooth assembly. Then, we printed four sets to test the appropriate gap for our car. Depending on the test result, we decided a 0.3 mm gap for fitting parts and a 0.5 mm gap for smooth parts. In this testing, we found that the bottom of the printed part was a little bigger than the upper part as seen in the yellow cycles in Figure 4. We decided that it was the elephant foot effect and we could neglect that effect because all print parts needed the correct dimension only at the upper portion.

Figure 4. CAD design and testing shrinkage effect

5.3 CAD Design

In order to fulfil the third objective, our team discussed and designed a CAD model of the toy car. We discussed some features that our product can be printed easily, our print parts don't need support structures, minimize the number of parts to print, and to make our product more realistic. We designed a total of 12 parts including body frame left and right, spring, main gear, gear locker, secondary gear, axel gear, axles for front and rear, wheels, tires, spacer and key, and some of them are shown in Figure 5. For the main body frame, we designed to get the maximum print volume of the printer because it was the biggest part of our car.

Figure 5. Some Components of CAD Design

5.4 Printing Process

In the printing process, there were many factors and parameters to consider. Our group focused on the printing temperature, layer height, shell parameters, and infill density. Moreover, the filament was the major requirement. In this project, our team used PLA material. According to the brands, the printing temperatures of the PLA filament were different ranging from 190℃ to 220℃. And we also had to consider the print bed temperature because our 3D printers had heated print beds. The print bed temperature was ranging from 40℃ to 60℃ depending on the room temperature and printed volume. Other factors like layer height, shell parameters, and infill density were considered according to the required print parts. To print a toy car, the components were divided into four groups according to the printing setting.

- Customize shell parameter printing setting
- Customize infill density printing setting
- Multi-colour printing setting
- Normal printing setting

5.4.1 Customize shell parameter printing setting

In our project, the gears (main, secondary and axel) needed to be strong enough but in order to save material and time, our team decided not to increase the infill density but to increase the shell count parameter. For a normal printing setting, the shell count perimeter is normally 2. For our gears, our team printed with standard resolution (0.27 mm layer height), standard infill (15%) and shell count parameter 4 for accuracy and long-lasting gear teeth.

5.4.2 Customize infill density printing setting

Our team printed the main parts of our project which were spring for controlling the movement of the main gear and gear locker that acts as the interface between gear and spring. We had to print both of them with infill 100% and shell count parameter 4 because it was important to have no gap inside the print parts to have good strength for resistance to tension.

5.4.3 Multi-colour printing setting

In order to make a realistic car, the multi-colour printing was also important. On the other hand, we faced some material limitations as one colour was not available enough. Therefore, our team decided to choose the multi-colour printing process involving black, white and red. According to this issue, some parts such as spring, gears and axle were not much important in colour choices, however, the main importance was the car body frames, wheels and tires. For this printing process, we set the required height of the print part, make the printer pause, reloaded the required colour of the filament and resumed the printer again. Finally, we got a colourful body frame as seen in Figure 6.

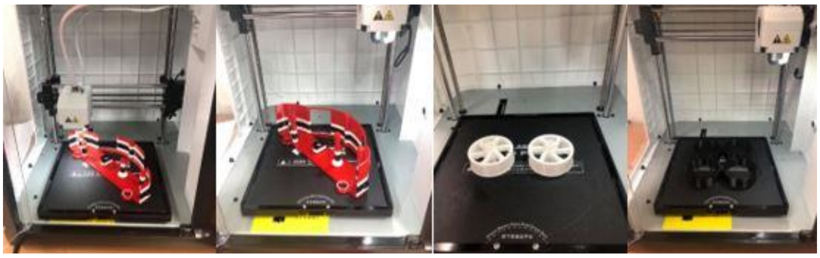


Figure 6. 3D printing process of some components

5.4.4 Normal printing setting

The rest of the parts, wheels, tires, front and rear axles and spacer were printed with normal printing setting; layer height 0.27 mm, infill 15%, shell parameter 2.

5.5 Problems and Errors in Printing Process

After we designed and printed the parts out, they made some errors. As illustrated in Figure 7, the first parts broke easily because of infill density. It just only had a 10% infill. The second one was 100% infill however, it still broke because the load of the spring was too strong. The reason behind the break of the third part was the insufficiency of the shell count parameter. The fourth part had some rough surface in the first layer and the last part had a problem with layer shifting where layers of the printed object were shifted from their intended positions. Getting rough surfaces and layer shifting in the printing process was because of the bad calibration that was measuring the distance between the nozzle tip and the print bed.

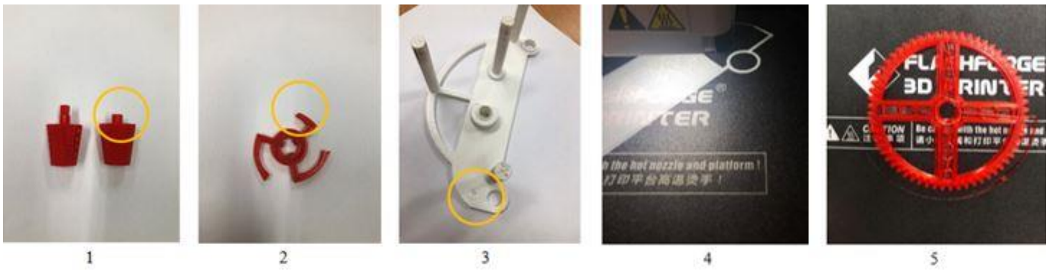


Figure 7. Problems and errors in printing process

5.6 Finishing and Assembly

In most cases, the quality of 3D printed models does not meet the user's particular requirements. In such cases, additional finishing by blasting, sanding, varnishing, and so on is required. Finishing has to be done in any case but it is not an entire element of the AM process. In our project, we tried to design our parts to their best not to require a finishing process.

There were two parts in the assembly process, first model assembly, and final product assembly. Figure 8 displays the components of the final product before making assembly.

Figure 8. On the way to final product

5.7.1 First Model

The white car in Figure 9 is our first model. The gaps between body frame and gears were not smooth enough, and for the strength of the body frame that we can see, some parts broke accidentally as shown in the yellow circle. It broke because of insufficient infill density and shell count parameters as we mentioned above.

5.7.2 Final Product

Learning from the experiences from the first model, we made some improvements to get the most satisfying result of our product. The gears could rotate correctly and the spring could perform well. The assembly process got easier and It could be done within 2 minutes because of the dimension parameters and printing setting. Moreover, in our final model, we did not need to make additional finishing processes.

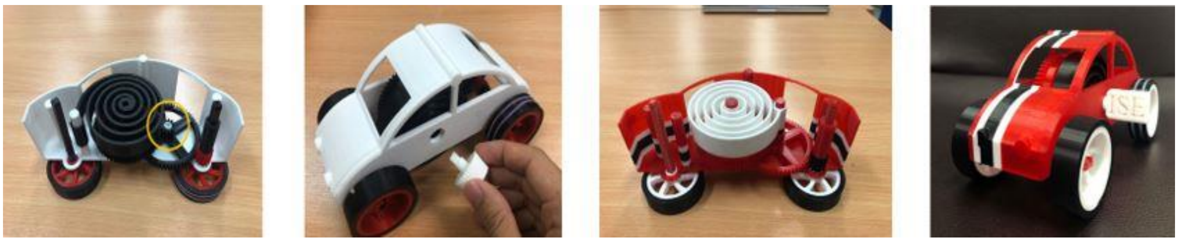


Figure 9. Assembly process

6 Result and Testing

The red car illustrated in Figure 9 was our final model and it was easy to print, and easy to assembly within 2 minutes. Then we added the multi colours in the main body frame. For this car, it took 27 hours to print out. But it also had drawbacks. We encountered that the rear wheel tires can slip easily. So, we managed the rubber band for the rear wheels to prevent the car from slipping. Moreover, our model was designed to meet the maximum size of the build plate. At the same time, printers in our AM space are not big enough to print out all parts together. That's why we had to print the parts separately in a consequent manner. Furthermore, it was also made only for short way drives. Eventually, our final product met our satisfaction of easy to print and assembly, realistic, movable, and the most important, having an elastic and flexible spring.

7 Conclusion

The active learning method that the instructor applied in the Additive Manufacturing and Reverse Engineering course allowed us to engage more in our learning. With his teaching approach by providing a big picture and key points for each of the topics and giving us different subtopics to study, we were encouraged to explore in the team for more information and shared it with other teams. More importantly, the project-based learning in the form of the group project allowed us to work and manage as a team, to express our creativity, and to learn to handle challenges encountered. We learned to tailor individuals' ideas to obtain a group's idea. Not only to understand our idea, but we also learned to understand the capability and limitations of the machine we used. Through this learning by doing, it was not only much easier for us to understand about Additive Manufacturing than listening passively to the lectures but also stimulate our thinking and trained us to keep asking ourselves questions. This course also improves our transversal skills.

Figure 10. Our team

8 References

Huang, Y., Leu, M. C., Mazumder, J., & Donmez, A. (2015). Additive manufacturing: current state, future potential, gaps and needs, and recommendations. *Journal of Manufacturing Science and Engineering*, *137*(1).

Gibson, I., Rosen, D. W., & Stucker, B. (2010). Design for additive manufacturing. In *Additive Manufacturing Technologies* (pp. 299-332). Springer, Boston, MA.

Muniz, B. G., & Peters, K. M. (2016). *An analysis of additive manufacturing production problems and solutions*. Naval Postgraduate School Monterey United States.

Chua, C. K., Leong, K. F., & Lim, C. S. (2010). *Rapid prototyping: principles and applications (with companion CD-ROM)*. World Scientific Publishing Company.

Tang, Y. M., & Mo, J. P. (2015). Problem Based Learning of Systems Engineering Supported by Additive Manufacturing Processes. In *Industrial Engineering Research Special Issue of the International Conference of Technology Education (ICTE)* (Vol. 8, No. 1, pp. 77-91).

Ergül, N. R., & Kargın, E. K. (2014). The effect of project based learning on students' science success. *Procedia-Social and Behavioral Sciences*, *136*, 537-541.

Peer-Assessment for Holistic Student Development (PAHSD): Implementing a Digital Application on a PBL Platform

Simone B. S. Monteiro[1], Khaled B. Hafaiedh[2], João M. da Silva[1], Ana C. F. Lima[1], Everaldo S. Júnior[1], Mateus H. Torres[3], Mohamed Boufaied[2], Adem B. Zarb[2], Mohamed A. B. Rekaya[2], Iheb Zouaghi[2], Dianne Magalhães Viana[4]

[1] Professional Master´s Degree Program in Applied Computing, University of Brasília, Brasília, Brazil
[2] Esprit School of Engineering, Tunis, Tunísia
[3] Production Engineering, Faculty of Technology, University of Brasília, Brasília, Brazil
[4] Mechanical Engineering, Faculty of Technology, University of Brasília, Brasília, Brazil

Email: simoneborges@unb.br, khaled.hafaiedh@esprit.tn, joaomello@unb,br, anacristina.limafernandes@gmail.com, everaldo.junior@aluno.unb.br, mateushalbe@aluno.unb.br, mohamed.boufaied@esprit.tn, adem.benzarb@esprit.tn, medaziz.benrekaya@esprit.tn, iheb.zouaghi@esprit.tn, diannemv@unb.br

Abstract

The traditional education in which the teacher introduces the concepts to be studied and students passively try to absorb the knowledge has been questioned. At the same time, the collaborative and inductive students-centred approaches, such as the Project-Based Learning (PBL), are gaining importance as students are increasingly concerned with obtaining competencies to deal with real-life situations, proposing solutions to problems and/or getting the most of the opportunities, by working in teams. In this context, a structured peer evaluation process is required to measure students´ competences and create a solid feedback flow. However, the teachers have difficulties to effectively detect the student's strengths and weaknesses, making it challenging for them to help their students to develop the required competences. In this paper, it is presented the development of a digital solution for a structured, methodological and continuous process of Peer Assessment for students. This tool, denominated Peer-Assessment for Holistic Student Development (PAHSD), will be a module of the Platform for Unifying Methodologies of Active learning (PUMA), which is a platform for centralization and automation of PBL processes for university courses. With the PAHSD module, historical data from peer evaluation are used to identify which student's competences need to be improved and to measure which were already improved during his academic journey. The PAHSD indicates the specific training for personal improvement and allows students to compare themselves and also for the professor to make a complete analysis on students results. The PAHSD will be tested on PBL engineering projects in Brazil and Tunisia and could be extended to any education institution that adopt the PBL methodology in any area.

Keywords: Peer-Assessment; PBL Methodology; Machine Learning; Training via PBL.

1 Introduction

At the end of the university graduation period, students seem to have a growing concern about transitioning the skills and abilities they acquired during their undergraduate course to please the needs and demands of companies (Schoenau-Fog, Reng, & Kofoed, 2015). Many studies highlight that applying engineering courses into a real-world practical context brings many benefits to students (Cano, López, & Rebollar, 2008; Habash & Suurtamm, 2010; Tran & Nathan, 2010; Peterson, Hartmann, Fruchter, & Fischer, 2011). In this context, there is an increase in the use of inductive approaches, such as Project-Based Learning (PBL), which emphasizes that the teaching-learning process should be student-centered, meaning the students should assume greater participation and responsibility for their education (Prince & Felder, 2006).

PBL is part of the main educational vision at Esprit (Bettaieb, 2017). Project-Based Learning (PBL) has become the norm for modern education as an effective collaborative learning methodology for increasing motivation, engagement, and social presence of students involved in a project while maximizing time in dealing with real-world situations. Therefore, its application propels the university to work focused on making a real impact on society (Esprit, 2020).

The Production Engineering undergraduate program of the University of Brasília (UnB) acknowledges the importance of this scenario and cooperates with corporations for employee development to create a profile aligned with the professional practice. It adopts the PBL method, which embraces its eight units of Production

Systems Project (PSP) courses as well as undergraduate students' final projects (Monteiro, Reis, Silva & Souza, 2017).

Both UnB and Esprit are continuously looking for ways to ensure quality in the PBL application. In this context, the Platform for Unifying Methodologies of Active learning (PUMA) is being developed to support the application of the PBL method in the PSP courses in the Production Engineering Undergraduate Program at UnB. (Silva Júnior, Monteiro, Lima, Mariano & Silva, 2019). PUMA is a platform centered in academical culture and encouragement towards using Information and Communication Technology (ICT) as a useful tool to measure the efficiency of the PBL method, acquiring feedback and substantial and trustable information to redirect PSP courses over the years, besides watching market demands and maintaining the course always aligned to the stakeholder's expectations (Monteiro, Lima, Mariano & Silva Júnior, 2020).

Given this context, the structure proposed in this document seeks to answer the following research problem: how to use the module of a web platform to automate the peer evaluation process and, thus, improve the application of the PBL methodology? This article aims at presenting the development of the PUMA Peer-Assessment for Holistic Student Development (PAHSD) module, a structured, methodological, and with retrievable data digital tool. Since teams are the basis of work in the modern knowledge era, it is a growing concern that they work properly, meaning to have committed people with the correct skills and profiles to accomplish the expected results. The university plays a very important role in the evolution of individuals in both hard and soft skills, and PBL provides a more auspicious environment for that. Having the professor specific data about students' performances and, consequently, about their strengths and weaknesses is a key point to make possible more focused stimulus from the professor to the development of the students.

This article exposes the development of the peer assessment module of the Platform for Unifying Methodologies of Active Learning (PUMA). Everything from the justifications for choosing this problem, and treating it as an opportunity, to the development details is clarified in an organization line that includes Literature Review, Methodology, Development, and Conclusion. The literature review compiles the main researches that served as a foundation for development decisions. The methodology presents the information related to the iterations and dynamics of the international partnership, through which this project was developed, as well as the technologies and techniques used and how the project fits into the PUMA. In the Development topic, referred to as Platform for Unifying Methodologies of Active learning (PUMA) - Peer Assessment Module, the technical details are approached, including both Product Engineering and Computer Science/Engineering aspects. Finally, the conclusion reveals the results, lessons learned, and future project possibilities.

2 Literature review

The literature review comprises a group of important researched subjects that include the main existing knowledge in the search area. The procurement of a solid knowledge basis has been focused on the following topics: Project-Based Learning (PBL); Skills and Peer Assessment; and Platforms to support Peer Assessment.

2.1 Project-Based Learning (PBL)

The Project-Based Learning (PBL) approach emphasizes that the teaching-learning process must be student-centered, which means that the students must assume a more relevant role and accountability for their education, especially in collaborative executions of projects (Blumenfeld, Soloway, Marx, Krajcik, Guzdial, & Palincsar, 1991)

PBL method results show that it is a teaching approach designed to engage students in the investigation of real problems and the development of professional and human skills (Lima, Mesquita, Rocha, & Rabelo, 2017). The development of interdisciplinary skills, cooperation, project management, leadership, problem-solving abilities, among other aspects, is considered essential to building current engineers' training (Taajamaa, Kirjavainen, Repokari, Sjöman, Utriainen, & Salakoski, 2013).

The Project-Based Learning method has been increasingly tested and adopted in several educational institutions around the world (Condliffe, 2017). The PBL puts the student at the center of his/her learning process during the execution of each project, which can be defined as a complex task, an opportunity, or a real problem whose execution involves research, planning, needs assessment, among other stages of development (Alfaro, Apaza, Luna-Urquizo, & Rivera, 2019).

2.2 Skills and Peer Assessment

PBL method is an educational approach designed to engage students in the investigation of real problems and the development of skills (Lima, Mesquita, Rocha, & Rabelo, 2017). The development of interdisciplinary skills, cooperation, project management, leadership, problem-solving abilities, among other aspects, is considered essential to building current engineers' training (Taajamaa, Kirjavainen, Repokari, Sjöman, Utriainen, & Salakoski, 2013).

Buhari, Valloo, and Hashim (2017) state that, from the employer's perspective, hard and soft skills are significant, being hard skills focused on technical knowledge, while soft skills are mainly based on communication, documentation, leadership and other personal skills.

A research conducted by Patacsil and Tablatin (2017) shows the gaps in soft and hard skills in students, starting from the perception of students and industry. For the authors, several studies relate ten common soft skills in the fields of business and computer technology. The soft skills are communication, critical and decision-making capacities, interpersonal skills, negotiation, problem-solving, self-confidence, self-management, teamwork, and worth ethics. A proposal for a professional development training program could help students to improve their soft skills and to get prepared for the market. On the other hand, Hard skills are used as a basis of the educational curriculum, attending the needs of the market. For example, to an Information Technology (IT) Program, the hard skills could be considered as standard software applications, knowledge of programming languages, databases, networking, and computer hardware, as well as the ability to design user-friendly graphical interfaces. The study focused on the gaps of soft and hard skills and selected the ones that would be more useful in an industrial environment.

The study Hwang, Hung and Chen (2014) reveals that peer review can improve students' achievements, motivations, and problem-solving skills, reinforcing the potential of peer assessment to help students make reflections that can help them to discover their learning problems and the possible ways to deal with them (Merrill and Gibert 2008). Self-assessment and peer assessment are becoming central aspects of student-centered education, such as PBL, becoming useful for developing essential skills for students, for example, taking more responsibility for their learning, developing a better understanding of content, evaluation criteria and their values and judgments, thus maturing a critical reflection skill (Wanner & Palmer, 2018).

2.3 Platforms to support Peer Assessment

Peer assessment is an effective tool for applying active learning methods. Students are stimulated to review themselves critically when performing a task or set of tasks, then communicate constructive feedback for each other's improvement. When examining the work of colleagues, students consider the significance of good work in general, especially if they use a detailed questions script as a guide (Schankman, 2015). Using peer assessment in group work can increase engagement, participation, and social presence in the course. In fact, students give feedbacks to each other, and the teacher can focus on more directed orientation. The key to receiving successful peer feedback is a constructive and honest environment in which students feel confident to share honest but useful constructive criticism about each other (Schankman, 2015).

As a previous step to the development, a research effort on the existing Peer Assessment platforms, which are here defined as any platforms that contain the Peer Assessment functionality for application in a teamwork educational environment, was carried out. The main two platforms that corresponded to the mentioned criteria were: Peergrade, a free online platform to facilitate peer feedback sessions among students (Peergrade, 2020); and PEAR (Peer Evaluation, Assessment, and Review), an online application developed by Teaching Support Services at the University of Guelph which helps instructors and teachers to apply peer assessment processes in their courses (Teaching Support Services, 2020)

The main qualities of the platforms were their functional effectiveness, being able to perform Peer Assessment surveys and store the data, and that they allowed students to access their own results. On the other hand, it was evaluated that both had a lack of modern ergonomics, usability and simplicity, with unnecessary complexity within the allocation of teachers and students, and a lack of workshops or any other way to help students to improve their diagnosed weaknesses, and could be defined as professor-centred.

3 Research methodology

The Peer Assessment module design method is introduced in topics 3.1 and 3.2. The project was developed by students from Brazil and Tunisia with the supervision of professors from both coutries. The following parts detail the workflow as well as the decision-making procedures in the development process.

3.1 Method

As for the approach to the research problem presented in section 1, this study is a qualitative research concerning both the work and study areas of Esprit and UnB (Silveira & Córdova, 2009). In this context, the Case Study methodological approach was chosen, seeking to develop knowledge that allows the design and construction of the peer evaluation module, which had the participation of students and teachers from both universities. The Peer Assessment module was developed by Tunisian and Brazilian students and professors. Therefore, the methods that made possible the reported development reflect the terms of the partnership, as the steps of development describe below.

3.2 Development Process of the PUMA Peer Assessment Module (PAHSD)

The PAHSD module was created to be integrated to the PUMA platform in the future. The development process of this module consisted of seven steps (Pressman, 2011), Figure 1

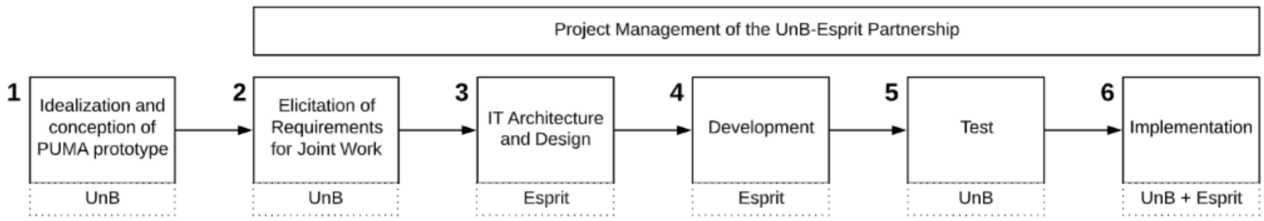


Figure 1. Steps of research.

The Peer Assessment module is designed to be added to PUMA. Seven steps organized the development process: (i) Idealization and conception of PUMA prototype; (ii) elicitation of requirements for joint work; (iii) IT architecture and design; (iv) development; (v) test; (vi) implementation.

3.2.1 Step 1 - Idealization and conception of PUMA prototype

The beta version of the PUMA PAHSD module was developed applying the basic requirements in a prototype in Excel and was tested for 5 semesters in 1 course, denominated Production System Project 5 (PSP5), of the UnB production engineering undergraduate program. Each student received a spreadsheet with the name of all members of his team (his own included) and should evaluate himself and the others in 20 different micro-skills related to 6 macro skills like communication, leadership, effectiveness, professionalism, manageability, and cognitive abilities. The spreadsheet was applied in two different moments of the course: in the middle and one week before the end. Thus, the students' progress was recorded, and it was also possible for the teacher to intervene in the student teams to remedy possible problems when the evaluation result isn't good. The result of the peer assessment is necessary to improve the students' skills. Besides, a prototype in HTML was developed for the front-end, which included the same functions as Excel, including now the enhancements from the PSP5 cycles of validation.

3.2.2 Step 2 - Elicitation of requirements for joint work

Identifying the requirements of a problem is a major challenge for system developers (Pressman, 2011). The engineering requirements help to communicate the expected effects of the software on the company and support product development. This step involved three parts, from identifying requirements to documentation, as described below:

- **Requirements identification and analysis:** This phase included the collection of requirements, by identifying, through interviews and brainstorming, target group needs with the project participants.
- **Requirements specification:** It included the assignment of all functions required for the complete set-up of the software based on the use case diagram.
- **Requirements Documentation**: This phase was accomplished by fully describing the requirements of each assigned functionality, including all of the following details: Purpose of functionality; Prototype; Pre-Conditions; Business rules; and Messages.

3.2.3 Step 3 – IT architecture and design

For the architecture, the MERN Stack Development was used. The main advantage for developers using the MERN stack is that every line of code is written in JavaScript. This is a programming language that's used everywhere, both for client-side code and server-side code. With one language across tiers, there's no need for context switching, Figure 2.

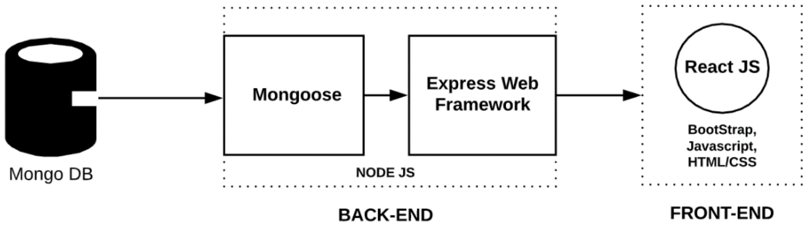


Figure 2. Technologies adopted in the module development

- **Front-End Development (React):** As a JavaScript library for building user interfaces, the React library can be used for creating views rendered in HTML.
- **Back-End Development (Node.js):** It's designed to build scalable network applications, and can execute JavaScript code outside of a browser.
- **Database (MongoDB):** It is a NoSQL (non-relational) document-oriented database. Data are stored in flexible documents with a JSON (JavaScript Object Notation)-based query language.

3.2.4 Step 4 – Development

For the development methodology, SCRUM, an agile methodology with incremental characteristics, was chosen. At this project management method, the work is divided over several time slots called sprints until the achievement of the project as a whole. Each increment is integrated into the components of the previous sprint, connecting the different development stages. At each stage of the development process, the product is implemented, tested, and then integrated (Scrumstudy, 2016), Figure 3.

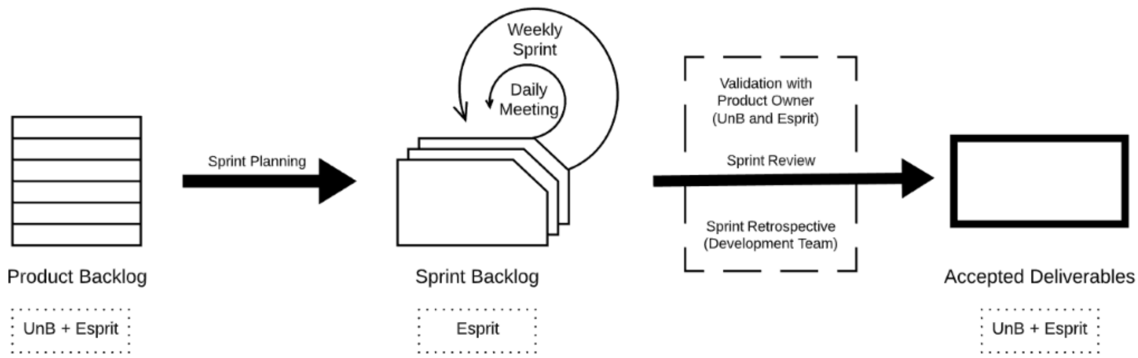


Figure 3. Scrum Methodology applied in the project

Scrum methodology proposes quick and frequent meetings. There were during this project daily meetings with all the team members, and a weekly meeting with the scrum master and the Brazilian team to discuss the project progress. Discord was used as main communication tool to keep track of each other's work, and GitHub was used for the integration of the work.

3.2.5 Step 5 - Test

As a previous phase to the release of the module for proper use in project-based learning courses, testing sections with the development team is essential. A university course environment is simulated and fictional teams with project members are created to anticipate the user experience and ensure that the front and back ends are functional. All functional situations have been tested by the development team and the other APIs in BackEnd have been tested with Postman.

3.2.6 Step 6 - Implementation through Engineering Courses

This step consists of the validation and improvement of the module developed. It will include two engineering teams from UnB and Esprit who, during the second semester of 2020, will work on diagnosing the functionalities and verifying the effectiveness of the PAHSD. In this step, it is expected to raise new requirements, test and refine the features developed, and implement the changes. Thus, obtaining a version of the module that is ready to be applied in PBL courses.

4 Platform for Unification of Methodologies of Active Learning (PUMA) - Peer Assessment Module

The Platform for Unifying Methodologies of Active Learning (PUMA) was conceived to an A3M (Learning for the 3rd Millennium) Program of University of Brasilia (Monteiro, Campos, Lima, A & Mariano, 2018). In 2018, the Brazilian team developed two modules: the first was related to project management and the submission of projects by stakeholders (companies, for instance); and the second was the module for the publication of news in the platform (Silva Júnior, Monteiro, Lima, Mariano & Silva, 2019). In 2020, the other two modules of PUMA, Peer Assessment and Team-Building have been developed by a multidisciplinary team composed of students and professors from Tunisia and Brazil. The main structures of the Peer-Assessment for Holistic Student Development (PAHSD) module with a description of the functionalities and exposure of the development stage of the front-end can be understood in 5 main parts, as presented in the following sections.

4.1 Module developed and technical information regarding the Peer-Assessment

Students generally have a good understanding of one another and peer assessments allow them to share perceptions on each other's areas of mastery and weakness. By doing so, they discover ways to overcome their obstacles and address deficiencies in ways that work best for them, instead of through prescribed interventions provided by a teacher. The success of the evaluation is closely related to how much the students adopt standardized criteria and processes. Subsequently, the teacher takes part in it by adding workshops targeting the weaknesses of the majority of his students, as well as challenging students with specific weaknesses to take positions that push them to solve these gaps. By doing so, he makes sure the student develops holistically in macro skills and have the actual achievement of their potential.

4.1.1 Registration/Profile

The student and the teacher need to register to the application. Then, the administrator, after checking the information with the university, decide to give or deny access to the application. After getting the validation from the admin, they both can update their profile and add the needed information, Figure 4.

Figure 4. Registration of Users

4.1.2 Add Skills

The teacher can also add any macro skill wanted and immediately include it as a peer assessment criterion to a group of projects, being a hard or a soft skill, Figure 5.

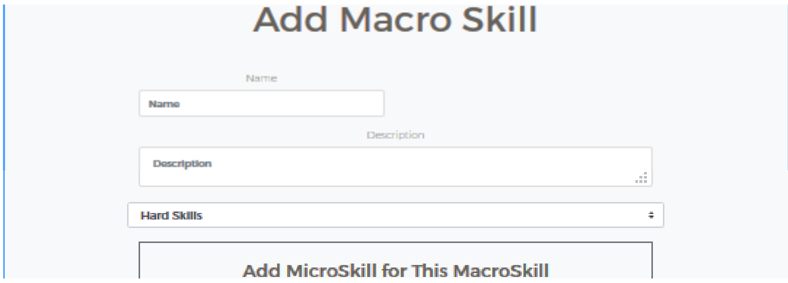


Figure 5. Add Macro Skill and Micro Skill

4.1.3 Peer Evaluation Process

After logging in, the student can proceed to the Peer Assessment by just choosing one of the projects he's participating in. After selecting the project, he will be able to evaluate all the members engaged in it. If he already had assessed his teammates, he won't be able to do it again. Else, if he/she hadn't done it yet, after clicking on the Evaluate button, the peer evaluation Form, Figure 6, will open with permission to fill in.

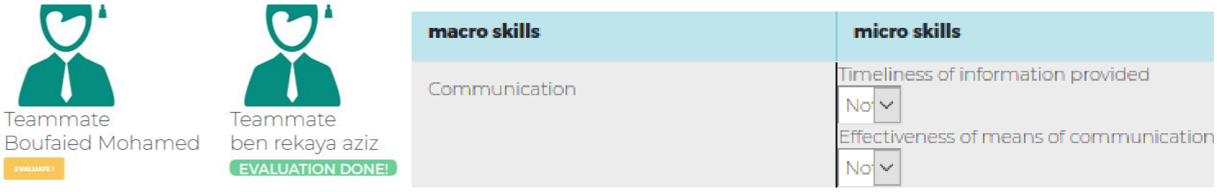


Figure 6. Step of Peer Evaluation Process

The Evaluator needs to grade every micro skill using a behaviourally anchored, 6 scale rating (Excellent =5, Very good = 4, Satisfactory = 3, Ordinary = 3, Unsatisfactory = 2, No show = 0). After everyone in a team having evaluated the other and himself, every student can check his evaluation from the project. He would be also able to compare his results with his teammates with a comparation graph, this Figure 7.

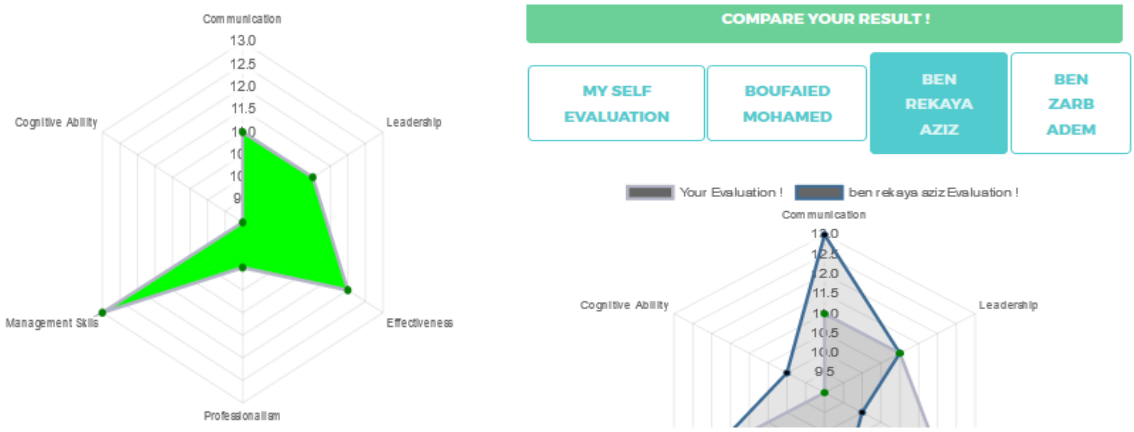


Figure 7. Comparison of your evaluation with the teammate

The teacher is able to keep track of the students and check their performances, comparing their results in, for instance, student-student and student-average models, and check the best evaluation per macro skill. The professor can also compare a student's performances in different projects over time, Figure 8.

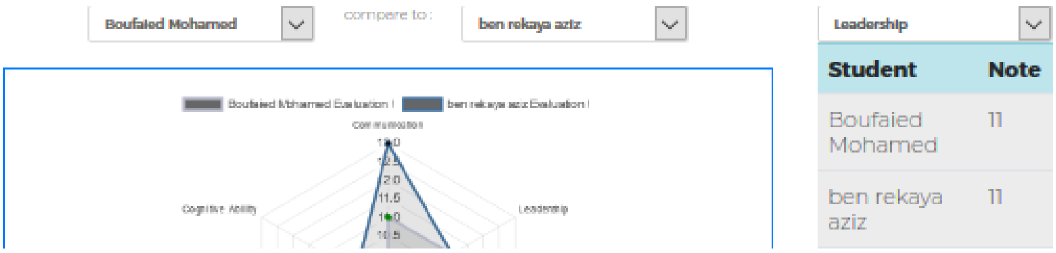


Figure 8. Comparison of student evaluation per Macro Skill

4.1.4 Workshops

The teacher can also add a workshop targeting the general weaknesses of students in any micro skill. Every workshop has a description of the specific skill, a date for its occurrence and a limit number of participants.

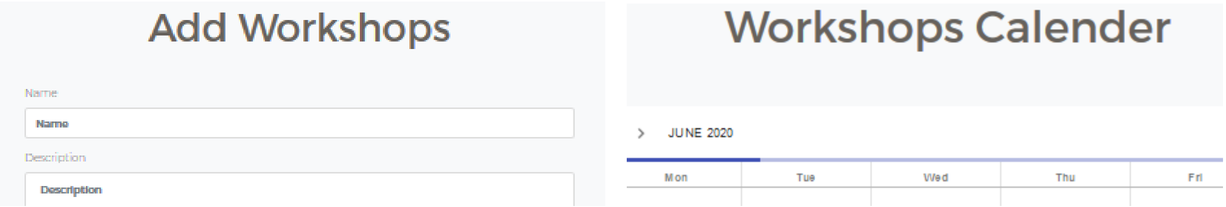


Figure 9. Suggested workshop for Macro Skill to be developed

After adding the workshop, the students can visualize the complete list of planned workshops in a calendar, in which they can select to participate in the workshop or not.

5 Conclusion

The tool developed in this project as a PUMA module in the context of the Brazil-Tunisia partnership corresponds to the requirements to solve the teacher's scarcity of student performance information. The PAHSD empowers educators them not only to direct efforts towards student skill evolution, but also to have a quick diagnose on project teams that are underperforming, thus maximizing the efficiency of the whole Educational system.

Therefore, with the development and presentation of a support module for peer evaluation in the PBL context of UnB and Esprit universities, the objective of this research was achieved, having also answered the main research question investigated, by means of developing the platform and using it to automate processes in educational environments.

This partnership between Brazil and Tunisia evidenced important possibilities of real achievements with international entrepreneurship in the University context, with win-win ties. Brazilians had a project of a platform that assesses the students in the active learning process, and the Tunisians had the computer science skills to carry out the development. The joint work was the key to transform these latent possibilities into one unified concrete result.

The evolution of the student's competencies and skills occur over time and not only in one course. Therefore, it is important to have a standardized amount of a peer evaluation system that utilizes the same criteria over time in order to allow the comparison of historical data in short, medium and long-term. PUMA as a centralized multi-courses platform having the PAHSD module will allow a proper understanding of the evolution of the students' performances and, consequently, of the educational approaches applied, allowing continuous improvement.

The final implementation plan of the PAHSD module developed will be carried out in three to five courses that use active methodologies, at least two in Brazil and one in Tunisia. This test consists of a complete simulation of the application of the module in the course and provides a full-functional version of the module, hosted on a temporary PUMA server in Brasilia. The students will be required to register and establish their teams into the platform, in a way that they can start their project and will peer assess each other at least 3 times during the semester. In the end of the course, the professors and students will be submitted to a survey to evaluate their respective environments in the module, in order to provide feedback. The team will then evaluate the feedbacks received and proceed to the next phase, which is the improvement.

PUMA's peer assessment functionalities are mainly contemplated by this project, but many usability and data management functional will require future work with an incremental approach. The other modules of PUMA are also future work to be developed through the Brazil-Tunisia partnership framework, stablished by UnB and Esprit.

6 References

Alfaro, L., Apaza, E., Luna-Urquizo, J., & Rivera, C. (2019). Identification of Learning Styles and Automatic Assignment of Projects in an Adaptive e-Learning Environment using Project Based Learning. In *International Journal of Advanced Computer Science and Applications* (IJACSA), 10(11), 2019. doi:10.14569/IJACSA.2019.0101191

Bettaieb L. (2017). Esprit PBL Case Study. In: Guerra A., Ulseth R., Kolmos A. (eds) PBL in *Engineering Education.* SensePublishers, Rotterdam. doi: https://doi.org/10.1007/978-94-6300-905-8_7

Blumenfeld, Soloway, Marx, Krajcik, Guzdial, & Palincsar (1991) Motivating Project-Based Learning: Sustaining the Doing, Supporting the Learning, *Educational Psychologist*, 26:3-4, 369-398, DOI: 10.1080/00461520.1991.9653139

Cano, J. L., López, I. L., & Rebollar, R. (2008). Learning project managment through working with real clients. *The International journal of engineering education*, 24(6), 1199-1209.

Condliffe, B. (2017). Project-Based Learning: A Literature Review. *Working Paper. MDRC*.

Esprit (2020). Accréditations. Retrieved June 10, 2020, from https://esprit.tn/

Habash, R. W. Y. & Suurtamm, C. (2010). Engaging High School and Engineering Students: A Multifaceted Outreach Program Based on a Mechatronics Platform. In I*EEE Transactions on Education*, 136-143 doi: 10.1109/TE.2009.2025659.

Hwang, G. J., Hung, C. M., & Chen, N. S. (2014). Improving learning achievements, motivations and problem-solving skills through a peer assessment-based game development approach. *Educational Technology Research and Development*, 62(2), 129-145.

Prince, M. J., & Felder, R. M. (2006). Inductive teaching and learning methods: Definitions, comparisons, and research bases. *Journal of engineering education*, 95(2), 123-138. doi:10.1002/j.2168-9830.2006.tb00884.x

Merrill, M. D., & Gibert, C. G. (2008). Effective peer interaction in problem-centered instructional strategy. *Distance Education*, 29(2), 199–207

Monteiro, S. B. S., Reis, A. C. B., Silva, J. M. da, & Souza, J. C. F. (2017). A Project-based Learning curricular approach in a Production Engineering Program. *Production*, 27(spe). https://dx.doi.org/10.1590/0103-6513.226116

Monteiro, S. B. S., Campos, M. R. M., Lima, A. C. F., & Melo, A. (2018). Evaluating direct and indirect results of the active methodology in learning: proposal of an integrative design in 360º via unified platform. In *International Symposium on Project Approaches in Engineering Education (PAEE)* Vol. 8, pp. 768-775.

Monteiro, S. B. S., Lima, A. C. F., Mariano, A. M., & Júnior, E. S. (2020). Plataforma Unificada de Metodologia Ativa (PUMA): um projeto multidisciplinar. *Revista Ibérica de Sistemas e Tecnologias de Informaçã*o, (E28), 766-778.

Lima, R. M., Mesquita, D., Rocha, C., & Rabelo, M. (2017). Defining the Industrial and Engineering Management Professional Profile: a longitudinal study based on job advertisements. *Production*, 27(spe), e20162299. Epub July 24, 2017. doi:10.1590/0103-6513.229916

Patacsil, F. F., & Tablatin, C. L. S. (2017). Exploring the importance of soft and hard skills as perceived by IT internship students and industry: A gap analysis. *Journal of Technology and Science Education*, 7(3), 347-368.

Peergrade (2020). Retrieved April 01, 2020, from https://www.peergrade.io/

Pressman, R. S. (2011). Engenharia de Software: Uma abordagem profissional. Setima Edição. Porto Alegre: AMGH.

Schankman, L. (2015). Peer evaluation. In Teaching Improvement Guide. Retrieved from http://www.uwlax.edu/catl/teaching-guides/teaching-improvement-guide/how-can-i-improve/peer-evaluation/.

Schoenau-Fog, H., Reng, L., & Kofoed, L. B. (2015). Fabrication of games and learning: a purposive game production. In European Conference on Games Based Learning (p. 480). Academic Conferences International Limited.

Scrumstudy (2016). *A Guide to the Scrum Body of Knowledge* (SBOK™ Guide). 3ª Ed.

Silva Júnior, E.; Monteiro, S.B.S.; Lima, A. C. F.; Mariano, A. M., Silva, V. B. N. S. (2019). Unified Platform of Active Methodology (PUMA): Development Steps of the Module Divulgation and Request Projects. In: 1*1th International Symposium on Project Approaches in Engineering Education (PAEE) and 16th Active Learning in Engineering Education Workshop (ALE)*, Tunísia, África, v. 11/16. p. 357-365.

Silveira, D. T., & Córdova, F. P. (2009). Unidade 2–A pesquisa científica. Métodos de pesquisa, 1, 31.

Taajamaa, V., Kirjavainen, S., Repokari, L., Sjöman, H., Utriainen, T., & Salakoski, T. (2013). Dancing with ambiguity design thinking in interdisciplinary engineering education. In *IEEE Tsinghua International Design Management Symposium*, Shenzhen, pp. 353-360, doi:10.1109/TIDMS.2013.6981258.

Teaching Support Services (2020). PEAR - A Peer Evaluation, Assessment and Review Tool, Retrieved April 01, 2020, from https://peartool.opened.uoguelph.ca/

Tran, N., & Nathan, M. J. (2010). An investigation of the relationship between pre-college engineering studies and student achievement in science and mathematics. *Journal of Engineering Education*, 99(2), 143-157.

Wanner, T., & Palmer, E. (2018). Formative self-and peer assessment for improved student learning: the crucial factors of design, teacher participation and feedback. *Assessment & Evaluation in Higher Education,* 43(7), 1032-1047.

Team Building through Student's Preferences and Competences (TBSPC): implementation on a PBL platform

Khaled B. Hafaiedh[1], Simone B. S. Monteiro[2], João M. da Silva[2], Everaldo S. Júnior[2], Mateus H. Torres[3], Mejri Nizar [1], Nader Abdellaoui[1], Zied Kouki[1], Amine Ayari[1], Ari M. Mariano[2], Paulo Celso Reis [3]

[1] Esprit School of Engineering, Tunis, Tunísi
[2] Professional Master´s Degree Program in Applied Computing, University of Brasília, Brasília, Brazil
[3] Production Engineering, Faculty of Technology, University of Brasília, Brasília, Brazil

Email: khaled.hafaiedh@esprit.tn, simoneborges@unb.br, joaomello@unb.br, everaldo.junior@aluno.unb.br, mateushalbe@aluno.unb.br, nizar.mejri@esprit.tn, nader.abdellaoui@esprit.tn, zied.kouki.1@esprit.tn, mohamedamine.ayari@esprit.tn, arimariano@unb.br, pcrgomes@unb.br

Abstract

Project-Based Learning (PBL) has been widely used in education, helping students to develop technical knowledge within a critical thinking, collaboration, creativity and communication environment. Thus, PBL has the students as the main object, enabling them to decide on real-life focus situations, proposing, through teamwork, solutions to problems and/or getting the most of the opportunities. PBL promotes enjoyable learning, allowing the direct mandatory participation of students, teachers and the owners of the real-life situations under consideration, as well as the eventual participation of other relevant stakeholders. However, in most cases, the choice of teams is made manually by the teacher, through criteria that many times result in lack of coherence and equity between the project teams. This undesirably affects the overall group performance due to conflicts, communication gaps and lack of transparency. In this paper, a flexible module is proposed to digitize and automate team-building processes, based on students' preferences and competences. This module, called Team Building through Student's Preferences and Competences (TBSPC), may be applied to any type of PBL project and offers to students the possibility to contribute in the PBL team pre-creation phase, allowing their decision-making based within some settings previously established by teachers. This makes PBL teams coherent, complementary and congruent with the project. The effectiveness of the mechanisms for creating teams and their impact on the teams' performance in PBL courses are a focus for the TBSPC module development in the context of the Brazil and Tunisia partnership. This module will be part of the Platform for Unifying Methodologies of Active learning (PUMA) which is a platform for centralization and automation of PBL processes for university courses.

Keywords: Team Building; Student´s Preferences and Competences; PBL Methodology; PUMA.

1 Introduction

Problem Based Learning (PBL) is a student-centred, collaborative, non-traditional approach to education in which students learn about a subject through the experience of solving an open-ended problem as a central place in the learning activity (Adderly, 1975; Prince & Felder, 2006). However, PBL is not always successfully implemented as students are constantly challenged to unlearn old learning habits to make way for new learning styles collaboratively (Meireles & Bonifácio, 2015). Pitfalls such as social distraction, groupthink, overdependence on a dominant leader, overcommitment to goals, and diffusion of responsibility are challenging key factors that may reduce team effectiveness when teams intentionally focus on Project Based Learning (Kayes, Kayes, & Kolb, 2005). To learn from their experience, teams must create a conversational space where members can reflect on and talk about their experience together (Martins & Frezatti, 2015).

Since its foundation in 2003, The Private Higher School of Engineering and Technology ESPRIT embraced the PBL methodology by having students working on projects and real problems during the entire graduation period, to enhance their engineering reasoning skills before they graduate (Bettaieb, 2017). Since its beginnings, Esprit implemented PBL courses and curricula agreeing that, as an outcome of the PBL process, students have greater retention of learning and increased ability to apply knowledge in engineering settings. By using the Project Based Learning method, the students become intrinsically involved in their training and education. This is one of the reasons why Esprit obtained the EUR-ACE accreditation provided by the French organization CTI (Committee of Engineering Titles) in September 2017 (Esprit, 2020).

The Production Engineering Undergraduate Program of University of Brasília (UnB) has also acknowledged the benefits of education through real-world problems and its power to cooperate with the market by developing students with the holistic skills, both hard and soft. It adopts the Project Based Learning (PBL) method, especially in the eight Production Systems Project (PSP) courses and in the final graduation projects developed by students (Monteiro, Reis, Silva & Souza, 2017). PBL aims to make students apply theoretical knowledge by solving real issues, by which they are instigated to learn. In all stages of project development, from planning until closure, they need to acquire different kinds of knowledge and understand the many dimensions involved in the problem-solving process.

In the context of ensuring proper application of this methodology, the Platform for Unifying Methodologies of Active Learning (PUMA), a digital platform that structures and automates PBL processes in university courses, was idealized at UnB as an opportunity to optimize PBL application (Silva Júnior, Monteiro, Lima, Mariano & Silva, 2019). A Brazil-Tunisia partnership for PBL project-development started at the 11th International Symposium on Project Approaches in Engineering Education (PAEE) and at the 16th Active Learning in Engineering Education Workshop (ALE) which took place in Tunisia in 2019. In the beginning of 2020, the partnership was already mature and there was an agreement to include Esprit in the PUMA development. For both universities, PUMA represents a way to ensure quality in the different PBL courses, by standardizing and centralizing procedures and information as well as connecting the market to the university, bringing real clients and problems to the student teams working in the PBL framework.

The courses that use the project-based approach adopted by the courses at the University of Esprit and the University of Brasilia, generally adopt different procedures for the division of teams, obtaining varied results. Some courses at these universities often divide teams randomly; after that, students choose a project after a short time of getting to know each other. Therefore, some students may not be satisfied with their team members or even hold teachers responsible for any relationship problems between team members. It should also be noted that students can be happy because they can work with people to whom they have affinities, but they need to make smart choices about the proposed topics to have the chance to be contemplated with team members who want to work together.

Another important point is that, in many courses at Esprit and UnB, the allocation of team members does not consider the necessary competencies in advance. Therefore, some problems may arise during work, as the team lacks the skills and knowledge required for developing the projects. In these cases, students may have problems with the lack of certain competence in the team, which can affect the performance of the project, giving rise to a dysfunctional group. This can be a problem for the progress of the project, as it can create an unceasing atmosphere of creative tension. It is in the face of these pedagogical aspects that team building through students' preferences and skills should be applied in the classroom, to encourage collaboration, problem-solving, and decision making through the creation of teams more efficient.

This article aims at presenting the results of the development of a methodological digital tool to the PUMA team building module. Since teams are the basis of work in the modern knowledge era, it is a growing concern that they really bring together people with the proper skills and profiles to accomplish the expected results. To establish a solid process that matches some of the basic requirements for the process concept, such as to be repeatable and provide trustable and standardized results, a computer science digital platform was created and this article presents its development.

Everything from the justifications for choosing this problem/opportunity until the development technical details is clarified in an organization line: The literature review compiles the results of the main researches that served as a foundation for development decisions. The methodology presents the information related to the iterations and dynamics of the international partnership through which this project was developed, as well as the technologies and techniques used. In the Development topic, referred to as Platform for Unifying Methodologies of Active learning (PUMA) - Team-Building Module, the technical details are approached. Finally, the conclusion reveals the results, lessons learned and future project possibilities.

2 Literature review

The literature review encompasses a group of key research points that support the development of the work. The focused themes for the acquirement of a solid basis for the project were PBL, from which the methods to be inserted in the platform come, specifics about students' competences and preferences surveys, which are the basic criteria for the team building, and search of the existing digital platforms with team building functionalities.

2.1 Project-Based Learning (PBL)

The Project Based Learning allows students to learn pushed by a problem that cannot be solved with the current level of knowledge and/or way of thinking about the issues (Araújo, Rodrigues, Silva, & Soares, 2015). Therefore, working for an extended period of time to investigate and respond to a real-life problem is crucial to produce further ideas/hypotheses and learning issues to acquire necessary knowledge and skills required to make reasonable judgments about solving the problem (Margetson, 2001).

There are several student-centred teaching strategies, one of them is the Project-Based Learning (PBL), as students are able to build their knowledge, alongside their professors, through the execution of projects about various themes (Torres & Irala, 2014).

Buhari, Valloo and Hashim (2017) emphasize that a strong relationship can be built between university and industry/company through projects, enabling benefits as follows:

- Companies gain low-cost access to college's skills and infrastructure, as well as high-performing students and professors.
- Companies can meet students' abilities for employment.
- Students can better understand the company's problems, processes and technical requirements, increasing their skills before graduation.
- Students can learn creative approaches to solve real problems of companies.
- Universities can develop strong and continuous partnerships with the companies, which are mutually beneficial, as they help each other by building and sharing knowledge through students.

2.2 Preferences and Competencies of Students

Students have individual preferences and competences, insomuch that they have different ways of how they perceive and process information. These individual preferences and competences are called Learning Styles (Alfaro, Apaza, Luna-Urquizo, & Rivera, 2019). Learning Styles are personal qualities that influence students' abilities to acquire information, interact with others and enabling them to participate in learning experiences (Agudelo, Urbina, & Gutiérrez, 2010).

Students tend to focus more on acquiring human competencies, such as leadership, communication and collaboration, since these cannot be assumed by autonomous machines, especially in the advance of Industry 4.0 (Panthalookaran, 2018). However, hard skills, centred on technical knowledge, are still significant for companies (Buhari, Valloo & Hashim, 2017)

Individual preferences and competences affect team building based on their interest in the project proposals and what type of group students want to have (Jensen, 2018). Teams are a primary mechanism for executing an organisational work. Consequently, team building, team size and cooperation are critical factors in a PBL project execution (Kim, 2018).

2.3 Platforms to support Team Building

Non-digital executive control doesn't allow continuous and precise monitoring of teams as the digital does, being, thus, essential the availability of a platform that supports all the involved processes in achieving effective PBL application. Before developing the Team Building through Student's Preferences and Competences (TBSPC) module, it was carried out a thoroughly analysis of the existing platforms on the market, looking for inspiration and to identify their possible shortcomings and the areas in which they need improvement. The targeted platforms were the ones that had team building functionalities and were focused on students' projects.

The main three platforms that conformed with the cited criteria were: Cloverleaf, a famous platform for team management (Cloverleaf, 2020); Crowdschool, a popular Project-Based Learning platform (Crowdschool, 2015), and Team Building Support System (TSS), which supports students in PBL courses to organize their teams effectively (Kim, 2018).

However, these three platforms have the same bottleneck, which is the absence of any kind of means of communication, and students have no way to interact, manage tasks and make key project decisions. Thus, it is necessary to develop a platform that allows more effective communication, interaction among students and management of teams, focused on the PBL methodology.

3 Research methodology

The research methodology is presented in topics 3.1 and 3.2. The section 3.1 presents the research method and the section 3.2 shows the step by step of the team building module development. Workflow detailing as well as decision-making paths in the development process are subsequently presented.

3.1 Method

This research presents a case study with qualitative approach, involving Esprit and UnB. The team building module was developed by Tunisian and Brazilian students and professors. Therefore, the configuration of the partnership itself is directly connected to the methods that allowed its creation. The development of the module followed the coming steps that will be detailed in section 3.2.

3.2 Development Process of the PUMA Team Building Module

The development process involved seven steps, based in software engineering concepts (Pressman, 2011), Figure 1.

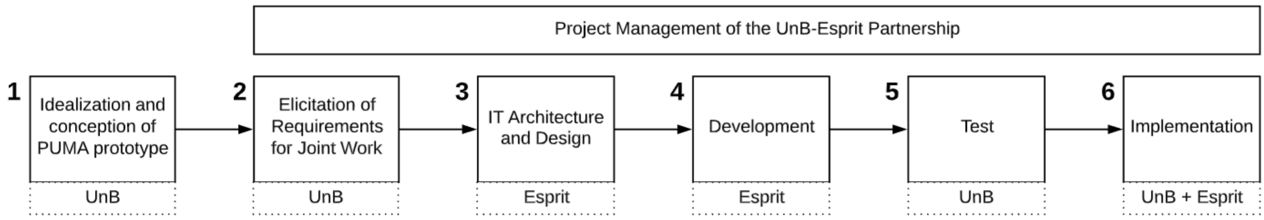


Figure 1. Steps of research.

The Team Building Module will be added to the PUMA platform. The development process involved seven steps: (i) Idealization and conception of PUMA prototype; (ii) elicitation of requirements for joint work; (iii) IT architecture and design; (iv) development; (v) test; (vi) implementation. All the mentioned steps were already complied, except for the (vi) implementation. These steps are described below.

3.2.1 Step 1 - Idealization and conception of PUMA prototype

The Beta version of the team-building module was carried out in Microsoft Excel and has been developed and pre-implemented in a project-based learning course (PSP1) in the production engineering undergraduate program at UnB. The initial formation of the Project Groups defined by the PSP1 2019/2 coordination was then submitted to the preferences of each of the 54 enrolled in relation to the (i) 14 Project contents; and (ii) classmates with who each would like to work as a team. To collect such preferences, each student answered 3 questions on a Questionnaire of Preferences, that constituted the basic requirement for the TBSPC module development: 1-Select your name: 2-Answer on project preference; and 3-Indicate the 6 classmates you would preferably select to work on your project team.

Furthermore, there was a prototype developed in HTML for the front-end, which encompassed the same functionalities of the above-mentioned Excel implementation, but with the improvements from the Excel experience. For both Excel and HTML versions, students would be allocated in teams based on prioritization of (i) and (ii) combined.

3.2.2 Step 2 - Elicitation of requirements for joint work

According to Pressman (2011), understanding the requirements of a problem is among the most difficult tasks faced by system development professionals. In this way, the requirements engineering tasks, help to bring the understanding of what the impact of the software on the business will be and support the construction of the product with the development team. This step, comprised performing of 3 phases, from the elicitation of the requirements to its documentation:

- **Requirements elicitation and analysis:** This phase comprised the survey of requirements, by understanding and identifying needs with project stakeholders, through interviews and brainstorming.
- **Requirements Specification:** It covered the mapping of all necessary functionalities for the complete construction of the software, through the use case diagram, in which it was possible to identify all of them for the complete construction of the product.
- **Requirements Documentation:** This phase was carried out, through the complete description of the requirements of each mapped functionality, comprising all details: Purpose of the Functionality; Prototype; Pre-Conditions; Business Rules, and Messages.

3.2.3 Step 3 – IT architecture and design

The topics below compile the main technologies and details over the development of the software architecture, Figure 2.

- **Databases:** the main technology applied was MongoDb, a NoSQL database that offers many benefits over relational databases. NoSQL databases have flexible data models, scale horizontally, have fast queries, and are easy for developers to work with.
- **Front-End:** the main technology applied was React JS, an efficient, declarative, and flexible open-source JavaScript library for building simple, fast, and scalable frontends of web applications.
- **Back-End:** the main technology applied was ExpressJS, a prebuilt NodeJS framework for, among other functions, creating server-side web applications.

IT Architecture		
DataBase: MongoDB	Front-End: React JS	Back-End: Node JS

Figure 2. Technologies used for module development

The recommendation is based on the preferences and previous experiences of students, required competencies for development projects, and a measure of similarity to other students. The main steps of this approach are: (I) Students' previous experiences. and preferences and required competencies on each project are saved; (ii) a subgroup of students is identified whose experiences and preference are similar to those of the user (student) seeking the recommendation and competencies required on projects; and (iii) the resulting preference function is used to recommend students to the platform user looking for the recommendation. Thus, after gathering the needed data from students' profiles and the projects created, the recommendation algorithm starts automatically within the application to give a list of candidates that their skills, previous experiences, and preferences match the required ones for the project. In this way, this algorithm consists of optimizing team-building by bringing together people who would like to work together on a topic they appreciate. It can maximize the performance of the project from the beginning.

3.2.4 Step 4 - Development

For the development methodology of the module, SCRUM, an agile methodology with incremental characteristics, was selected. The work is divided over several time slots called sprints until the achievement of the project as a whole. Each increment is integrated into the components of the previous sprint. At each stage of the development process, the product is implemented, tested and then integrated (Scrumstudy, 2016), Figure 3.

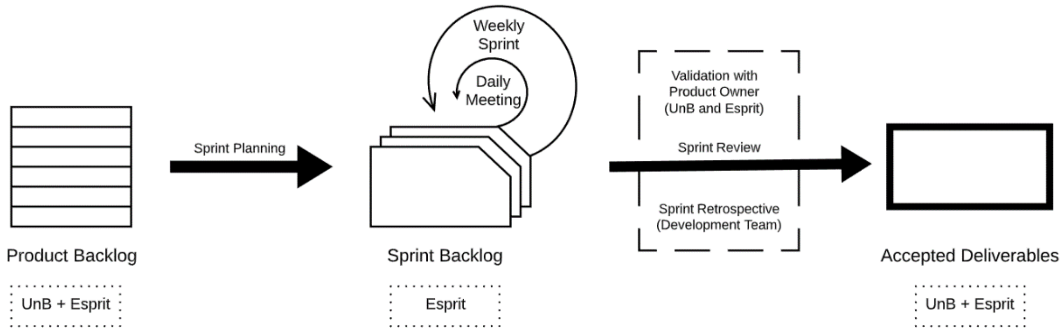


Figure 3. Methodology applied in the project management

In the present case, Scrum was adopted with some modifications, in view of the context in which the project is inserted. The main Framework ceremonies such as daily meetings (development team) and weekly meetings with our scrum master (professors) and the Brazilian team (product owner), and Trello, a web-based Kanban-style list-making application, was used to keep track of our progress during the development period, with GitHub for the work integration. Ceremonies and techniques such as Sprint Planning, Sprint Review, Sprint Retrospective were carried out according to the official Scrum Framework.

3.2.5 Step 5 - Test

Before releasing the module for proper application in project-based learning courses, it is important to submit the software to a group of tests with the development team. This is done by simulating an university course environment and making fictional teams with the members of the project to reproduce the user experience and guarantee that both the front and back-end are functional. All of the functional scenarios were tested thoroughly by the development team by testing the rest APIs in the Back-End using Postman.

3.2.6 Step 6 - Implementation through Engineering Courses

This phase is planned to involve a cycle of improvement during the second semester of 2020 when two engineering teams from UnB and Esprit will work on diagnosing the functionalities and verifying the effectiveness of the TBSPC. This validation consists of a complete simulation of the module hosted on a temporary PUMA server in Brasilia. In this step, it is expected to raise new requirements, test and refine the features developed, and implement the changes.

4 Platform for Unifying Methodologies of Active learning (PUMA) - Team-Building Module

PUMA is being developed to support the application of the PBL method along subjects at universities. It is a platform centered in academical culture and encouragement towards using Information and Communication Technology (ICT) as a useful tool to measure the efficiency of the PBL method (Silva Júnior, Monteiro, Lima, Mariano & Silva, 2019). Providing and receiving feedbacks in easier and more standardized way is also a focus, with substantial and safe information to redirect PBL courses over the years (Monteiro, Campos, Lima, A & Mariano, 2018). It also allows continuous alignment with market demands for students' capacities as the platform involves companies in the university PBL activities.

It can be understood that the PUMA Platform is a tool that integrates input and results of the projects developed by students along their graduation period, being the entrance door to the stakeholders' demands to be investigated by students in real problem-solving situation (Monteiro, Lima, Mariano & Silva Júnior, 2020).

4.1 Module developed and technical information of Team Building through Student's Preferences and Competences (TBSPC)

This section presents the main structures of the software developed with a description of the functionalities and exposure of the development stage of the front-end. The Team Building module can be understood in 5 main parts: creating an account and a profile; project assignment and group creation; project creation and validation; team management; and Voting System and means of communication.

4.1.1 Creating an account and a profile

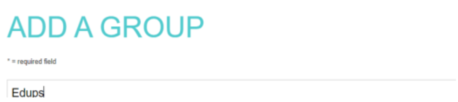
Each applicant will create their own account by simply signing up into the application and, after validating their accounts by email verification, the user will complete his own Profile by adding his previous experiences, educational background, skill set, social media, and other details about them, Figure 4.

Figure 4. Create profile and add experience interfaces

4.1.2 Project assignment, group creation and validation

After having their Profiles completed, applicants will be able to create their own groups, by choosing a project that has pre-edited settings, and add other members. The application will recommend other applicants based on their skills and background. After submitting the application, the group needs validation from the admin. Teams are deleted if not enough people join within 48h from its creation. Figure 5.

The teachers, stakeholders, and admin users are able to create projects by filling the specified form: the name of the project, documentation and required skills, as well as the voting system, if the creator already wants to define it (students can also be responsible for the choice). After this process, the project needs to be validated by the administrator so it can be visible for the students, Figure 6.



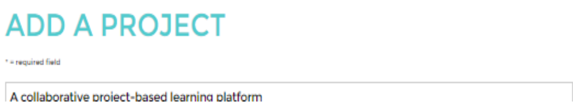


Figure 5. Add a group interface

Figure 6. Add a project interface

4.1.3 Team management

While the group creator is choosing the team members, the application gives him a set of suggestions based on the competences and skills needed for that specific project. The group creator will have a matching set of skills with the ones required for the project. The team leader is the member who created it in the system. After the team is assembled, the members can change the leader by having a vote section or the responsible teacher/instructor can select manually another team leader.

There are three possibilities for participants who are not in any group and who missed the deadline: the first one is to send a request to an existing group and, if they haven't reached the maximum amount of students yet or are missing one to complete the team, the group members can vote and either accept or reject his/her request; in the second option, members of one existing group send an invitation to the participant to join their group; in the third option, the teacher can add any participants to any group if he/she decides to do so, Figure 7.

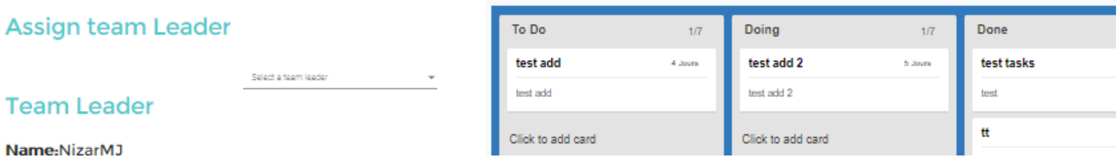


Figure 7. Assign team leader by teacher and Trello

The students are able to continue using the platform while working on their project by having an embedded Trello application within which they can divide the work into tasks and making sure to have continuous progress. The professors have access to project Trello boards.

4.1.4 Voting System and means of communication

To ensure the fairness, equitability, and equality between the team members, the platform contains a voting system. It covers many conflicts between members, including decision-making controversies. The voting form is composed of a vote title, subject, and choices that could be yes or no, or multiple choices based on the voting type that the groups have chosen from the beginning, Figures 8 and 9.

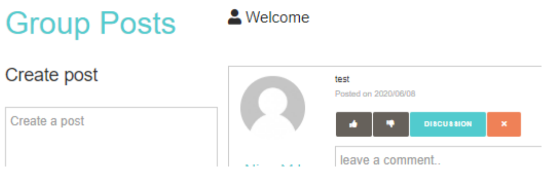


Figure 8. Communication and vote interface

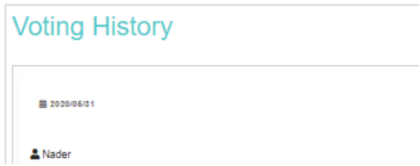


Figure 9. Voting history interface

By putting the power in the hands of the students, since they can choose their partners, distinguished by their specific skills (soft or hard), the TBSPC allows the enrolled students to deny or accept new applicants. The lack of central authority or external entity imposing decisions improve students decision-making capabilities. As a productive team needs a lot of daily communication and workflow control, the platform also provides a timeline and an optional voting system.

5 Conclusion

Team Building through Students Preferences and Competences (TBSPC) module would represent progress to PBL projects, since it encourages organic collaboration, by joining people with already stablished relationships or ties, and by having them working in projects in which they genuinely believe. It is a web-based system to manage group creation, project assignment and project management. Administrators can add any kind of actor, instructors, students or courses to the database. Instructors can add new projects and attach any kind of files to them to provide all of the needed details.

Teamwork is a fundamental part of PBL's differential in relation to traditional methods. It promotes collaborative learning, given that students can learn from each other's work and pinpoint the aspects in which they need improvement, and simulates the market projects and any project with an environment of uncertainty and complexity. This provides the students with real project experience, as well as increases the university position as a value deliverer to society. To maximize the results in this context, a platform that structures and automates team building is an element that not only brings more efficiency to university initiatives and projects, but also tends to improve and optimize the entire educational process.

With the development of a support module for creating teams in educational environments, the objective of this research was achieved. However, it is worth remarking that the limitation of the research is in proposing something that is focused on the context universities, not considering the business environment, even if most organizations face the same challenge of team building and would not have the possibility to select members based on precise criteria. Therefore, the application and evaluation of this module for the job market is suggested as future work, in addition to a study focused on how to improve the necessary the students' skills to deal with dysfunctional teams in professional environments. These skills must be developed even in courses that will apply the proposed module.

Another important suggestion for future work is the presentation of the results of the team creation module, after applying the validation and evaluation methodology proposed in section 3.2.6 in the workshop and courses because until the end of this study it was not used in the context of a real-life situation. PUMA's team building functionalities, including further automation, possibly with team allocation using AI data driven decisions is already a proposal for future works on the TBSPC module. The other modules of PUMA will also be developed through the Brazil-Tunisia partnership framework, stablished by UnB and Esprit.

6 References

Adderly, K. (1975). P*roject method in higher education.* London: Society for Research into Higher Education. Research into higher education monographs, 24.

Agudelo, L. N. R., Urbina, V. S., & Gutiérrez, F. J. M. (2010). Estilos de aprendizaje basados en el modelo de Kolb en la educación virtual. *Apertura*, 2(1).

Alfaro, L., Apaza, E., Luna-Urquizo, J., & Rivera, C. (2019). Identification of Learning Styles and Automatic Assignment of Projects in an Adaptive e-Learning Environment using Project Based Learning. *In International Journal of Advanced Computer Science and Applications* (IJACSA), 10(11), 2019. http://dx.doi.org/10.14569/IJACSA.2019.0101191

Araújo, D., Rodrigues, A., Silva, C., & Soares, L. (2015). O ensino de computação na educação básica apoiado por problemas: Práticas de licenciandos em computação. In *Anais do XXIII Workshop sobre Educação em Computação* (pp. 130-139). SBC.

Bettaieb L. (2017). Esprit PBL Case Study. In: Guerra A., Ulseth R., Kolmos A. (eds) PBL in Engineering Education. *SensePublishers*, Rotterdam. doi: https://doi.org/10.1007/978-94-6300-905-8_7

Buhari, A., Valloo, S., & Hashim, H. (2017). A Streamlined Approach to Enhance the Capacity of Undergraduate IT Students to Deliver High Quality and Demand-Driven Final Year Project: A Conceptual Framework on Collaboration between Industry and University. In *2017 7th World Engineering Education Forum* (pp. 910-914). IEEE. doi:10.1109/WEEF.2017.8467126.

University of Wisconsin-La Crosse (2020). Retrieved April 01, 2020, from https://cloverleaf.me

Crowdschool (2015). Retrieved May 15, 2020, from http://crowdschool.co/

Esprit (2020). Accréditations. Retrieved June 10, 2020, from https://esprit.tn/

Kayes, A. B., Kayes, D. C., & Kolb, D. A. (2005). *Experiential learning in teams. Simulation & Gaming*, 36(3), 330–354. doi:10.1177/1046878105279012

Kim, M. S. (2018). A Web-based system to build teams for project-based learning courses: an industrial engineering case. *Global Journal of Engineering Education,* 20(2), 91-99.

Jensen, L. P. (2018). Is team performance in project based PBL better if all team members have the same work ethic? In R. Clark, P. Munkebo Hussmann, H-M. Järvinen, M. Murphy, & M. Etchells Vigild (Eds.), Proceedings of the 46th SEFI Annual Conference 2018: Creativity, *Innovation and Entrepreneurship for Engineering Education Excellenc*e (pp. 897-904).

Margetson, D. (2001). Can all education be problem-based: can it afford not to be. In *Problem-Based Learning Forum, Hongkong Centre for Problem-based Learning*.

Martins, D. B., & Frezatti, F. (2015). Problem-Based Learning no Ensino em Contabilidade Gerencial: Experiência numa Instituição de Ensino Superior. In *Congresso USP de Controladoria e Contabilidade*. São Paulo, Brasil.

Monteiro, S. B. S., Reis, A. C. B., Silva, J. M. da, & Souza, J. C. F. (2017). A Project-based Learning curricular approach in a Production Engineering Program. *Production*, 27(spe), 2017.https://dx.doi.org/10.1590/0103-6513.226116

Monteiro, S. B. S., Campos, M. R. M., Lima, A. C. F., & Melo, A. (2018). Evaluating direct and indirect results of the active methodology in learning: proposal of an integrative design in 360º via unified platform. In *International Symposium on Project Approaches in Engineering Education* (PAEE) (Vol. 8, pp. 768-775).

Monteiro, S. B. S., Lima, A. C. F., Mariano, A. M., & Júni, E. S. (2020). Plataforma Unificada de Metodologia Ativa (PUMA): um projeto multidisciplinar. *Revista Ibérica de Sistemas e Tecnologias de Informação*, (E28), 766-778.

Meireles, M., & Bonifácio, B. (2015). Uso de Métodos Ágeis e Aprendizagem Baseada em Problema no Ensino de Engenharia de Software: Um Relato de Experiência. B*razilian Symposium on Computers in Education (Simpósio Brasileiro de Informática na Educação - SBIE)*, 26(1), 180. doi:10.5753/cbie.sbie.2015.180

Panthalookaran, V. (2018). Gamification of physics themes to nurture engineering professional and life skills. In *2018 IEEE Global Engineering Education Conference (EDUCON)* (pp. 931-939). IEEE. doi:10.1109/EDUCON.2018.8363330

Pressman, R. S. (2011). Engenharia de Software: Uma abordagem profissional. Setima Edição. Porto Alegre: AMGH.

Prince, M. J., & Felder, R. M. (2006). Inductive teaching and learning methods: Definitions, comparisons, and research bases. *Journal of engineering education,* 95(2), 123-138. doi:10.1002/j.2168-9830.2006.tb00884.x

Scrumstudy (2016). A Guide to the Scrum Body of Knowledge (SBOK™ Guide). 3ª Ed.

Silva Júnior, E.; Monteiro, S.B.S.; Lima, A. C. F.; Mariano, A. M., Silva, V. B. N. S. (2019). Unified Platform of Active Methodology (PUMA): Development Steps of the Module Divulgation and Request Projects. In: *11th International Symposium on Project Approaches in Engineering Education (PAEE) and 16th Active Learning in Engineering Education Workshop (ALE*), Tunísia, África, v. 11/16. p. 357-365.

Torres, P. L., & Irala, E. A. F. (2014). Aprendizagem colaborativa: teoria e prática. Complexidade: redes e conexões na produção do conhecimento. Curitiba: Senar, 61-93.

Evaluation of a Pilot Course of Project Management for Industry 4.0

Rui M. Lima[1], Diana Mesquita[1,2], André Luiz Aquere[3], Cristiano de Jesus[1]

[1] Department of Production and Systems, ALGORITMI Centre, School of Engineering, University of Minho, Guimarães, Portugal
[2] CIEC–Research Centre on Child Studies, University of Minho, Portugal
[3] Department of Civil and Environment Engineering, Faculty of Technology, University of Brasília, Brasília, Brasil

Email: rml@dps.uminho.pt, diana@dps.uminho.pt, andre@unb.br, b12121@algoritmi.uminho.pt

Abstract

The fourth industrial revolution created the need for the development of new competences for Industrial Engineering and Management. In order to address this need an Erasmus+ project, developed by a consortium of nine universities, has been engaged in Curriculum Development of Master's Degree Program in Industrial Engineering for Thailand Sustainable Smart Industry (MSIE4.0), co-funded by the European Commission. In the context of this project, there are 16 master level courses being developed and piloted. One of the courses is Project Management for Industry 4.0 (PM4I4). The objective of this paper is to present the evaluation of this course based on the perceptions of the enrolled students. This evaluation was based on written reflection of the course delivered at the end of the course by a total of twelve students. Most of students enrolled (10/12) provided a positive perspective about the course, considering that will contribute for their professional practice in the future and recommend it for other engineering students. Part of these students considered the project related to the development of a questionnaire of I4.0 in a company quite interesting and contributing for their formation and other students considered it less practical that they expected to. It is worthwhile to notice that most of the students really enjoyed the diversity of pedagogical experiences and teachers engaged in the process (a total of 4), and the development of transversal competences, but some of them would prefer to have contact with less teachers. Thus, as final contributions, it could be recommended to create better framework for the Industry 4.0 questionnaire project and create opportunities for the students to enrol in management of more practical projects related with that main theme.

Keywords: Project-Based Learning; Project Management; Industry 4.0; Industrial Engineering and Management.

1 Introduction

The mental and structural process of the efforts to systematize knowledge relating to the phenomenon called Industry 4.0 is widely known. It is known that this is a movement of reconfiguration of productive systems, which consists of the paradigm shift from mass production to product configuration plus the aggregation of value through services, digitization of operations and expansion of resources to support decision-making. All these transformations involve new technologies such as Internet of Things (IoT), Cloud Computing, Virtual Reality, Augmented Reality, Additive Manufacturing (or 3D Printing) and Autonomous Artificial Intelligence Systems (Machine Learning and Deep Learning). However, this description refers only to the first layer of perception of all the high proportion and range dynamics that are in process. The technological apparatus, therefore structural, presents in an almost obvious way its immediate implications, namely, the need for technological updating of productive systems and industrial management tools on the one hand and of the technical competences of human resources on the other. However, these new resources bring with them new possibilities of relationships among all agents involved, but they are only possible if the technology is not appropriated by all as just a new instrument to be operated. The new possibilities need to be explored. Within the discipline of project management, there is a wide range of frameworks that enable initiatives to update business models. However, doing the same as always, with a newer technology, technically and financially, is not a challenge, but taking advantage of new opportunities to deliver a product or service with added value and therefore differentiated, does require unprecedented efforts of reflection, strategy and action, which involve a perspective of progressive transformation guided by a maturity model with a continuous improvement approach (Agostini & Filippini, 2019; Crnjac, Veza, & Banduka, 2017; Gracel & Łebkowski, 2019).

According PMI-PMBOK (2017), Project Management is the application of knowledge, skills, tools, and techniques to project activities to meet project requirements. In this definition attention must be given to the expression "project requirements". In any situation the project requirements – not only the product requirement - guide the way in which the project will be organized and executed. The new Industry 4.0 brings to project management a new set of requirements and a new challenge to this field of knowledge. With the emergence of organizations in Industry 4.0, "connected people" or "professionals 4.0" appear, who are distinguished by being more efficient, more flexible, faster and, consequently, more competitive, thanks to the total connectivity among machines, systems, and people (Cerezo-Narváez, Otero-Mateo, & Pastor, 2017).

So, how to work in an environment that demands agility to adapt to very dynamic requirements? How to make decisions in a constantly changing environment? How to communicate with teammates in a multicultural, geographically disperse and, sometimes "nonhuman" teams? All these questions, among others, demands new competences from the workers in this new industrial model. Besides technical competences, transversal competences must be included in the background of the industrial engineer to the ID 4.0.

In the context of Industry 4.0, a consortium of nine universities has been developing a master program for Industry 4.0, co-funded by the European Commission (https://msie4.ait.ac.th/). One of the courses of this program is Project Management for Industry 4.0 (PM4I4). This course was designed to help students to develop competences related to Project Management in context of Industry 4.0. In order to accomplish this objective, the main pedagogical assumption is the need to use active learning (Christie & de Graaff, 2017; Freeman et al., 2014; Prince, 2004; Prince & Felder, 2006) approaches for competence development. In this course we propose to use a project-based learning approach to solve open problems, which is known as one of the main strategies to give autonomy to the student in the development of competences (Edström & Kolmos, 2014; Graaff & Kolmos, 2003; Lima, Dinis-Carvalho, Flores, & Hattum-Janssen, 2007; Lima et al., 2017). Additionally, we use this project has one of the ways of bringing Industry 4.0 into the content. Students will have to develop their knowledge and skills in this context developing a project related with I4.0 with companies. Another way to bring I4.0 to the content is through the use of agile approaches and collaborative and multicultural project management content in a new era of digitalization, which are the main requirements in this new era for project management.

The objective of this paper is to present the evaluation of a pilot version of this course based on the perceptions of the enrolled students. This paper will present the context of the course, followed by the methodology of evaluation and results and recommendations.

2 Context

In the new world of Industry 4.0, digitized connectivity may be considered the main driver of change that industries have to deal with. This change increases the opportunities to create new business models, exploring network of systems that will allow to increase the cooperation between and across companies and industries. It is expected an increase in customized services that ultimately can become a service for each customer. In this case, we will be dealing with a project service for each customer each time. These projects will be developed by interdisciplinary distributed teams using digital platforms.

This course aims to prepare graduates to perform in and manage projects and teams in the new highly agile digitized challenging smart industries. Thus, it was defined that students on the completion of this course should be able to:

CLO1 - Discuss Project Management relevance in the context of IND4.0 (Apply)

CLO2 - Evaluate the needs of an organization regarding IND 4.0, taking into account maturity / readiness models (Evaluate)

CLO3 - Plan, develop and manage projects in the context of IND 4.0, using frameworks of project management, such as PMI, IPMA and Agile/Lean (Create)

CLO4 - Support team decision making processes in accordance with the contingencies and uncertain environments of IND 4.0. (Evaluate)

CLO5 - Perform as a member of an extraordinary team, either distributed or co-located, using different tools and techniques, considering the team development phases (Create).

CLO6 – Develop a project within a real context, in interaction with an industry organization.

The course is structured in two modules. The first one, Management of Industry 4.0 Projects, has a higher focus in the project management frameworks and processes. The second one, Module 2 - Project Team Management for Industry 4.0, is more related to the need to develop people focused competences for project management in the context of industry 4.0. Along the two modules there will be a project to be developed in interaction with industrial companies. The objective of this project is to develop an instrument to measure the maturity level of the company in a specific dimension of industry 4.0, according to the acatech framework (Kagermann, Wahlster, & Helbig, 2013; Schuh, Anderl, Gausemeier, Hompel, & Wahlster, 2017).

The choice for the creation of an instrument to evaluate the level of maturity of organizations for the concept of Industry 4.0 came from an expectation that consisted in (1) it was a concrete opportunity to clarify the complexity and multiple dimension of reconfiguration projects for Industry 4.0, that is, that it is not only about technological updating and technical competences, (2) it was expected that the instrument could show the progressive nature of a transformation process for Industry 4. 0 where the strategic, systemic, project-based and focused on a perspective of continuous improvement is a critical factor of success, and (3) it was expected that the creation of an instrument to assess the level of maturity of organizations for Industry 4.0 would show the uniqueness of projects of this nature and therefore require unique strategies and actions.

3 Methodology

The evaluation of the pilot version of the course presented is based on narratives provided by the ten of the twelve students enrolled in the course. The narratives were delivered at the end of the course and aiming at to include a self-reflection about the course, in terms of the relevance of the contents and the activities developed during the course, teaching practice and interaction with teacher and students, amongst other issues, in which students were free to present. The narratives, as a technique of data collection, reinforce the authenticity of the information, because it is all about the voice of the participant in a specific context or situation, and not an abstract idea or assumption (Czarniawska, 2012). Thus, this study focuses on students' perceptions about this course, considering their personal experience, beliefs, and motivations.

From the content analysis of the narratives, it was possible to identify three main categories, namely: 1) Course topics; 2) Teaching and learning approaches; 3) Project scope and activities. These categories were defined by the authors, who were engaged in the course and were able to provide and understand the meaning of the students' voices.

4 Results

The analysis of the narratives allowed to identify and categorise the main ideas the students have about the pilot course.

4.1 Course topics

At the end of the course it was possible to obtain a view of the students on the topics covered in the discipline and to evaluate the effectiveness in reaching the objectives CLO1 to CLO6.

Four topics were mentioned most frequently by the students, having a similar weight among them: project management tools, teamwork and leadership, coaching and communication. Among the twelve students who responded to the assessment, there are seven highlights to the themes of project management and teamwork / leadership, while the themes of communication and coaching appear prominently in six.

In the topic of project management, the management tools are highlighted:

> *"In this course, it was possible to get to know and improve our knowledge of tools for successful team management, highlighting SCRUM, where it is possible to have a vision of the project and divide work tasks equally among the members of the group. " (student 2)*

> *"We learned to use management support tools such as PM Canvas, which is very useful for project planning and for clarifying objectives within work teams." (student 7)*

However, in addition to learning the management tools, another aspect highlighted was the Lean / Agile approach to project management, either by frequent reference to SCRUM, or by mentioning Lean principles:

> *"It is important to understand very well what problems we intend to solve with our project so that tasks that do not add value and do not contribute to the success of its completion are not carried out." (student 7)*

Finally, it was possible to identify space for expansion of the project management approach with inclusion of new topics or deepening of others:

> *"I wish there were more classes on project management methodologies, such as prince, pert etc. However, I understand that the time was short to address all topics related to project management." (student 3)*

Topics teamwork / leadership, communication appear together in many of the demonstrations, highlighting the growing importance of communication skills in a teamwork:

> *"For me, the most important aspect in this course was to convey the importance of knowing how to lead and communicate." (student 7)*

> *"Several leadership and communication styles were presented that, perhaps, if they had not been addressed, I would not think of them anytime soon." (student 4)*

> *"We realize the importance of communication in a successful team. Often the way we communicate leads to totally different interpretations and that is why it is very important to think about the way we do communication as well as the barriers that may arise." (student 7)*

The concept of coaching appears in students' manifestations as a tool for personal growth and the development of transversal competences.

> *"We were also introduced to a concept that is quite talked about in our day-to-day lives, but not clear, I mean the concept "Coaching", this concept is spoken, but few people know the true meaning, and in this class we can better understand ."* (student 2)

> *"Some topics such as Coaching, Scrum and Communication were contents that, in my opinion, make perfect sense to be included in this UC and in which there was a lot of quality and effectiveness in the exhibition."* (student 1)

> "*I think it was very useful to understand certain skills that we need to develop in order to be able to deal with differences within a work team. (...) With this class I realized that a coach simply gives us the tools and that all the work has to be done for us. I believe that Coaching makes us more and better!!*!" (student 7)

4.2 Teaching and Learning approaches

Regarding to the teaching and learning process, data point out the importance of the link between theory and practice. The teacher approach to present and deliver the content is a key-issue for student's engagement. In other words, the attractiveness of the content will depend on the teaching approach, in terms of communication, activities and resources used.

"I think that all the practical activities added-value to understand the themes, as well as the videos and examples presented (…) However, certain classes were very theoretical, turning everything to much exhaustive, because each class had 4 hours." (student 12)

"Many of these topics were approached in a very theoretical way, which does not capture the students' attention (…) If the way that the topics do not get our attention, we just shut down until something or someone catches our attention. When we did exercises or group activities, everyone interacted, but when we had only one speaker, the group lowered their heads and everyone stayed in their own world." (student 4)

It is not new that an active learning environment foster students' engagement and motivation through opportunities in which students need to mobilize knowledge in several activities. This process must be considered in the course planning, as well as in the teaching approach.

The course coordinator invited three teachers to collaborate in this course. This diversity enhances the expertise of each teacher, because they were responsible to deliver sessions oriented to specific topics (e.g. Coaching). At the same time, they are able to monitoring the project developed by the students, which is an added-value for student's support.

"Everyone [teachers] was very helpful and always willing to help and answer any questions that arise in classes or projects." (student 12)

However, in some cases this diversity might be considered a limitation in the student experience.

"Regarding to teachers, I consider that there is no need to have so many in a course because it confuses students and we end up not realizing who to address when doubts arise". (student 11)

Thus, teacher' role is a key-dimension for an effective and meaningful teaching and learning approach. Considering the data from this study, it is possible to highlight three main elements that influences the teacher role: 1) the teaching approach in terms of balance between theory and practice; 2) the importance of support, encouraging and inspiring students in their own learning process, providing interesting opportunities and contact with different professionals in Project Management (experts and/or practioners); 3) the close relation between teacher and students, in terms of communication: to align and clarify expectations and to provide feedback.

"Every week the classes were very dynamic and interactive. The teacher, and guests, knew how to captivate the students' attention and encouraged the critical spirit of the class." (student 6)

4.3 Project

The actions related to the theme of Industry 4.0 in the discipline of Project Management were guided from the following trajectory: (1) awareness of the students regarding the dimension and complexity of the theme, (2) choice of an action applicable in reconfiguration projects for Industry 4.0, and (3) orientation of an exercise of operationalization of the construction of the instrument.

The first stage foreseen in this design was carried out through a lecture type class in which the fundamental characteristics of the model now called Industry 4.0 were presented, including its structural and technological configuration, the change of paradigm regarding products and services as well as the transformations that this requires in the concept of productive system, in the consequences imposed on business models, and in the demands for new competencies of human resources. An effort has been applied to provoke reflection on the initiatives related to the reconfiguration projects for Industry 4.0 in which they frequently present strategies focused on technological updating.

The operationalization of the planned actions presented positive and other challenging aspects. If on the one hand the students had the opportunity to deepen researches and readings about the Industry 4.0 theme and at the same time observe in companies the applications of these concepts, on the other hand, the construction of an evaluation instrument involves foundations and techniques independent of the Industry 4.0 theme and Project Management. The requirement to develop critical knowledge about the construction of evaluation instruments, especially in a short period of time, proved to be a source of discomfort for students, as can be seen in student comments:

> *"(...) themes that turned out to be very theoretical (...) as was the case with our theme 'Self-evaluation instrument of the maturity of Industry 4.0 in Resources' (...), I was a little disappointed, since Industry 4. 0 is a theme that I have a lot of curiosity and interest." (student 1)*

> *"I found the work quite constructive, as I learned a lot about it, but honestly I did not think it had a great impact in terms of people management and teamwork (...), is a very interesting and useful topic because it will be the future of the industry and in this way we have already understood the basic concepts for its implementation." (student 4)*

> *"(...) forced us to waste a lot of time investigating on the subject (...), it was initially difficult to apply project management and team management". (student 11)*

It became clear in the comments that the students have a great interest in the subject and that they understood about the multidisciplinary range of projects of this nature, as can be observed in the following comment in particular:

> *"The industry 4.0 approach was also very useful to learn the basic concepts of this subject (...), through the tool for assessing the level of maturity of the companies that we develop in the work we realized that most companies are still in a very early stage. I don't think it's an easy task due to the investments needed not only in technology but also in people's training. Perhaps the most complicated job will be to implement the changes in people's mentality and culture, and in that sense we realize the importance of unconditional support from top management". (student 7)*

5 Recommendations and Final Remarks

Most of the students (10/12) wrote that the course was good or very good and above their expectations, reinforcing that idea by telling that this elective course should be delivered in the following years. A good summary for the perceptions of the students could come from the excerpt that summarizes a student's overview of the course:

> *"I consider the topics covered very interesting, starting with Industry 4.0, PM Canvas and SCRUM, to some more related topics with our soft skills such as teamwork, leadership, communication and coaching. The soft skills have been increasingly important in the labor market and will be for the Accenture, one of the most important requirements in the "jobs of the future." These are areas that cannot be learned, where there is no magic formula, but only trained and cultivated. I think it is very important to start instilling this in students from an early age, in order to be more prepared for the "future" market and even for the "now" market." (student 4)*

Despite the fact that the majority of the students really enjoyed the diversity of pedagogical experiences, some of them would prefer to have contact with a lower number of teachers in this course. It should be noted that this is not unanimous and some students told that they enjoyed the opportunity to interact with several teachers during the classes. Thus, as final contributions, it could be recommended to create better framework for the Industry 4.0 questionnaire project and create opportunities for the students to enrol in management of more practical projects related with that main theme.

No doubt the theme on Industry 4.0 arouses interest in students, however, the planning of a short time for the presentation of the general aspects and fundamentals on the theme, so as to imply an over-expositive approach, generates discomfort in students who expect more opportunities for interaction, more examples and practical actions. It is also a hypothesis that the greatest expectation of the students regarding Industrial 4.0 are the new possibilities offered by new technologies such as artificial intelligence, additive manufacturing, virtual reality, etc. If this is true, a work focused on maturity level assessment may generate some disappointment. The requirement to develop critical knowledge about the construction of assessment tools, although it is relevant to the understanding of the need for a judicious procedure for surveys of this type are valid, has proved to be a critical point and requires a new approach. The proposal is that this content should be approached as a topic of one or more classes so that it results in an application structure for the students and thus they can dedicate more time in the construction of the instrument and in the interaction with the companies.

As a final remark we would like to share a general comment from student 7:

> *"In general, I think this course will be very important for my professional career and my personal development. It gives us the basis for what will be our job as engineers and the skills we need to develop in order to be successful."*

6 Acknowledgments

A special thanks to the students that collaborated with us in this pilot course.

This work is the outcome of project "Curriculum Development of Master's Degree Program in Industrial Engineering for Thailand Sustainable Smart Industry (MSIE 4.0)" that has been funded with support from the European Commission (Project Number: 586137-EPP-1-2017-1-TH-EPPKA2-CBHE-JP). This publication reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

This work was partially supported by FCT – Fundação para a Ciência e Tecnologia within the R&D Units Project Scope: UIDB/00319/2020.

7 References

Agostini, L., & Filippini, R. (2019). Organizational and managerial challenges in the path toward Industry 4.0. *European Journal of Innovation Management, 22*(3), 406-421. doi:10.1108/EJIM-02-2018-0030

Cerezo-Narváez, A., Otero-Mateo, M., & Pastor, A. (2017). *Development of professional competences for industry 4.0 project management*.

Christie, M., & de Graaff, E. (2017). The philosophical and pedagogical underpinnings of Active Learning in Engineering Education. *European Journal of Engineering Education, 42*(1), 5-16. doi:10.1080/03043797.2016.1254160

Crnjac, M., Veza, I., & Banduka, N. (2017). From concept to the introduction of industry 4.0. *International Journal of Industrial Engineering and Management, 8*, 21-30.

Czarniawska, B. (2012). *Narratives in social science research*. London: Sage Publications.

Edström, K., & Kolmos, A. (2014). PBL and CDIO: complementary models for engineering education development. *European Journal of Engineering Education, 39*(5), 539-555. doi:10.1080/03043797.2014.895703

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences, 111*(23), 8410-8415. doi:10.1073/pnas.1319030111

Graaff, E. d., & Kolmos, A. (2003). Characteristics of Problem–Based Learning. *International Journal of Engineering Education, 19*(5), 657-662.

Gracel, J., & Łebkowski, P. (2019). The Concept of Industry 4.0 Related Manufacturing Technology Maturity Model (Manutech Maturity Model, MTMM). *Decision Making in Manufacturing and Services; Vol 12 (2018): No. 1-2*. doi:10.7494/dmms.2018.12.1-2.17

Kagermann, H., Wahlster, W., & Helbig, J. (2013). *Recommendations for Implementing the Strategic Initiative INDUSTRIE 4.0*. Berlin: Industrie 4.0 Working Group of Acatech.

Lima, R. M., Dinis-Carvalho, J., Flores, M. A., & Hattum-Janssen, N. v. (2007). A case study on project led education in engineering: students' and teachers' perceptions. *European Journal of Engineering Education, 32*(3), 337 - 347. doi:10.1080/03043790701278599

Lima, R. M., Dinis-Carvalho, J., Sousa, R. M., Alves, A. C., Moreira, F., Fernandes, S., & Mesquita, D. (2017). Ten Years of Project-Based Learning (PBL) in Industrial Engineering and Management at the University of Minho In A. Guerra, R. Ulseth, & A. Kolmos (Eds.), *PBL in Engineering Education: International Perspectives on Curriculum Change* (pp. 33-52). Rotterdam, The Netherlands: Sense Publishers.

PMI-PMBOK. (2017). *A guide to the project management body of knowledge (PMBOK guide)* (6th ed.). Pennsylvania, USA: Project Management Institute (PMI).

Prince, M. (2004). Does Active Learning Work? A review of the Research. *Journal of Engineering Education, 93*(3), 223-231.

Prince, M., & Felder, R. M. (2006). Inductive Teaching and Learning Methods: Definitions, Comparisons, and Research Bases. *Journal of Engineering Education, 95*(2), 123-138.

Schuh, G., Anderl, R., Gausemeier, J., Hompel, M. t., & Wahlster, W. (2017). *Industrie 4.0 Maturity Index – Managing the Digital Transformation of Companies*. Retrieved from https://en.acatech.de/wp-content/uploads/sites/6/2018/03/acatech_STUDIE_Maturity_Index_eng_WEB.pdf

Application of Scrum and PM Canvas in a Project-based Learning Approach

Costa Ferreira[1], Hermenegildo Baptista[1], André L. Aquere[2], Rui M. Lima[1,3], Anderson A. Morais[4]

[1] Industrial Engineering and Management Integrated Master, Department of Production and Systems, School of Engineering, University of Minho, Guimarães, Portugal
[2] Department of Civil and Environment Engineering, Faculty of Technology, University of Brasilia, Brasília, Brazil
[3] Centre ALGORITMI, School of Engineering, University of Minho, Guimarães, Portugal
[4] Federal University of Itajubá – Unifei, campus Itabira, Brazil

Email: ferreiraroda@gmail.com, hermenegildo59@hotmail.com, andre@unb.br, rml@dps.uminho.pt, andersonamorais@gmail.com

Abstract

Project-based Learning (PBL) is a teaching and learning strategy that allows students to develop competences while working on projects. It is important to apply good management approaches in order to achieve all project and learning objectives. This paper presents an application of Scrum and Project Model Canvas (PM Canvas) to manage learning projects developed by teams of students in interaction with industrial companies. These projects are part of a Project-based Learning (PBL) approach developed in the fourth year of an integrated master program in Industrial Engineering and Management. A group of 5 students from the fifth year of the same degree gave support to the PBL teams regarding the utilization of these tools. The work was developed during one month with meetings every Fridays. These project management tools were applied to help the PBL teams to organize and share the tasks, as well as visualize and control the whole project. To evaluate the teams' performance and the way they are realizing the tasks, it was counted the number of tasks done in each weekday and the students were inquired in order to understand their perceptions of the use of these project management tools. The results revealed that the groups performed most of the tasks on Wednesday and the inquiry revealed that most of the PBL teams did not know and had never used project management tools. The inquiry also revealed that the project management tools were considered helpful for the control and organization of the project tasks, improving overall team performance.

Keywords: Project-based Learning; Project Management; Scrum; Project Model Canvas.

1 Introduction

Nowadays, the engineering education all over the world is more focused in adopting teaching and learning methodologies more student-centered and where the student plays a more active and collaborative role in the learning process (Lima et al., 2014). These methodologies help students to develop competences (while learning) that are much needed in today's market. One of the most used methodologies for this is active learning (Lima, Carvalho, Sousa, Arezes, & Mesquita, 2017).

Active learning is a student-centered teaching methodology that actively involves and allows the students to put what they have learned into practice (Harmin & Toth, 2006). Active learning can be applied using several methods and one of them is Project-based Learning (PBL). PBL is an active learning approach in which students solve real problems through projects (Lima et al., 2017). For (Alves et al., 2015), teachers considered PBL positive as a learning approach. Student's motivation, engagement, a better understanding of the application of concepts in real-life situations were considered important outcomes for students when using PBL.

This approach is used in fourth year of the Industrial Engineering and Management, Integrated Master program, at University of Minho, Portugal, and it is offered in the Integrated Project II in Industrial Engineering and Management (IPIEMII) curricular unit. This PBL approach is developed in industrial environment, where students are challenged to try to solve real problems in companies (Lima et al., 2017). It lasts one semester, i.e., students are divided into teams and each team is allocated to a previously selected company. The good performance of the teams is very important for the success of these projects, and therefore, it becomes important to use project management techniques and tools to achieve the project objectives.

In PBL context, the quality of deliveries and the effectiveness of learning depend heavily on the project management adopted by the students, as well as on the project management skills of the elements that compose the team (Almeida, Carrer, Carvalho, & Lima, 2011). Project management aims to predict problems and plan, organize and control activities so that projects are completed successfully despite all risks (Kerzner, 2017). A successful project management ensures that the project is completed on time, within the established budget and in accordance with the project specifications (Project Management Institute, 2017).

This article aims to evaluate the application of two project management tools in four IPIEM II teams, namely the PM Canvas and Scrum. These tools were applied with the help of a group of fifth year's students within the scope of Project Management and Lean Teams (PMLT), who during one month helped the teams to manage their projects and implement some improvements using these tools and adapting them to the type of project that the teams were developing.

2 Literature Review

There is currently a great trend on the way like the new ideas and strategies are put into practice in engineering. In most diverse areas of engineering, products, services and procedures are conceived through projects. This can be seen by the increase in the number of companies that are adopting project management methodology (Kerzner, 2017). Project Management is the art of coordinating activities in order to achieve the expectations of individuals and organizations directly involved in the project or those whose interests may be affected positively or negatively during the project or after its completion (Project Management Institute, 2017). Project management offers many tools that allow to divide the project into activities, work in a more balanced way and set short and long-term goals. Among these tools can be mentioned the Project Model Canvas (PM Canvas) and Scrum.

2.1 PM Canvas

PM Canvas is a project management tool that integrates all knowledge of the project, i.e., it allows to see all stages of the project, the objectives, the stakeholders and all other important aspects related to the project (Osterwalder & Pigneur, 2010; Silva & Cardoso, 2019). The main idea of the Project Model Canvas is to simplify and reduce the bureaucracy of the project management plan, through a visual model inspired by the Business Model Generation, in which the way to prepare a business plan is very clear through visual stimuli that allow processing fast and intuitive mental (Silva & Cardoso, 2019).

According to Finocchio (2013), the principles that guide the PMC are visual appeal, groupings made clearly, simplification, the concern to establish a base with stakeholders and the idea of sequence easily introduced by the visual appeal of the tool. In its design, there are four important steps to be followed by the Project Model Canvas, that are: *I. Conceive*: the components are grouped into six essential questions (Why, What, Who, How, When and How much), resulting in a sequence with a specific order; *II. Integrate*: then, it is necessary to validate the elements contained in the blocks, to relate them to each other; *III. Resolve*: stakeholders must find possible inconsistencies, points that deserve attention or inconsistencies in the design; *IV. Share*: finally, the canvas will serve as an official document or serve as a guide for the elaboration of other documents.

2.2 PM canvas in PBL

To prepare a project plan using PM canvas it is necessary to answer five questions as if we were applying the 5W tool shape.

2.2.1 Why?

At this stage, we justify carrying out the project, defining the objectives and also defining the future benefits of carrying out the project. In the first major justification, it is obviously the curricular unit for students and the objective is the delivery of reports. As for the justification in the company, these are the problems to be solved or even the opportunities for improvement. In relation to the objectives in the company, they need to be SMART, that is, Specific, Measurable, Attainable, Relevant and Timebound. The benefits are linked to increased productivity, increased profits, efficiency of machines and or of employees, well-being of employees, etc.

2.2.2 What?

This question defines the product that varies according to the company's activity and requirements. In the requirements, companies describe what they think is needed in the product or processes.

2.2.3 Who?

This is one of the most important questions. Here we define all the people involved in the Project and other external facts, from students' teams to external stakeholders, teachers and company representatives in the case.

2.2.4 How?

At this stage, we assume some premises, define restrictions and deliveries. In the premises we make assumptions taken for granted (i.e. every Wednesday the teams will be in the company, the sector where teams are working will always be in operation). Constraints are usually driven by assumptions and constraints; the idea is to always focus on relevant deliveries and component deliveries first. The restrictions are limitations imposed at work that diminish the options.

2.2.5 When and how much?

The last issue concerns "Risks", "Costs" and "Timeline". The risks are usually associated with uncertainties. For example, the team may go to the company where they are developing the project and become without work because that day the company is facing some urgency and the project receives less attention. The costs are directly linked to all the investment necessary to carry out the project, from transportation to the purchase of materials. Delivery times are dates when delivery is assumed.

After answering all these questions, teams are prepared to plan their projects using PM canvas (**Error! Reference source not found.**).

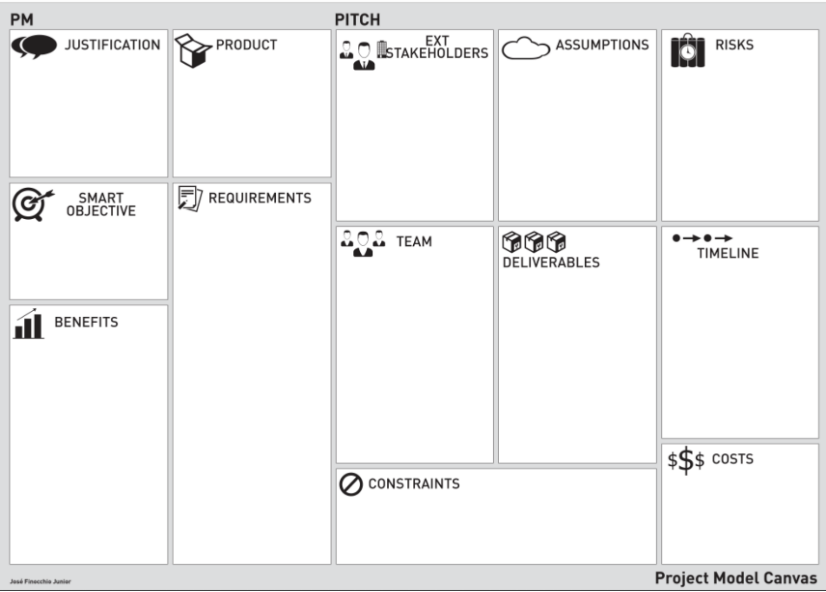


Figure 1. Project Model Canvas (Finocchio, 2013)

2.3 Scrum

Agile is a project management philosophy for collaborative working which consists of a set of values and principles that can be employed in any sector. Scrum is an agile methodology which is widely used in the software industry and thus in teaching (Naik, Jenkins, & Newell, 2020). As a project management tool it helps to define tasks to achieve project objectives set for short deadlines (Popli & Chauhan, 2011; Sutherland, 2014). These tasks are performed at fixed and pre-defined time intervals, these periods are known as Sprints. Sprint is considered the main practice of Scrum. It is the period in which the work items defined in the Product Backlog are implemented by the Scrum team. The Product Backlog is a list of activities that are likely to be developed during the project (Popli & Chauhan, 2011).

The Sprint Planning Meeting serves to define the product backlog. And at the end of each sprint, the Sprint Review Meeting takes place. In it, the team discusses their mistakes, alerts and issues learned. The person responsible for conducting these meetings and ensuring the fulfillment of activities, is called Scrum Master. Another important role in the scrum is that of the Product Owner. This team member usually represents the customer (internal or external). The Product Owner defines the requirements and the degree of importance and priority of each one (Sutherland, 2014).

The last artifact of Scrum is the burndown chart. It is a graphical representation of the remaining work compared to the work already done. Generally, the amount of work is placed on the vertical axis and the time on the horizontal axis. It is very useful for predicting when all work will be completed and for alarming the team in case of delay (which will be very apparent). Usually a line is drawn with the representation of the execution of the work. This line represents the effort already made in the execution of tasks. It is expected that the execution of the activities (tasks) will lead the starting line in Y to the meeting of X, that represents the end of the task executions (Popli & Chauhan, 2011).

2.4 Scrum in PBL

Scrum is an agile project management methodology. In the scrum, projects are divided into normally monthly cycles that are called sprint. However, due to the short term and the dynamism of IPIEM II projects, a weekly sprint was determined. To perform this sprint, the product owner must first define a list with all the features for the product and this list is called a product backlog.

During the Sprint planning meeting, the product owner prioritizes some product backlog requirements and describes them team development, these requirements are met for the sprint backlog. When doing this, the team breaks the product backlog into one or more tasks and with that the work is easily divided among the group members.

To coordinate the work, the scrum needs a scrum master, who during the first month were the fifth year's students.

2.4.1 Sprint Meeting

Every week the scrum master, the development team and anyone else interested in the project meet to define the tasks that are a priority for that week and assign to one or more team members (Figure 2).

Figure 2. Scrum Board (Upper and Lower Part, in portuguese).

2.4.2 Burndown chart

To monitor the progress, the team updates a burndown chart at the end of each sprint meeting. The burndown chart horizontal axis shows sprints; the vertical axis shows the amount of work that needs to be done at the beginning of each sprint. The work that needs to be done can be presented in a preferred unit of the team, in this case it is demonstrated in terms of scoring.

2.4.3 Sprint Review

At the end of every sprint meeting, a sprint review is done. During this meeting, the development team presents what was achieved during the sprint. During the sprint review the project is evaluated in relation to the sprint objectives, determined at the last sprint meeting.

2.4.4 Sprint retrospective

It is done at the end of each sprint to see what worked well, what worked poorly and what steps to take to improve.

3 Methodology

3.1 Project Description

To familiarize students with the challenges of the real world, the Integrated MSc in Industrial Engineering and Management introduced in its syllabus a curricular unit called Integrated Project in Industrial Engineering and Management II (IPIEMII), which is taught during the first semester of the course in fourth year. This curricular unit is supported by other courses of the same semester – Ergonomic Studies for Workstations; Integrated Production Management; Production Systems Organization II; Simulation; Production Information Systems. For more details in the dynamic of the course, please see (Lima et al., 2017).

For the accomplishment of this project, at the beginning of the semester students formed groups from 8 to 10 elements and are assigned to a company belonging to a list of companies presented by the university. The university collaborates with companies from different sectors, like textile sector, footwear industry, electrical and automotive, among others. The main idea is to solve problems of the various sectors of the company that use the type of industry, product or even the activity productive system type. So, the objective of this project is to identify, propose solutions and implement if time and the company allow it and, no less important, to improve the skills of teamwork, but always having as main base the other curricular units taught during the semester.

After the selection of the company, the team and one or more representatives of the company meet in order to define the team's working hours in the company, the team's workspace in the company, and make known the rules that govern that same company. The definition of the team's area of activity varies according to the company's need or availability. When the teachers idealized this project, it was part of the objectives for the companies to make a diagnosis, that is, to identify how it was mentioned in the project's objectives and to decide the area or areas of operation, but most of the time what happens is that the companies prepare in advance a problem to be solved by the teams (Lima et al., 2014).

The teams also have a space at the university that is granted to them to work when they are not in the respective companies and can also interact with the teachers in turn.

As a matter of monitoring and evaluation, teachers determine three delivery dates that serve as control points. The first date is expected as a result that the students present the identified problems and quantifying them, already on the second delivery date the preliminary solutions of the identified problems are expected as a result and finally on the last delivery date the students to present the proposals well-designed solutions and the results of their implementations if applicable.

In order to achieve all of these goals on their respective delivery dates with a large percentage of success with a dozen people on the team and so many other external stakeholders, it is necessary to have a well-defined plan. And to prepare the planning of this project, students use different types of project management tools, from the classic to the most modern ones.

PMLT team roleThe PMLT team, during one month, tried to share their project management experience with the PBL teams, in order to help them to overcome their difficulties in using project management tools for planning work, monitoring their performance and progress and also to ensure that after one month, the teams would be capable of using project management tools by themselves.

The implementation of the Project Management tools begun with the presentation of Scrum and PM Canvas to all the PBL teams, by a group of students from fifth grade who had already used it on the previous year. The fifth-grade group composed by the authors played the role of Scrum Masters (SM). In this presentation, SM explained to the PBL teams how to use scrum and PM Canvas and agreed with them that weekly meetings would be on Friday's afternoons, as it was the only compatible schedule between the teams and the Scrum Masters. The number of tasks performed on each working day of the week was defined as a performance indicator for the job of PBL teams.

The weekly meetings took place for four weeks. The meetings usually started with an analysis on the PM Canvas, to define the next tasks and when they should be delivered. After that, the tasks performed on each working day of the week were counted and compared with the past count. The last phase of the meetings was reserved for the scrum ceremonies. The Figure 3 shows a filled scrum and PM Canvas by one of the PBL teams.

Figure 3. Scrum and PM Canvas filled at the end of one meeting.

In order to know the perspective of the PBL teams about the tools applied and the whole experience with the scrum masters, the PBL teams answered a questionnaire, with open-ended and closed questions in the following format:

- Have you heard of any project management methodology before this project? If so, which ones?
- Have you ever used SCRUM during a project before this project?
- Have you ever used PM Canvas during a project before this project?
- In the company where you are carrying out the project, do you use any project management methodology? If so, which one?
- Is there any project management tool you think would be more useful than PM Canvas or Scrum? If so, which ones?
- Do you feel that you could play the role of the project management in other PBL?
- Do you intend to continue using Scrum in this project?
- Do you intend to continue using PM Canvas in this project?
- How do you evaluate the Scrum Masters performance?

The questionnaire had a response rate of 75%, that is, 36 responses in 48 students. An analysis of all responses showed that they were all valid and will be presented briefly in the next section. The data presented in this article refer only to the four weeks of monitoring done by the authors.

4 Results

PMLT groups helped the IPIEM II groups to set performance indicators for their projects. In Figure 4, it is represented the average tasks performed by each weekday. It is clear that the day most dedicated for IPIEM II was Wednesdays, when the students had the whole day to dedicate to the project. On Fridays it is possible to identify some dedication, as Fridays' afternoons were also dedicated for tutoring by teachers and for group meetings. As the factors that lead to an unbalance of tasks at each day, pointed out by PBL teams and that caused this overload on Wednesdays are: precedence of some tasks, unavailability either by the company as by the teacher (tutor), need to go to the company to perform some tasks, lack of time and organization.

Although most tasks were performed on Wednesday, due to the factors already mentioned, students recognized the importance of using project management tools. This can be seen from the survey results. 76%

of respondents said they had never heard of project management methodologies before. 80% of respondents said they had never used SCRUM and 85% said they had never used PM Canvas. These answers can help to explain why there was some resistance from the PBL teams at the beginning of the semester.

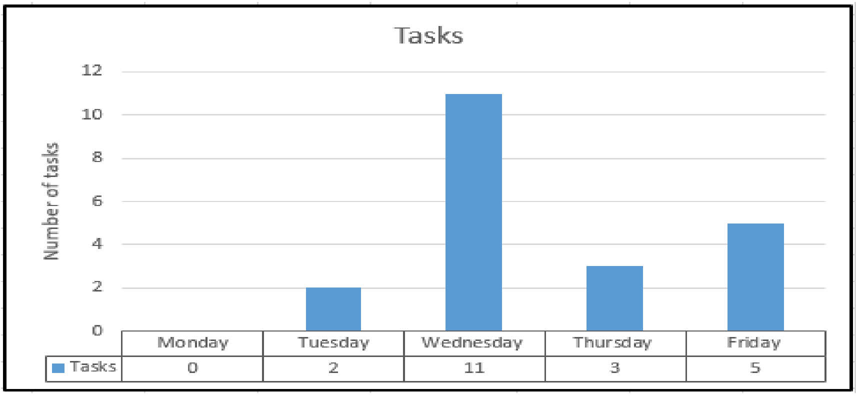


Figure 4. Average of tasks performed by all groups per weekday.

All respondents stated that no project management methodology was used in the companies where they were carrying out the project. As the weeks went by, the projects became more complex and the students looked for other tools and that is why 80% of the respondents pointed out that Trello® would also be a good tool for this context. (Naik et al., 2020) used a Trello-based agile Scrum methodology for teaching and learning purposes at no cost. Trello is a free project management and collaborative working tool, although it is not particularly designed for Scrum. However, the authors observed a significant improvement in overall performance and the Trello-based practical and collaborative working helped all students in understanding, clarifying and correcting their project activities in a timely manner. As a suggestion, this approach could be used in the future for the newcomer students of the next years.

At Table 1 are listed the main problems and solutions observed and reported by students.

Table 1 – Problems identified and tips for improvement, in students' views.

Problems identified	**Tips for improvement**
Too many tasks to be done on Wednesdays	More flexible classes schedules
Focus mainly on the closest deliveries	Pay more attention to PM Canvas and change Post-it®
Companies' resistance for the application of PM Canvas and Scrum	Incentive by companies to apply these methodologies

The feedback on the interaction with the Scrum Masters was very positive, as it helped the teams to make the most of their time; it provided a better control project tasks; improved orientation and organization of the teams; helped in solving problems within the group. The following excerpts, made by the students, underline the importance of this interaction:

> *"These methodologies helped a lot in the division of tasks and in time management." Narrative A.*

> *"The Scrum Masters team was very clear in the way they transmitted their knowledge, and this made it easier to adapt to these tools." Narrative B.*

5 Conclusions

Students from IPIEM complained about the time they have to dedicate to the project at the companies, because they have only one day to do it (in this case, Wednesdays), so they suggest having one more day to dedicate exclusively to the project. This way, they consider they could have more time to collect data at companies and improve the project's outcomes. The class schedule and the lack of availability of teachers made it difficult to fulfill some sprints and caused many tasks to be performed on the same day.

The application of project management tools had a very positive effect on the way the groups organized the project. Despite the good results, the groups showed a lot of resistance to using these tools in the first meetings because they had never used similar tools. Bearing in mind that the project takes place in an academic and industrial environment, the companies in which the groups were inserted did not encourage the use of these tools and that was another factor that made the groups resist the application of these methodologies.

In general, the objectives of the project were achieved and allowed all students involved to develop various skills related to project and team management. It also allowed the exchange of experiences between students of different curricular years and this exchange of experiences meant that with this approach PBL teams did not make some kind of mistakes at the beginning of the project that could have had compromised the entire project.

6 References

Almeida, N., Carrer, C., Carvalho, J. D., & Lima, R. M. (2011). Project Management Guide for Student Project Teams. *International Symposium on Project Approaches in Engineering Education (PAEE'2011): Aligning Engineering Education with Engineering Challenges*, 197–204.

Alves, A. C., Sousa, R. M., Fernandes, S., Cardoso, E., Carvalho, M. A., Figueiredo, J., & Pereira, R. M. S. (2015). Teacher's experiences in PBL: implications for practice. *European Journal of Engineering Education*, *41*(2), 123–141. https://doi.org/10.1080/03043797.2015.1023782

Finocchio, J. (2013). *Project Model Canvas*. ALTA BOOKS.

Harmin, M., & Toth, M. (2006). *Inspiring Active Learning: A Complete Handbook for Today's Teachers* (1st ed.). Assn for Supervision & Curriculum.

Kerzner, H. (2017). *Project Management: A Systems Approach to Planning, Scheduling, and Controlling*. John Wiley and Sons.

Lima, Rui M., Carvalho, J. D., Campos, L. C. de, Mesquita, D., Sousa, R. M., & Alves, A. (2014). Projects with the Industry for the Development of Professional Competences in Industrial Engineering and Management. *Sixth International Symposium on Project Approaches in Engineering Education (PAEE'2014)*, (2002), [1-11]ID13. Retrieved from http://hdl.handle.net/1822/30134

Lima, Rui Manuel, Carvalho, J. D., Sousa, R. M., Arezes, P., & Mesquita, D. (2017). Development of competences while solving real industrial interdisciplinary problems: A successful cooperation with industry. *Producao*, *27*(Specialissue). https://doi.org/10.1590/0103-6513.230016

Naik, N., Jenkins, P., & Newell, D. (2020). Learning Agile Scrum Methodology Using the Groupware Tool Trello $$^{\textregistered }$$ Through Collaborative Working. *Advances in Intelligent Systems and Computing*, *993*, 343–355. https://doi.org/10.1007/978-3-030-22354-0_31

Osterwalder, A., & Pigneur, Y. (2010). *Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers* (1st ed.). John Wiley and Sons.

Popli, R., & Chauhan, N. (2011). Scrum: an Agile Framework. *International Journal of Information Technology*, *4*(1), 147–149. Retrieved from http://csjournals.com/IJITKM/PDF 4-1/30.Rashmi Popli1 & Naresh Chauhan2.pdf

Project Management Institute. (2017). *A Guide to the Project Management Body of Knowledge (PMBOK Guide)*. Project Management Institute.

Silva, H., & Cardoso, A. (2019). Research Project Model Canvas. *Computer Science and Information Technology*, *7*(3), 55–64. https://doi.org/10.13189/csit.2019.070301

Sutherland, J. (2014). *Scrum: The Art of Doing Twice the Work in Half the Time* (1st ed.). Currency.

University-business cooperation on SMEs: An intervention program on creativity, critical thinking and trust

Ana Teresa Ferreira-Oliveira[1],Ana Bouças[2], Ana Rita Alves[3]

[1] CISAS, Escola Superior de Tecnologia e Gestão, Instituto Politécnico de Viana do Castelo, Rua Escola Industrial e Comercial de Nun´Alvares, 4900-347, Viana do Castelo, Portugal
[2] Escola Superior de Tecnologia e Gestão, Instituto Politécnico de Viana do Castelo, Rua Escola Industrial e Comercial de Nun´Alvares, 4900-347, Viana do Castelo, Portugal
[3] Escola de Psicologia, Universidade do Minho, Braga, Portugal

Email: ateresaoliveira@estg.ipvc.pt;

Abstract
University-business cooperation is crucial on sustainable knowledge exchange and co-creation of knowledge. Regarding small and medium-sized enterprises (SMEs) the topic gains even more relevance. Academia has been developing relevant projects of cooperation with organizations but we have still a long way to go in diminishing the gap towards SMEs. This paper presents results from an intervention program developed by a professor and her students. It was implemented in 5 SMEs with 25 participants, ranged between 20 to 45 years. The intervention and training program had a total duration of 5 sessions with 50 minutes each. The program used a workshop "hands on" approach. An initial and final individual evaluation on creativity, trust and critical thinking was conducted through within-process and cross-process skills. The "hands on" was developed based on active learning, with the use of creativity dynamics, fostering critical thinking and trust dilemmas, developing cross-process skills. At the end of the program an individual report was delivered to each participant and feedback was sent individually in an incremental and developmental approach, associating each effective individual gains. This paper presents results from this intervention program integrating quantitative results, initial and final individual evaluations. Results show significant increases in all skills and creativity standing out as the most enhanced skill on the individual developmental process. The paper will also discuss future policies implications towards competence development on this area and the role of higher education institutions.

Keywords: active learning, creativity, critical thinking, trust, innovative experiences, competence development, training

1 Introduction

Small and medium-sized enterprises (SMEs) and academia are still working on establishing relevant university-business cooperation. Some efforts are being made on training modules but a stronger and cohesive work is relevant in order to enhance innovation and development (Ferreira-Oliveira & Bouças, 2020). This paper presents results from an intervention program developed by a professor and her students in SMEs with the purpose of fostering trust, creativity and critical thinking. It was implemented in 5 SMEs with 25 participants, between 20 to 45 years. The intervention and training program had a total duration of 5 sessions with 50 minutes each. The program used a workshop "hands on" approach and as major goals: a) to develop creativity and critical thinking skills in the participants; b) to promote knowledge about theories of thought and creative behavior, critical thinking theories; c) to understand the level of organizational trust experienced in the company; d) to promote hetero-knowledge; e) to develop students proficiency in these skills development.

2 Trust, critical thinking and creativity

2.1 Trust

Organizational trust has been highlighted as a relevant attitude in organizational processes and related to the development of individual skills in organizational settings (Ferreira-Oliveira & Bouças, 2020; Ferreira-Oliveira, Keating & Silva, 2018). There is a vast literature around the concept of organizational trust, characterized by several theoretical approaches, levels of analysis and empirical models (Mayer, Davis & Schoorman, 1995; Rousseau, Sitkin, Burt & Camerer, 1998; Spreitzer & Mishra, 1999; Dirks & Ferrin, 2001; Jr, Hansen & Pearson, 2004; Mollering, Bachmann & Lee, 2004; Keating, Silva & Veloso, 2010). It is important to clarify the trust construct analysed in this work. A distinction that helps to clarify the concept is the nature of the trusted. When the target of trust is an individual, it refers to interpersonal trust, if the target is an organization, institutional trust arises (Lewicki & Bunker, 1996). In this work, we will use the interpersonal trust model, based on Mayer, Davis and Schoorman (1995). Rousseau, Sitkin, Burt and Camerer (1998, p. 395) define trust as "a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behavior of another". Organizational trust has a recognized influence on individual and organizational results such as increased performance (Costa, Roe & Taillieu, 2001; Gould-Williams, 2003), well-being of employees (Baptiste, 2008), job satisfaction (Driscoll, 1978; Perry & Mankin, 2007), team development (Costa et al., 2001) the development of a positive supervisor-employee relationship (Brower, Schoorman & Tan, 2000) and the employee-organization relationship (Kuvaas, 2008). Despite different models, there is a consensus in the literature regarding the conditions for the existence of interpersonal trust (Mach, Dolan & Tzafrir, 2010; Lehmann-Willenbrock, Grohmann & Kauffeld, 2012) the presence of vulnerability (Mayer & Davis, 1999) and the acceptance of risk (the substitution of control mechanisms by trust), the existence of mutual interactions between the parties and, finally, the expectations of consistent conduct over time. Organizational trust comprises an associated expectation that in work relationships where there is trust (namely between employee and manager) more effective collaboration coexists between members of an organization. The acceptance of risk in trust development, as in creativity, can be relevant to foster skills on a training program.

2.2 Critical Thinking

The Organisation for Economic Cooperation and Development (OECD) and the European Commission revealed which are the indispensable competences for the exercise of full, active and creative citizenship in the XXI century (Vincent-Lancrin et al., 2019). Regarding the world of work and the advancement of society, is important to understand critical thinking as a key competence for success ((Vincent-Lancrin et al., 2019; Lopes, Silva, Dominguez, Payan-Carreira, Catarino, Morais & Vasco, 2019). Furthermore, considering that we live in a time with greatest complexity and information overload it has never been more important to develop critical thinking skills, which allow us to distinguish facts from opinions, truths from lies, what is trivial of what is important, and thus making decisions about what to believe or what to do (Levitin, 2014). Ruggiero (2014) distinguished characteristics of the non-critical thinker and the critical thinker, in order to enhanced scientific understanding. The first one – non critical thinker - refers to those who accept the truth of things even if it is not supported by any kind of evidence; those who consider controversial problems and issues as threats to the ego and who tend to follow their feelings and impulses. On the other hand, the critical thinker recognizes what he does not know, his limitations and errors; is interested in the ideas of others, even though they tend to disagree with them and are contained, controlling their feelings and think before acting (Cruz, Dominguez & Payan-Carreira, 2019). In short, a non-critical thought happens quickly, effortlessly, unconsciously, automatically, associative, heuristic, non-reflective and implicit; while critical thinking is structured slowly, effortlessly, consciously, controlled, based on rules, analytical, reflective and explicit (Ruggiero, 2014). Critical thinking is also combined with the ability to distance oneself from the problem considering various alternatives and make quality judgments based on these alternatives. The act of thinking critically is seen as a cyclic and an interactive process where the evaluation of results and their impact can result in a review of the task, that is, in a new analysis and consequently new designs, implementations and evaluations. In this sense, critical thinking can be developed respecting four states: a) investigate: identify and question assumptions and ideas or generally accepted practices; b) imagine: consider various perspectives of a problem based on different premises; c) do: explain the strengths and limitations of a product, solution or theory justified by logical, ethical or aesthetic criteria; d) reflect on the solution or position chosen in comparison to its possible alternatives (Vincent-Lancrin et al., 2019). In addition, it is important to understand the individual skills and dispositions that lead an individual to think critically and that were addressed and developed in this investigation. With regard to competencies, the authors indicate six: a) interpretation: understanding and expressing the meaning and relevance of a variety of experiences, situations, judgments, beliefs, rules, procedures and criteria; b) analysis: identify the actual and intended inferential relationships between statements, questions, concepts, descriptions or other forms of representation designed to express beliefs, judgments, experiences, information or opinions; c) deduction: identify and guarantee the elements necessary to draw reasonable conclusions and consider information to reduce recurring consequences in the implementation; d) evaluation: assess the credibility of extracts or other representations of beliefs, judgments, experiences, information or opinions; e) explanation: justify a decision based on conceptual and methodological considerations; f) self-regulation: conscious monitoring of cognitive activities and their results (Vincent-Lancrin et al., 2019). Regarding the internal dispositions necessary for the construction of a critical thinking, the authors named seven: a) search for the truth: openness to the search for the truth implies a greater receptivity for considering other facts and other perspectives; b) openness of mind: tolerance and understanding of divergent views and sensitivity to the possibility of one's own bias; c) analytical capacity: application of reasoning and use of evidence to solve problems, anticipating possible difficulties and being aware of the need to intervene; d) systematic thinking: being organized, orderly, focused and diligent; e) self-confidence: confidence in the solidity of their reasoned judgments and the ability to lead others in solving problems; f) curiosity: desire to learn, even when the application of knowledge is apparently not easy; g) cognitive maturity: making complex decisions involving several stakeholders, such as making ethical and policy-oriented decisions, particularly in environmental pressures (Vincent-Lancrin et al., 2019).

If, on the one hand, the study of the individual dimension of critical thinking is concerned with understanding the characteristics (competences and dispositions) that are behind what is or should be a critical thinker; the works of some authors interested in their interpersonal dimension seek to identify what a critical thinker does and what can become within a society. Cruz, Dominguez & Payan-Carreira (2019) says that educating for critical thinking ideally involves understanding education as a process of radical and transformative development, more than a mere process of cognitive development, enabling individuals to achieve their emancipation.

2.3 Creativity

In 1950, Guilford described divergent thinking, as the ability to originate a big number of noble ideas, and convergent thinking, the ability to choose ideas worth pursuing. Guilford described these two main processes integrated in creative thinking. Years later, Torrance (1970) added fluency, flexibility, originality and elaboration as aspects involved in the creativity processes. As Sternberg and Lubart (1999) put it "creativity is the ability to produce work that is both novel and appropriate". It can be found in all areas and creative people can be entrepreneurs, engineers, scientists and artists. With this diversity of domains, the best way to understand creativity is through the observed behaviours displayed by people labeled creative. These individuals usually look for ways to solve problems that others don't, are whiling to take risks and stand up for their beliefs (Sternberg & Grigorenko, 2007). To explain the concept of creativity, more recently Lubart in 2017, created a conceptualizing framework of creativity, the 7 C's: creators, creating, collaborations, contexts, creations, consumption and curricula. Being creators are the ones that originate the creative content; creating the process and all the steps the creator takes to come up with their creations with or without collaboration from others or from any type of device. Lastly, consumption refers to the adoption of the creations, that can be either ideas or products and curricula are all the efforts made to the development of creativity within educational programs. Based on this conceptual basis, there is evidence to acknowledge that contrary to the common "myth" that creativity is a talent or a gift, it is a skill that can be gradually developed with the training of the cognitive processes involved in being creative (Sternberg & Lubart, 1995). This popular myth has limited the promotion and training of creativity in all types of contexts and within all types of people, hence, even though psychologist and other type of creativity researchers have been studying processes leading to creativity since the middle of the 20th century. Also, scarce intervention has been developed and only now creativity promotion interventions or training programs are being fostered. In 2019, Vincent-Lancrin et al (2019) proposed creativity rubrics to implement in creativity training programs: ability to inquire, imagine, do and reflect. It is noteworthy to mention that these dimensions are individual phenomena that need to be integrated within context characteristics in order to be fully comprehended. Thus, creativity can only be promoted if the efforts to develop the cognitive processes involved in being creative take into account the individual's social networks, domains and fields of performance (Ryhammar & Brolin, 1999). Following this idea, contexts affect the levels of individual creativity with the degree of which it facilitates the generation of new ideas; the amount of encouragement and support it gives to the development of creative ideas and products; and the judgment in the evaluation of the creative product (Sternberg & Lubart, 1999). Due the particular role of creativity in the innovative capacity and entrepreneurship of organizations, their efficiency to foster creative contexts is of utmost importance in these times of change (Aggarwal & Bhatia, 2011). Gomes, Rodrigues and Veloso (2016) summarized the organizational dimensions that promote creative behaviours in their workers. These range from the physical characteristics of the workplace environment to aspects related to organizational culture and trust. To combine the development of internal and external dimensions to fully tackle the promotion of creativity in the workplace, corporations should enhance organizational dimensions, like support and encouragement from peers and leaders. In other hand, they should incorporate training programs for all staff with the purpose to develop competences that promote their creative potential and facilitate the innovation process (Stenberg, 2012; Gomes, Rodrigues & Veloso, 2016).

3 Method

This paper intends to present a project developed by a professor and her two master students who implemented the skills development program in 5 SMEs with 25 participants, between 20 to 45 years. The intervention and training program had a total duration of 5 sessions with 50 minutes each. The program used a workshop "hands on" approach. An initial and final individual evaluation on creativity, trust and critical thinking was conducted through within-process and cross-process skills. The "hands on" was developed based on active learning, with the use of creativity dynamics, fostering critical thinking and trust dilemmas, developing cross-process skills. At the end of the program an individual report was delivered to each participant and feedback was sent individually in an incremental and developmental approach, associating each effective individual gains.

Figure 1: Intervention training program "Hands on"

3.1 Procedure

SMEs were invited to participate in the program. The criterions used in these selection were regional recognition of good practices in people management and proximity with the university. This paper presents results at an individual level and not aggregated by organization.

The program had as major goals: a) develop creativity and critical thinking skills in the participants; b) promote knowledge about theories of thought and creative behavior, critical thinking theories; c) understand the level of organizational trust experienced in the company; d) Promote hetero-knowledge.

3.2 Participants

To participate in this program 5 SMEs were selected from different sectors: energy, development of new technologies, design and advertising. The sample had a total of 25 participants, 13 females and 12 males. Participants' age ranged between 20 to 45 years, with an average of 31,74 and a standard deviation of 7,37. Participants time in the company, in average, were 4,42 years with a standard deviation of 4,21.

Table 1: Participants

	Average	SD
Age	31,74	7,37
Seniority	4,42	4,21
Female	13	
Male	12	
Total of participants	25	25

3.3 Instruments

The program had an initial assessment on the first session. Regarding critical thinking, we choose to apply the Critical and Creative Thinking Test (TPCC). It was built and validated for the Portuguese population by José Pinto Lopes, Helena Silva e Eva Morais in 2018. TPCC is for children and adults from 12 years old and can be administered individually or in groups. It consists of presenting a current and everyday problem, where a set of problematic circumstances can be identified. It is intended, after exposing the problem, that the evaluated respond to a set of six questions that require the use of the following skills: a) interpretation – recognize the problem and define it without prejudice; b) analysis - identify the solutions making inferences and compare the solutions showing differences and similarities; c) explanation - defend your position with valid arguments; d) evaluation - recognize the relevant factors to assess the degree of credibility of a source of information or opinion and anticipate questions or objections and assess the weaknesses of the arguments; e) synthesis - improve the solution presented or defined with new arguments and alternatives; and f) production / creation - develop new ideas and solutions in an imaginative and innovative way (Lopes, Silva, Dominguez & Nascimento, 2019). After the application, responses are evaluated using a grid. For each of the six questions, answers are evaluated from 0 to 4, except for 2b and 6b, which are scored from 0 to 3 points (Lopes, Silva, Dominguez & Nascimento, 2019). In this study two different set of problematic from TPCC were applied – one in the first session and other in the last one. Participants initial evaluation of Organizational Trust included specifically organizational level, colleagues/team and management level trust and organizational support. The questionnaire was compiled by Costa (2016). This instrument gathers an adaptation from trust in the Organization, adapted by Robinson and Rosseau (1994), Trust in management, adapted and validated by Adams and Sartori (2006) and Trust in Colleagues, adapted and validated by Adams and Sartori (2006); All items were classified on a seven-point Likert rating scale, which varies between (1) "strongly disagree" and (7) "strongly agree", except for the variable Trust in the Organization, which varies between (1) "strongly disagree" and (5) "strongly agree".

Creativity needs to be assessed as a skill that shows itself in ordinary life, not with standardized test (Sternberg, 2012). Therefore, over the years that have been created batteries of test and prompts to assesses the use of creativity skills in contexts and scenarios (Agnoli, Corazza & Runco, 2016; Sternberg & Coffin, 2012; Torrance, 2018). The Torrance Tests of Creative Thinking - Figural(TTCT-F) embraces five separate norm-referenced assessments of creativity measures, as Fluency, Originality, Elaboration, Abstractness of Titles and Resistance to Premature Closure and criterion-referenced assessments of creativity, as *Storytelling Articulateness, Movement or action, Expressiveness of Titles, Synthesis of Incomplete Figures, Synthesis of Lines, Unusual Visualization, Internal Visualization, Extending or Breaking Boundaries, Humor, Richness of Imagery, Colorfulness of Imagery* and *Fantasy.* During the intervention, the TTCT was applied two times, with different figures, on the first and the last session. After making these assessments, the scorer looks for evidence of creative strengths, those thirteen, giving ratings of (+) (for 1 or 2 occurrences) or (++) (typically for 3 or more occurrences). The results only refer to criterion-referenced assessments of creativity. This were translated to a 0-2 scale (0 – no occurrence and 2 – 3 or more occurrences) for a better understanding of the results. Synthesis of Incomplete Figures and Synthesis of Lines are not described in the results because those are assessments with TTCT's test that were not applied doing the training course.

3.4 Data Analyses technique

The quantitative analysis of the data was performed in the Statistical Package for Social Sciences (SPSS). Descriptive statistical analysis and two-way mixed variance analysis were performed to study differences in the different moments of data collection. Considering the reduced sample size we used non parametric statistic, namely Wilcoxon.

4 Results

This paper presents a pre and post evaluation performed to participants on the training program. Concerning the first TPCC application, presented in the first session, results show low levels of critical and creative thinking among participants. From the six skills evaluated, analysis (M=1,57) and production/creation (M=1,27) revealed the higher levels. In the last session, a second and different version of TPCC was applied. It is possible to see in table 2 a positive evolution. This time it was analysis (M=2,22), explanation (M=1,49), synthesis (M=1,224) and evaluation (M=1,20), that show the higher levels. Fairly to production/creation skill, it shows a negative evolution (M=1.27; M=0.90). Differences were not statistically significant. Regarding to gender differences in TPCC, they also were not statistically significant. Results show that female participants have higher levels of critical and creative thinking in almost every skill evaluated.

Table 2. Results of TPCC I and TPCC II

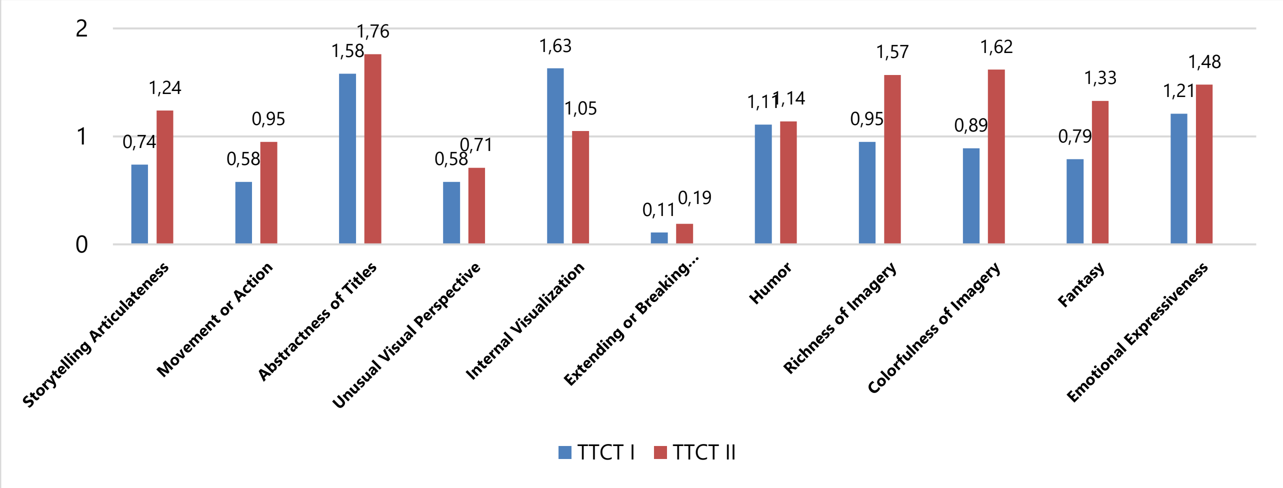
	TPCC I		TPCC II	
	X	SD	X	SD
Interpretation	0,704762	0,263932	0,873016	0,357407
Analysis	1,569048	0,260527	2,221005	0,252143
Explanation	1,047619	0,218218	1,493968	0,503014
Evaluation	1,038095	0,313419	1,201624	0,300052
Synthesis	0,7	0,353698	1,224614	0,225225
Production/Creation	1,271429	0,521575	0,902931	0,214335

As we can see from the table 3, from the six skills evaluated, it was analysis (M=1.71; M=2.54), explanation (M=1,5; M=2.15), synthesis (M=0.75; M=2.07) and evaluation (M=1,25; M=1.54) that had higher levels and the most positive evolution. Furthermore, results indicated higher levels of interpretation in the male (M=0.75; M=1) rather than on the female participants (M=0.58; M=0.75). Although the male has lower levels than female participants in the two applications of TPCC, we can also perceive their positive evolution.

Table 3: Gender differences in TPCC

	TPCC I				TPCC II			
	FEMALE		MALE		FEMALE		MALE	
	M	SD	M	SD	M	SD	M	SD
Interpretation	0,58	0,67	0,75	0,80	0,75	0,77	1,00	1,50
Analysis	1,71	0,52	1,50	0,65	2,50	2,54	2,00	1,00
Explanation	1,58	0,80	0,60	0,83	2,15	2,15	1,33	1,12
Evaluation	1,25	0,89	0,93	0,71	1,54	1,54	1,11	0,78
Synthesis	0,75	0,80	0,67	0,62	2,08	2,08	1,22	0,83
Production/Creation	1,41	1,68	1,08	1,16	1,46	1,46	0,89	0,78

Results reveal high levels of Organizational Trust among the participants, namely *Trust in the Leaders* (M = 6, SD= 28.91) and *Organizational Trust* (M = 4.31, SD= 4.67), followed by lower levels related to *Trust in colleagues* (M = 3.5; SD= 64.20). Results related to Creativity, reveal an average increase in the recognition of all the dimensions evaluated, except in the *Internal visualization* dimension. As you can see from graph I, and according to Wilcoxon test, the dimensions with the most positive evolution *were Storytelling Articulateness, Richness of imagery, Colorfulness of imagery* and *Fantasy*. The *Colorfulness of imagery* revealed a statistically significant positive evolution z= -2,879, p≤.005.



Graph 1 – Creativity Differences Pre and Post

5 Conclusions

This training course was designed for participants already in the work force, but its results show that with efforts focused on critical thinking and creativity these skills can be enhanced and useful for jobs that require a higher education. As Badran (2007) and Ahern, O'Connor, McRuair, McNamar & O'Donnell (2012) put it, critical thinking and creativity should be explicitly addressed in engineering curriculums in order to help students become critical thinkers and consequently, add value to products and services provided by them. On that note, it's important to add the promotion of these skills to the learning objectives of engineering courses. In future researches related to this investigation this goal can be targeted by studying the adaptation and results of this training course with students, more especially engineering students that can benefit and become more prepared to enter on the work force if these set of very appreciated skills are promoted beforehand.

University-business cooperation is crucial on sustainable knowledge exchange and co-creation of knowledge. Regarding SMEs this topic gains even more relevance as academia has been developing relevant projects with organizations but have not being able to diminish the gap towards SME´s (Ferreira-Oliveira & Bouças, 2020). This paper presents results from an intervention program, a workshop "hands on" approach with major goals: a) to develop creativity and critical thinking skills in the participants; b) to promote knowledge about theories of thought and creative behavior, critical thinking theories; c) to understand the level of organizational trust experienced in the company; d) to promote hetero-knowledge; e) to develop students proficiency in these skills development. In this paper we present results from the evaluation pre and pos of participants that were under the training sessions. The project had relevant impact in student's professional and personal development; it also showed significant increases in all skills; creativity stands out as the most enhanced skill. The training program was very short, 5 sessions, however regardless, this training had relevant results on participants. Results show relevant differences in skills development, namely on creativity.

University Business Cooperation and Higher education institutions have a very relevant role on establishing bridges with SMEs. Universities should act as talent-engines, developing and validating students 'competences but also as a life partner, upskilling professionals (Davey, 2020). In Portugal, the majority of our enterprises are SMEs therefore academia should continue to establish relevant bonds with these organizations that will ensure that they see Higher Education Institutions as major partners through their whole development phase. Future studies should present more extensive programs and an organizational level approach with results from each organization and sector levels of achievement.

6 References

Aggarwal, Y., & Bhatia, N. (2011). Creativity and innovation in management: a fuel for growth. International Journal of Multidisciplinary Research, 1(5), 288-296.

Ahern, A., O'Connor, T., McRuairc, G., McNamara, M., & O'Donnell, D. (2012). Critical thinking in the university curriculum – the impact on engineering education. European Journal of Engineering Education, 37(2), 125–132. doi:10.1080/03043797.2012.666516

Badran, I. (2007). Enhancing creativity and innovation in engineering education. European Journal of Engineering Education, 32(5), 573–585. doi:10.1080/03043790701433061

Baptiste, N. R. (2008). Tightening the link between employee wellbeing at work and performance: A new dimension for HRM. Management Decision, 46(2), 284–309. doi:10.1108/00251740810854168.

Brower, H. H., Schoorman, F. D., & Tan, H. H. (2000). A model of relational leadership : The integration of trust and leader-member exchange. Leadership Quarterly, 11(2), 227–251.

Costa, A.C., Roe, R. & Taillieu, T. (2001). Trust within teams: The relation with performance effectiveness. European Journal of Work and Organizational Psychology, 10(3) 225-244.

Cruz, G., Dominguez, C. & Payan-Carreira, R. (2019). A importância e o desafio de educar para o pensamento critico no séc. XXI. In. Educar para o pensamento crítico na sala de aula. Coord. Lopes, J. Silva, H., Dominguez, C., Nascimento, M. Pactor: Edições de Ciências Sociais, Forenses e da Educação.

Davey, T. (2020). The future of universities.UIIN. 2019 University-Industry Interaction Conference.

Dirks, K. T., & Ferrin, D. L. (2002). Trust in leadership: meta-analytic findings and implications for research and practice. Journal of Applied Psychology, 87(4), 611–628. doi:10.1037//0021-9010.87.4.61.

Driscoll, J. (1978). Trust and participation in organizational decision making as predictors of satisfaction. The Academy of Management Journal, 21 (1) 44-56.

Ferreira-Oliveira, A. T., & Bouças, A. F. (2020). Retaining Knowledge and Human Resource Management in IT Sector: How We Are SMEs Doing This? Advances in Intelligent Systems and Computing, 35–44. http://doi:10.1007/978-3-030-45688-7_4

Ferreira-Oliveira, A. T., Keating, J., & Silva, I. (2018). Decision Making on Human Resource Management Systems. Trends and Advances in Information Systems and Technologies, 1040–1045. doi:10.1007/978-3-319-77712-2_99

Gomes, J. F. D. S., Rodrigues, A. F., & Veloso, A. (2016). Regresso às Origens: A importância do Indivíduo na Criatividade nas Organizações. Revista de Administração Contemporânea, 20(5), 568-589.

Gould-Williams, Julian. (2003). The importance of HR practices and workplace trust in achieving superior performance: A study of public-sector organizations. The International Journal of Human Resource Management, 14(1), 28–54. doi:10.1080/09585190210158501

Guilford, J.P. (1950), "Creativity", American Psychologist, Vol. 5/9, pp. 444-454, http://dx.doi.org/10.1037/h0063487.

Jr, J. L. M., Hansen, M. H., & Pearson, A. W. (2004). The cognitive and affective antecedents of general trust within cooperative organizations. Journal of Managerial Issues, 16(1), 48-64.

Keating, J., Silva, I., & Veloso, A. (2010). Confiança organizacional: teste de um modelo. In A. S. & M. C. T. C. Nogueira, I. Silva, L. Lima, A. T. Almeida, R. Cabecinhas, R. Gomes, C. Machado, A. Maia (Ed.), VII Simpósio Nacional de Investigação em Psicologia (pp. 2451–2466). Braga: Associação Portuguesa de Psicologia.

Kuvaas, B. (2008). An exploration of how the employee organization relationship affects the linkage between perception of developmental human resource practices and employee outcomes. Journal of Management Studies, 45(1) 1-25. doi:10.1111/j.1467-6486.2007.00710.x.

Lehmann-Willenbrock, N., Grohmann, A., & Kauffeld, S. (2012). Promoting multifoci citizenship behavior: time-lagged effects of procedural justice, trust and commitment. Applied Psychology, 62(3), 454-485. doi:10.1111/j.1464-0597.2012.00488.x.

Levitin, D. (2014). The Organized Mind: Thinking Straight in the Age of Information Overload. New York: Penguin Publishing Group USA.

Lewicki. R. & Bunker, B. (1996). Developing and maintaining trust in work relationships . In Kramer, R. & Tyler, T. (Ed.) Trust in organizations : frontiers of theory and research , 114-140. Thousand Oaks: Sage Publications.

Lopes, J. P., Silves, H. S., Dominguez, C., & Nascimento, M. M. (2019). Educar para a sala de aula pensamento: Planificacão estratégias e avaliação (1st ed., Vol. 1). Lisboa: Pactor.

Lopes, J., Silva, H., & Morais, E. (2019). Teste do Pensamento Crítico e Criativo para estudantes do ensino superior. Revista Lusófona de Educação, 44(44).

Lopes, J., Silva, H., Dominguez, C., Payan-Carreira, R., Catarino, P., Morais, F. e Vasco, P. (2019). O feedback na promoção do pensamento crítico. In. Educar para o pensamento crítico na sala de aula. Coord. Lopes, J. Silva, H., Dominguez, C., Nascimento, M. PACTOR: Edições de Ciências Sociais, Forenses e da Educação.

Lubart, T. (2017). The 7 C's of Creativity. The Journal of Creative Behavior, 51(4), 293-296.

Mach, M., Dolan, S., & Tzafrir, S. (2010). The differential effect of team members' trust on team performance: The mediation role of team cohesion. Journal of Occupational and Organizational Psychology, 83(3), 771–794. doi:10.1348/096317909X473903.

Mayer, R. C., Davis, J., & Schoorman, F. (1995). An integrative model of organizational trust. The Academy of Management Review, 20(3), 709–734.

Mayer, Roger C; Davis, J. (1999). The effect of the performance appraisal system on trust for management. Journal of Applied Psychology, 84(1), 123–136.

Möllering, G., Bachmann, R., & Lee, S. H. (2004). Introduction: Understanding organizational trust - foundations, constellations, and issues of operationalisation. Journal of Managerial Psychology, 19(6), 556-570.

Perry, R. & Mankin; L. (2007). Organizational trust, trust in the chief executive and work satisfaction. Public Personnel Management, 36(2), 165-180.

Rousseau, D. M., Sitkin, S. B., Burt, R. S., & Camerer, C. (1998). Not so different after all: a cross-discipline view of trust. Academy of Management Review, 23(3), 393–404. doi:10.5465/AMR.1998.926617.

Ruggiero, V. (2014). Becoming a Critical Thinker. Scarborough, ON: Nelson Education.

Ryhammar, L., & Brolin, C. (1999). Creativity research: Historical considerations and main lines of development. Scandinavian journal of educational research, 43(3), 259-273.

Spreitzer, G. M., & Mishra, A. K. (1999). Giving up control without losing control: Trust and its substitutes' effects on managers´involving employees in decision making. Group & Organization Management, 24(2), 155-187.

Sternberg, R. J. (2012). The assessment of creativity: An investment-based approach. Creativity research journal, 24(1), 3-12.

Sternberg, R. J., & Grigorenko, E. L. (2007). Teaching for successful intelligence: To increase student learning and achievement. Corwin Press.
Sternberg, R. J., & Lubart, T. I. (1999). The concept of creativity: Prospects and paradigms. Handbook of creativity, 1, 3-15.
Sternberg, R.J. and T. Lubart (1995), Defying the Crowd: Simple Solutions to the Most Common Relationship Problems, The Free Press.
Torrance, E. P. (1972). Predictive validity of the Torrance tests of creative thinking. The Journal of creative behavior, 6(4), 236-262.
Vincent-Lancrin, S., et al. (2019), Fostering Students' Creativity and Critical Thinking: What it Means in School, Educational Research and Innovation, OECD Publishing, Paris, https://doi.org/10.1787/62212c37-en.

The role of partnership in launching PBL approach in cooperation with network of social enterprises – research case of Częstochowa University of Technology

Aneta Pachura[1] and Tomasz Nitkiewicz[2]

[1] Department of Logistics and International Management, Faculty of Management, Czestochowa University of Technology, Poland
[2] Department of Business Informatics and Ecosystems, Faculty of Management, Czestochowa University of Technology, Poland

Email: aneta.pachura@pcz.pl; tomasz.nitkiewicz@pcz.pl

Abstract

The objective of the paper is to share experiences in building and functioning of partnership between University and network of social enterprises for the purposes of launching project-based learning (PBL) approach. PBL was introduced within elective course titled Creativity management in business that is offered within Design and Project Management degree on Faculty of Management, Czestochowa University of Technology. Both, the PBL approach and partnership with social enterprises was introduced in 2019/2020 academic year. The objective of students projects was to identify the needs of social enterprises and develop business models with the use of creative approach. The scope of the paper is to present experiences of students, teacher and representatives of social enterprises involved, as well as, institutional partner: network agent. The partnership with institutional agent has started in spring 2019 while the student projects has been launched in fall semester 2019/2020. The structure of PBL approach has finally consisted of 6 separate projects groups with single small size social enterprise involved in each group and group of 3 students. The sequence of PBL introduction included the phases of recruiting the enterprises, objective settling, defining the scope of the project and its content, project realization, assessment and summarizing. The PBL use would be considered from the perspective of teaching and learning experience, partnership and eventual specificity of social enterprises sector with PBL approach. The key factors enhancing the partnership in the use of PBL approach and stimulating its benefits are related to the enthusiasm of institutional agent involved, openness of social enterprises, division of responsibilities within project teams and attitude of students and good networking and tutoring performance of the teacher.

Keywords: active learning, PBL, social enterprises, creativity management, social innovation

1 Introduction

The Project or Problem Based Learning (referred to as PBL), is a commonly recognized teaching approach aimed at engaging students in the investigation of real problems. In this model, students seek solutions to non-trivial problems by discussing ideas, making predictions, developing plans and/or experiments, collecting and analyzing data, communicating their conclusions to other students, raising new questions, and creating artifacts (Blumenfeld et al. 1991; Reis et al. 2019). PBL is also considered to stimulate interdisciplinarity (Lima et al. 2017a), combine program specific competences with transversal ones (Mesquita et al. 2015; Lima et al. 2017b) and to provide opportunities for collaborative learning within and outside universities (Mohd-Yusof et al. 2011; Reis et al. 2019). The differences between project- and problem-based learning have been discussed in literature but for the purpose of the paper could be summarized to learning process orientation. Problem-based learning focuses on knowledge acquisition, while project-based learning focuses on the application of knowledge (Perrenet et al. 2000; Hussadintorn Na Ayutthaya and Koomsap 2017). The collaborative approach within PBL is also related to the participation of companies that share its operational, technical and market insights in order to define project objective and possible make the solution coherent with real life conditions (Delgado and Ayala 2019).

While creating new curriculum of Design and project management, the coordination team of that task, realized on the Faculty of Management at Częstochowa University of Technology, has intended to use project- and problem-based learning in its centre in order to gain the abovementioned benefits and characteristics and provide students and graduates with unique but yet viable set of competences and skills. It was not planned from the beginning, but using the support of external partner for application of active learning approaches has significantly boosted the changes towards achieving these goals. The objective of the paper is to share experiences in building and functioning of partnership between University and network of social enterprises for the purposes of launching project-based learning approach.

2 Set up of pilot testing of PBL approach for Creativity management in business course

2.1 Framework

Faculty of Management (FM) on Częstochowa University of Technology has launched its cooperation with Jurrasic Centre of Social Economy Support (JOWES) in March 2019. JOWES is a branch of Regional Development Agency in Częstochowa (ARR), a public entity to support local and regional development. JOWES activities are co-financed by European Social Fund within the framework of *Regional Operational Program of Silesia Voivodship for the years 2014-2020* and its sub-action 9.3.1. "Support for social economy sector" (http://jowes.pl, accessed: 11.06.2020).

One of the objectives of cooperation between FM and JOWES is to enrich the educational processes with practical issues of social entrepreneurship and to improve the capacity of social enterprises within mutual knowledge exchange and learning, experience and competence sharing. JOWES has become institutional partner and overtook the role of networking agent for cooperation between social enterprises and academics.

The initiative of including social entrepreneurship practices within the educational process has been introduced on the Bachelor degree program of *Design and Project Management* (DPM) which is held by FM. Second year students of DPM program have faced real life problems from the perspective of social enterprises within the course titled: *Creativity management in business* (CMB). These active approach to the course has been introduced in autumn semester of 2019/2020 academic year as a pilotage. It is important to notice that DPM program and its CMB course has been approach with problem and project-based learning from the beginning and no other teaching approaches has been tested for this course. For this purpose an author teaching program for CMB course has been prepared by Aneta Pachura, PhD, an instructor for this course and co-author of this paper.

The aforementioned cooperation between JOWES and FM has been formalized into a cooperation task titled: Mutual learning. It's pilot testing has been launched in academic year 2019/2020. The official run of the course has been schedule from October 4th, 2019 till February 26th, 2020.

2.2 Project set up and specificity

The project within the CMB course has been designed as an answer for the need of development intersectoral cooperation, mutual learning and combining the potential of different environments for achieving social benefits. The objective of the PBL introduction has been twofold: 1) enriching the educational process with active approach and practical business issues and 2) capacity building for JOWES and FM cooperation, and, in more general context, strengthening the intersectoral cooperation.

The key content of PBL, namely project of CMB course has been designed to introduce the practical aspects of social entrepreneurship and creativity, which was assumed as significant for DPM program and important for achieving its program learning outcomes. The group of 18 students, divided into smaller project groups, has spent whole autumn semester in 2019/2020 academic year for preparing a project with cooperation with six social enterprises. The main objective of the project was to develop a business model for selected social enterprise. Students has been engaged into identification of real-life social enterprises problems and has been engaged into developing and proposing solutions.

2.3 Project objectives

As mentioned before the objective of the project was to develop a business model for selected social enterprise. The educational objective of PBL approach was to introduce practical issues of social enterprises functioning into educational process. The detailed objective of the PBL approach used were:

- Students engagement into initiatives of social entrepreneurship,
- Students engagement into practical problem solving, especially from the perspective of social enterprises,
- Elaborate on students competences on identification and analysis of external and internal factors influencing social enterprises,
- Elaborate on students abilities on creative thinking and testing potential business models,
- Elaborate on students competences on team working and decision making, cooperation and communication.

2.4 Project tasks

Before official starting of the project, the project set-up has been prepared between FM and JOWES. After defining the general objective and scope of the project the survey on PBL participation was distributed among social enterprises that are supervised by JOWES. After preliminary elimination of enterprises that was based on the survey results, the group of six social enterprises has been defined to participate in PBL. The selection process has been finalized around July 2019. The following months has been used to define the The schedule of the project with the tasks breakdown is presented in the Table .

Table 1. The schedule of the PBL approach and tasks breakdown

Tasks and its purposes	Time framework
Informative meeting with students – preparation of students for project work and division for project groups	04.10.2020
Meeting with social enterprises representatives – presentation of social enterprises and its business activities and potential scopes of the projects / finalization of project group division by assigning the groups to specific enterprises	25.10.2019
Study visits in social enterprises – project group presentations of actual location and activities of social enterprises	28.10.2019 r.-14.12.2019
Project work - realization of specific project tasks according to the project tasks forms within the project groups	04.10.2019 r.-29.01.2020
Evaluation of project results by the teacher	29.012020 r.-26.02.2020
Forwarding of the developed business models to the representatives of social enterprises	19.02.2020
Disseminating event for project results within the 3rd CSR Seminar – public presentation of developed business models by students, handing over the certificates for participation in JOWES-FM cooperation project by the president of Czestochowa municipality	26.02.2020

2.5 The results of applying PBL approach

The results of the project and PBL results should be considered from the perspectives of the students, academic teachers, social enterprises and institutional agent (JOWES). The general results are as follows:

- Original and innovative business models, developed for social enterprises engaged in the project,
- Enriching learning process with elements of practical issues of social entrepreneurship,
- Improvement of teaching workshop,
- Strengthening the development potential of social enterprises,
- Strengthening the project related competences,
- Development of cooperation and decision making competences,
- Increasing the competences of knowledge, skills and experiences sharing,
- Increasing of social economy awareness in academic environment,
- Development and strengthening the social interrelations.

2.6 Limitations of applying PBL approach

Despite the occurrence of clear benefits for all the actors involved within PBL application some limitations has been spotted and should be considered before launching next edition in 2020/2021 academic year and further developing PBL including courses in DPM curriculum. It is not possible to avoid all of them or to mitigate them to significant extent. The list of the identified limitations includes:

- Limited time framework for application of PBL – autumn semester lasts for 4 months and a course of CMB has 30 contact hours only,
- Excessive working time for social enterprises representatives over routine activities – it has impacted their engagement level into project consultation and discussion,
- Excessive project-related workload for students among different courses in the curriculum – it has impacted their engagement level into project work,
- Generational differences between project group members – it has impacted the efficiency of communication between the students and social enterprise representatives,
- Lack of external or internal financing – it has impacted the frequency, number and length of studying visits and potential preparation of prototype business and product solutions.

Since the application of PBL is considered from the perspective of one course only, the interpretation and possible actions towards decreasing the negative impact of these limitations should be mindful and should take into account the possible consequences for whole curriculum. Such actions as reconsidering the accounting the share of project work as contact hours, using internal financing for some cost bearing activities or changing the hourly structure of curriculum to give more hours for project-related work.

Some of the limitations are heavily influenced by interpersonal relations and personal characteristics of students and entrepreneurs involved. Through the course of the projects it seems that some issues has not been clearly disputed by academic teachers, JOWES and social enterprises representatives and it has led to some misunderstandings and mismatching the project work with the expectation of selected enterprises. Finally, the problem has not significantly impacted the outcomes of PBL application. As an example of such a problematic issue we can point out the expectations of some social enterprises to get marketing plan at the end of the projects. Since it was not the key outcome of the projects, students and teachers has stuck to the objective of developing a business model. Finally, the intervention of JOWES representative has helped to get the understanding of agreed project work. This example shows also the difference between the direct project-related cooperation between university and company and cooperation with additional engagement of institutional and networking agent, such as JOWES in the relation to supervised social enterprises.

The role of JOWES has been crucial with regard to overcoming some of the abovementioned limitations. From the perspective of social enterprises JOWES has many different roles that are quite important for its activities and possible external financing, competence development or networking and marketing events and efforts. In fact, JOWES supports social enterprises in many fields to help them to overcome the possible drawbacks towards regular enterprises and its competitiveness.

2.7 Management of PBL and project teams

The management of PBL application has been co-handled by all the actors directly involved into the process. Project teams, social enterprises, university and JOWES as an institutional partner has shared the competences of managing it. Projects has been realized by 6 interdisciplinary teams that included three students and at least one representative of social enterprise. Additionally, each project team has a contact person in JOWES that enabled the ongoing contact between the enterprise and students and teacher.

The work of project teams has been supervised by academic teacher, who participated in teamworking on the basis of consulting and mentoring. Additionally, teacher had the responsibility of monitoring the progress of projects and evaluated its outcomes. The role of the teacher has been related also to problem solving activities that lied beyond the competences of project team. As mentioned above, the teacher has been in ongoing contact with JOWES contact persons and its supervising board.

JOWES as an institutional partner has a role of communication enabler, supervisor of social enterprises engagement and problem solving agent, when the enterprise related issues were concerned. Social enterprises has settled the background for business model development by presenting its current activities and operating markets, as well as, showing its possible growth directions. Enterprises have provided the data and facilities for studying visits, analyses and development proposals.

The schedule of the project work has been prepared by the teachers, but project teams has performed its own time management schemes and selected individually the forms and intensity of project meetings. The main topic of the project has been settled by project teams. Each team has selected one of the students as its project manager who took the responsibility of maintaining contact with social enterprises representative, providing materials for academic teachers to document the progression of the project, communicating internally with all the project team members and organizing project work and meetings. Additional role of project manager was to handle possible interpersonal or thematic conflicts and communication problems, but it was done with the support of academic teach or JOWES representative if the problem occurred on the line between the students and social enterprise.

Each project team has a social enterprise as a provider of leading topic and its representative as a member. These representatives has not participated in project work as a whole but has provided the data on enterprise functioning, the scope of its current market undertakings and activities, the possible development and growth directions and has verified and accepted the assumptions of proposed business models and creative solutions concerning products, processes or organization.

2.8 Experiences of PBL actors

There has been four group of actors involved in the process of PBL application: students, teachers, social entrepreneurs and its employees and JOWES as an institutional and networking agent. Each one of the groups has its own perspective while experiences from PBL application are concerned. The list of experiences in relation to specific group of actors is presented in Table 2.

Table 2. Experiences of PBL actors

Students	Social enterprises
Contact with business practice Contact with social entrepreneurship Practice of designing business solutions Cooperation within interdisciplinary project teams Personal capacity building and using own potential	Contact with academic environment Contact with new ideas and proposals Social and inter-generational relation building Knowledge and competence sharing
Academic teachers	**Institutional agent**
Intersectoral cooperation Creating interinstitutional networks and relations Engaging students in out of the class activities Personal capacity building and using own potential Leadership and mentoring	Contact with academic environment and its potential Intersectoral cooperation Engaging students into activities of social enterprises

Additionally, to cover the experiences of social enterprises involved, their feedback was collected during the summarizing meeting on February 19th 2020. The meeting was held by JOWES and its main purpose was to discuss the business models as an outcome of the project, taking into account the perspective of social enterprises. Feedback was collected during personal meetings between the teacher and representatives of social enterprises. Received feedback was categorized within three areas: 1) usefulness and implementation possibilities of developed business models, 2) development potential of social enterprises and 3) evaluation of partnership within the PBL and cooperation with students.

As for the usefulness of the models developed, the representatives of companies have appreciated its reference to their actual needs. Implementation of business models proposed could contribute to the strengthening its market position and its further development. The models were assessed as complex and expressing the holistic approach towards social enterprises. Since the project teams worked closely with social enterprises, the models are suiting their current technical and organizational conditions and refer to actual market conditions. The problems spotted here are related to the additional resources that are required to comprehensively introduce the models and some internal (lack of resources and competences) and external risks (facing new competitors). Due to SARS-CoV-2 pandemic most of the implementation steps were cancelled or held back but it is expected that in the second half of the year some of the enterprises will start the implementation and prototyping.

As for the development potential, the representatives agreed that the cooperation within PBL with students' team have enabled the development process of their knowledge and competences. Additionally, the clash of pragmatic and innovative perspectives has been inspiring for them and their overview of their businesses. The key factor here is related to the openness for different perspectives and intersectoral cooperation that could be impactful concerning the strengthening of business and quality improvement.

The cooperation with students' project teams was a challenging task for representatives of social enterprises. It was mainly due to intergenerational composition of the teams and the differences in communication schemes and preferences. Overall assessment of this issue, from the perspective of social enterprises is positive and indicates the strengthening of its social competences. Its most visible outcome is the ability of creating, maintaining and using network social relationship.

3 Building partnership between university and social enterprises – key impact factors

Basing on the example presented above we could identify some key factors impacting the partnership building process between university and social enterprises.

3.1 Institutional agent

The purpose of settling the cooperation between FM and JOWES has not been originating from the potential of PBL application. In fact, the cooperation agreement, as negotiated between the partners has not referred directly to potential of PBL use in the social enterprises. But the potential of PBL application has been raised during the agreement negotiations and since then has become one of the key cooperation areas between the two institutions. In our opinion, it was due to openness of JOWES as a partner, and its sense of responsibility for supervised social enterprises. Cooperation on PBL has been perceived by JOWES as a chance for social enterprises, if not to get market ready business models, to get critical and external view on its activities and significant outlook on possible directions of its development. The enthusiasm of JOWES staff over PBL application has impacted the social companies that had a chance to participate in it. Assessing it from the time perspective, it is obvious that without JOWES engagement it would not be possible to establish the framework and gather business partners so quickly and in such a disciplined manner.

3.2 Social enterprises

Social enterprises are a challenging ground for implementing PBL but they are also different from regular enterprises. These difference could obviously work for the benefit of PBL application. First of all, social enterprises are not bound by the revenue objective only and have some other purposes for its activities. It could be a good opportunity to set PBL approach in a real, market-based context. Secondly, social enterprises are short on resources, not only financial but also human force, and could benefit from PBL application by setting its goals around its growth and development directions. Through PBL application they could achieve some of its long-term strategic goals without sparing on it its human resources that are needed for everyday challenges. Last but not least, social enterprises are often run not by economic drivers but for some higher purposes. In such a case, building partnership with university and its students is perceived as such a long-term investment and is good occasion to share its view and disseminate its activities.

3.3 PBL scheme

The cooperation between different actors in order to achieve program and course learning outcomes is always a challenging task. PBL scheme proposes the diversified toolbox for this purposes and is flexible enough to develop a clear path towards these objectives. The main advantage of PBL approach is related to the opportunity to share the responsibility between different actors and empower students in leading the process towards them. Such an advantage should not only be considered from the perspective of single course but also from the perspective of whole curriculum. As some evidence show (Arana-Arexolaleiba and Zubizarreta 2017; Lima et al. 2017b), system approach to introduce PBL could lead to build up a set of interdisciplinary benefits for academic actors and its business environment.

3.4 Students and teachers

Finally, the role of students should be mentioned, in order to give more personal factor on partnership building from the side of the University. Students participating in PBL application have been relatively unexperienced (2nd year of bachelor degree studies) but have managed to turn their potential weakness into the advantage in the process of partnership building. In contacts with representatives of social enterprises they naturally took over the role of the ones to be taught the "mysterious paths" of social enterprises but yet, they have managed to be leading the task, be critical and surprisingly creative towards their partner enterprises. Such circumstances led to building strong and fruitful relationship within most of the teams. Leading teacher of the course has also been engaged in some other networking and knowledge sharing activities with JOWES and social enterprises and its role has been much more different from PBL coordinator only. It could be the turning point in switching the relationship to more stable and mutual conditions.

4 Conclusion

Social enterprises are not large economic organisations, operate on a rather small scale and cooperate with a small number of economic partners. In such a situation, the potential for creating new ideas and initiatives is quite limited. At the same time, these entities did not have experience in adapting business solutions from outside. However, the experience of the academy (FM) in cooperation with external organisations was also quite limited. Similarly, the practice of JOWES in cooperation with the academy was negligible. So all the actors were learning this cooperation. The basic conclusions of this case study may oscillate around the following points:

- The basis for building effective local partnerships is system thinking,
- The development of cooperation between the academic community and social entrepreneurship fosters the improvement of the academic education "outside the university" and enriches the potential of social enterprises,
- Combining theory and practice through the introduction of factors from the practice of social entrepreneurship into the didactic process is a necessary direction for improving the processes of academic education based on project-based learning and promoting the idea of social economy,
- Mutual learning, flow of knowledge, experience and skills is an important result of cooperation,
- Without significant involvement of universities, social enterprises and institutional partner, the actions will be ineffective,
- Cooperation between academia and the social economy sector is a good laboratory for learning local cooperation and implementation of project-based learning approaches.

Thanks to participation in the project, social enterprises have encountered different views and approaches to running a business. This allowed them to see and experience how to solve problems thinking "outside the box". It seems that the experiences of all participants in the project were not only positive, but even enthusiastic. We managed to effectively implement the field of "win-win" game. It can be assumed that the described initiative was a kind of a living laboratory where solutions for project-based learning and local partnership building were tested. It seems that further development of such initiatives will also contribute to the implementation of the broadly defined "common good". One step forward, and such an approach with cooperation and partnership involved, could have become significant social innovation that would provide intellectual support for social enterprises. Certainly, this would require more comprehensive framework and better understanding of social enterprises sector and its needs.

5 References

Arana-Arexolaleiba N, Zubizarreta MI (2017) PBL Experience in Engineering School of Mondragon University. In: Guerra A, Ulseth R, Kolmos A (eds) PBL in Engineering Education. Sense Publishers, Rotterdam, pp 89–102

Blumenfeld PC, Soloway E, Marx RW, et al (1991) Motivating Project-Based Learning: Sustaining the Doing, Supporting the Learning. Educ Psychol 26:369–398. https://doi.org/10.1080/00461520.1991.9653139

Delgado A, Ayala B (2019) PBL methodology and SME's participation as a proposal for a new teaching methodology. In: 2019 IEEE World Conference on Engineering Education (EDUNINE), Lima, Peru. pp 1–6

Hussadintorn Na Ayutthaya D, Koomsap P (2017) ASSESSMENT OF STUDENT LEARNING EXPERIENCE WITH ' LOVE .' In: Proceedings of INTED2017 Conference 6th-8th March 2017, Valencia, Spain. pp 1973–1982

Lima RM, Andersson PH, Saalman E (2017a) Active Learning in Engineering Education: a (re)introduction. Eur J Eng Educ 42:1–4. https://doi.org/10.1080/03043797.2016.1254161

Lima RM, Dinis-Carvalho J, Sousa RM, et al (2017b) Ten Years of Project-Based Learning (PBL) in Industrial Engineering and Management at the University of Minho. In: Guerra A, Ulseth R, Kolmos A (eds) PBL in Engineering Education. SensePublishers, Rotterdam, pp 33–51

Mesquita D, Lima RM, Flores MA, et al (2015) Industrial Engineering and Management Curriculum Profile: Developing a Framework of Competences. Int J Ind Eng Manag 6:121–131

Mohd-Yusof K, Hassan SAHS, Jamaludin MZ, Harun NF (2011) Cooperative problem-based learning (CPBL): A practical PBL model for engineering courses. In: Global engineering education conference (EDUCON), 2011 IEEE. IEEE, pp 366–373

Perrenet JC, Bouhuijs PAJ, Smits JGMM (2000) The suitability of problem-based learning for engineering education: theory and practice. Teach High Educ 5:345–358

Reis ACB, Mariano AM, Silva JM, et al (2019) Proposal of a collaborative interaction in an engineering discipline with an active approach based on problems and projects. In: PAEE/ALE'19 Preparing Teachers and Students for Challenging Times in Engineering Education. pp 154–161

An OBE curriculum design for a Manufacturing Engineering program, from Thai traditional to outcome based education

Wanida Rattanamanee[1], Kunlapat Thongkaew[1], Supapan Chaiprapat[1], Suriya Jirasatitsin[1], Chukree Daesa[1] and Pichet Trakarnchaisiri[1]

[1] Department of Industrial Engineering, Prince of Songkla University, Songkhla, Thailand

Email: wanida.r@psu.ac.th, tkunlapat@eng.psu.ac.th, supapan.s@psu.ac.th, suriya.j@psu.ac.th, chukree.d@psu.ac.th, pichet.t@psu.ac.th

Abstract

Outcome based education (OBE) has been gaining popularity as an objective in a modern curriculum design. The outcomes imposed reveal what students are expected to accomplish by the end of the program of study. This paper aims to present a transformation of Thai traditional curriculum, a manufacturing engineering program, to be an OBE curriculum. The CDIO framework and requirements of the ABET accreditation system were applied in the design process. Work Integrated Learning approach was employed to provide opportunities for students to gain practical experiences from workplace for at least 1 year. Program Learning Outcomes (PLOs) were formulated out of a survey conducted with the program stakeholders, resulting in 10 PLOs. Knowledge, attitude and skills essential in achieving the PLOs were identified and translated into courses totalled up to 138 credits. All courses will be planned and operated systematically from content design through assessment. Active learning techniques are prioritized in conducting classes to promote student engagement with class activities. More involvement of stakeholders narrows down the gap previously existed between their needs and what the institution offered. With international accreditation in addition, graduates from this new curriculum now are given professional opportunities worldwide.

Keywords: OBE; CDIO; ABET; Curriculum design

1 Introduction

Over the last decade, many components of manufacturing systems have been rapidly changed due to the fourth industrial revolution. Advancement technologies, such as Internet of things, Cloud manufacturing and rapid prototyping empower customers to demand better responsiveness. As such, an emerging smart manufacturing system is designed to respond in real time to meet the ever-changing demands and conditions in the factory. Employees are also expected to be equipped with advanced skills, such as complex problem solving, critical thinking, creativity, judgment and decision making, etc. (WEF, 2016). Therefore, the graduated students who will be a manufacturing engineer should have their knowledge and competences to be ready for this new environment. However, the development of the students' competences will be not successful if the learning is improperly designed. Based on reviewing literature, most existing engineering curriculums have been designed principally based on a traditional curriculum model that stakeholder needs were not significantly considered to design a curriculum (Dym et al. 2005). In addition, teaching and learning subjects were developed depending on lecturers' knowledge or what they would like to teach. For example, a traditional manufacturing engineering curriculum in Thailand (PSU, 2016), four years study with approximately 146 academic credits was designed, and more than three quarters of developed subjects are based on theory, not practical subjects. With the study plan, the sequences of teaching subjects was not well organized in the connection between fundamental and advanced knowledge, leading to lack of continuous learning. At the fourth year students have their internships or do their cooperative education projects with industries in a short time period about one semester. This might not encourage students to gain deep experience.

Several selected papers related to curriculum development were reviewed in this research work (Mesquita et al. 2015; Mesquita et al. 2018; Lima et al. 2017). There were three challenges faced by university curriculum development in higher education. The first one was the relationship between teacher planning and pedagogical action, content selection processes and teaching strategies. The second one was the development of the students' competences. The last challenge was the emphasis on assessment as one of the key enhancers of curriculum innovation (Mesquita et al. 2018). In order to success these challenge, there are several techniques to develop curricula such as, Project-Based Learning (PBL) (Lima et al. 2017) and Outcome-Based Education (OBE) (Youhasan et al., 2019). The PBL had been used to develop the competency of students while working in industries by Lima et al. (2017) for Industrial Engineering and Management (IEM) curriculum. The framework of competences was developed through a process of analysis using a combination of methods and sources for data collection. There were four main steps including; characterization of knowledge areas, definition of competences, survey and application of the framework at the curriculum. The OBE also has vital in curriculum development. Youhasan et al. (2019) employed this principle for MBBS program (medical graduation in Eastern University, Sri Lanka. They found that the OBE curriculum had specific features and met the current trends and needs of medical education locally as well as internationally.

According the reviewing literature, therefore, this paper aim to developed a manufacturing engineer curriculum from traditional to outcome-based education (OBE) in order to produce graduated students having knowledge and skills to solve the real problems, and having good relationship among people in the systems. The OBE has been proved to an effective education principle to design curriculums as it is focused learning outcomes or graduated students competencies that are the most importance for designing curriculums (Ayyappan et al. 2019). CDIO framework ABET accreditation system were also applied in the design process. Finally, Work Integrated Learning (WIL) approach was employed to provide opportunities for students to gain practical experiences from industries. With the developed curriculum techniques, students will be taught systematically following to the program learning outcomes that enhance the student to have their better competences and stronger experience rather than the traditional curriculum concept.

2 Conceptual Background

2.1 OBE approach

OBE methods have been adopted in education systems around the world, at multiple levels (Eldeeb and NishaShatakumari, 2013). OBE can primarily be distinguished from traditional education method by the way it incorporates three elements: theory of education, a systematic structure for education, and a specific approach to instructional practice (Killen, 2007). OBE approach aims to obtain a well-designed educational system that offers a clear outcomes for all students to be able to accomplish by the end of their learning experience (Ayyappan et al. 2019). According to this purpose, students will understand what is expected of them and teachers will also know what they need to teach. The implementation of OBE requires consistency across desired outcomes of education, teaching and learning activities, and assessment methods and practices (Spady, 1994). The desired outcomes should be based on skills, such as life, professional and vocational, intellectual, interpersonal and personal, that students will perform in the real world. The operating principle of program design based on OBE is a downward direction from the culminating outcomes of program level to the course outcomes that are measured by specific learning tasks. In addition, the outcomes of course and program levels should be fundamentally linked to the culminating outcomes of education. Hence, in this study, OBE approach emphasizes on the utilization of CDIO framework, ABET accreditation system and work Integrated Learning approach in order to achieve OBE curriculum design for a Manufacturing Engineering program. The concepts of CDIO framework, ABET accreditation system and work Integrated Learning approach are discussed in the following topics.

2.2 CDIO framework

CDIO framework is an innovative educational framework for producing the 21th engineers that have been adopted in many universities (Pee and Leong, 2006; Lee et al., 2015). The framework provides students with an education stressing engineering fundamentals set in the context of Conceiving — Designing — Implementing — Operating (CDIO) real-world systems and products (Crawley, 2001). CDIO's emphasis on active learning encourages students to take more active roles in their own learning. The development of program is considered based on the mapping of four expectations; technical, personal, inter-personal and CDIO. A mature individual interested in technical attempts dominates a set of personal and professional skills. In order to develop complex value-added engineering systems, students must have mastered the fundamentals of the appropriate technical knowledge and reasoning. On the other hand, the interpersonal skills of teamwork and communications develop students for working in a modern team-based environment. Finally, in order to actually be able to create and operate products and systems, a student must understand something of conceiving, designing, Implementing, and operating systems (Crawley, 2001). In order to evaluate the developed program, CDIO also conducts 12 standards (Lee et al., 2015); CDIO as the context, CDIO syllabus outcomes, integrated curriculum, introduction to engineering, design build experiences, CDIO workspaces, integrated learning experiences, active learning, enhancement of staff CDIO skills, enhancement of staff teaching skills, CDIO skills assessment and CDIO program evaluation. The standards are divided into six standard groups, that is standards for curriculum, workspace/labs, teaching and learning methods, enhance of faculty competence, and assessment methods. Some educational criteria and approaches, such as ABET accreditation, STEEP analysis and knowledge taxonomies are usually applied with CDIO framework to develop engineering curriculums (Crawley, 2011). STEEP analysis is a popular framework applied to explore future trends and their implications through five categories: social & demographic, technology, economic, environment & nature, political & legal (Lee et al., 2018)

2.3 ABET accreditation system

ABET accreditation provides assurance that a university program meets the international quality standards of the profession in area of engineering, which worldwide universities has been applied (Bachnak et al., 2019). This is because students can graduate with a unique array of personal, interpersonal, and system-building experiences that allows them to stand out in real engineering teams, and produce new products and systems. According ABET accreditation system; all approved programs must achieve all of the eight criteria for Baccalaureate Level Programs. The criteria include student criterion, program educational objectives criterion, student outcomes criterion, continuous improvement criterion, curriculum criterion, faculty criterion, facilities criterion and institutional support criterion (ABET, 2017). For the fifth criterion of curriculum, the curriculum requirements specify subject areas appropriate to engineering. In addition, the program curriculum must devote adequate attention and time to each component, consistent with the outcomes and objectives of the program and institution. The professional component must include a combination of college level mathematics and basic sciences appropriate to the discipline, engineering topics both in engineering sciences and engineering design appropriate to the student's field of study. Finally, a general education component that enhances the technical content of the curriculum related with the program and institution objectives has to take into account. With the application of ABET accreditation for manufacturing engineering programs (ABET, 2017), the program should prepare graduates to have proficiency in five main areas; materials and manufacturing processes; process, assembly and product engineering; manufacturing competitiveness; manufacturing systems design and manufacturing laboratory or facility experience. As the result of this, students are prepared for manufacturing engineering practice to meet engineering standards and multiple realistic constraints.

2.4 Work Integrated Learning approach

Work Integrated Learning (WIL) is the term given to an activity or program that integrates academic learning with its application in the workplace. The practice may be real or simulated and can occur in the workplace, at university, online, face-to-face or any combination of these. WIL involves developing students' work readiness skills to industry standards and enhancing employability. Many universities have been included WIL in engineering programs (Edwards et al. 2015; Monash University, 2018). With WIL concept, students can contribute vibrant and diverse perspectives, knowledge, analytical and research skills. They can also explore solutions to real-world problems, exercise critical thinking and professional judgement and show technical skill in designing, conducting and reporting on a research project. These lead students to be flexible, talented, capable, enthusiastic, experienced for working. However, the achievement of WIL application is largely relying on individual students to find placements, which a more integrated approach is required to provide good quality work experience for university students (AWPA, 2014). Nevertheless, WIL can provide a potential source of inspiration in finding workplace models that are applicable beyond engineering and it might create pathways into sustainable employment for graduates (Stiwne and Jungert, 2010).

3 The Existing Curriculum

Usually for a traditional manufacturing engineering curriculum, the development of program learning outcomes (PLOs) has not systematically considered stakeholder expectations (Zou et al., 2012). In addition, the PLOs were not significantly related to course learning outcomes. There was also no assessment how competencies of students to the PLOs. Lecturers designed their own course objectives and focus on specifically course content. There was also no consideration the relationship among courses, and the course assessment methods were not clarified as such a rubric assessment that students can be scored equally (Chong and Romkey, 2012). In addition, students took courses with quite far different areas, leading to lose the concentration for the sequence subjects. Due to the limited time, students cannot also comprehend appropriately the concepts and develop their skills of a disciplinary area. According to these, students might clearly understand and gain knowledge and skills from the courses to achieve the PLOs. Figure 1 shows the current Manufacturing Engineering curriculum, Prince of Songkla University (PSU, 2016).

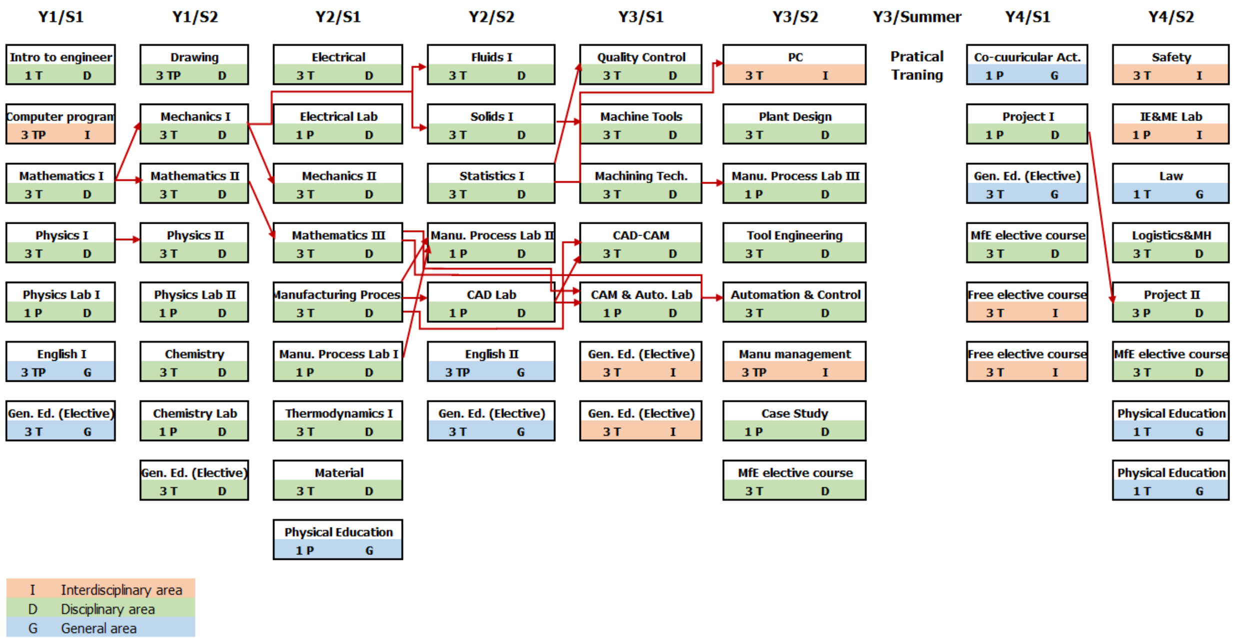


Figure 1 The current teaching and learning plan of Manufacturing Engineering program **(**PSU, 2016**).**

From the curriculum, there are 146 credits for four years study, where each semesters is dedicated on average of 21 credits. In the first year, most basic science knowledge for engineer is planned to study and most courses are in the disciplinary area. Most specific knowledge for engineer is included in study plan in the second year, while most specific knowledge for manufacturing engineer is contained in the third year. After third year, there are two study options, doing general project or doing cooperative project with industries. Practical training is registered for project option during the third year summer, another cooperative course is taken during the first semester for the fourth year. In this year, most courses are selective subjects, depending on students' interest subjects to fulfill their own knowledge. It can be seen that about 19 credits are determined for general area to improve general knowledge and skills, whereas approximately 23 credits are defined for interdisciplinary area to integrate specific knowledge and the other engineering field such as computer for engineering, free elective courses, etc. The left credits were specific knowledge for manufacturing engineering. Apart from that, the courses are in disciplinary area, in which specific knowledge subjects are determined in many groups, such as manufacturing process, manufacturing management and computer aided manufacturing. However, the sequence of teaching and learning courses is not properly design. The connection among courses for each knowledge group is also not considered seriously. This results in lack of understating in the relationship between courses and the concentration of the specific group subjects.

4 Implementation of OBE approach

4.1 Manufacturing Engineering program

With OBE proposed approach, the Manufacturing Engineering program was designed following the CDIO framework, ABET accreditation system and Work Integrated Learning approach. First of all, stakeholders having power to the program were listed and grouped into levels of their power to the program and the impact from the program to them, as shown in Table 1. The stakeholders in the group of high power and high impact are the first priority to consider their needs, following by high power and low impact, low power and high impact, and low power and low impact, respectively. In addition, more involvement of stakeholders able to narrows down the gap previously existed between their needs and what the institution offered will be considered. Furthermore, STEEP analysis was applied to analyse the stakeholders' needs in terms of social, technological, economical, environmental, and political to design the curriculum PLOs. With STTEP analysis, the stakeholders' needs were summarized in each areas as for economical area, the knowledge and technologies for manufacturing sectors should be developed by focusing on innovation for basic and new industries in Thailand, support of researches for AI and collaborative technologies and preparation of human ability and infrastructures. For social area, the support of aging society, the reduction of labor force and migration from rural to urban areas are required. For technological area, world trend technologies, such as artificial intelligence (AI), robotics, machine learning, internet of thing (IOT) and smart city to transform to Industrial 4.0 should be focused. For environmental area, green energy, alternative energy, recycled materials and climate change/low carbon society are major concerns. The regulations relating to environment and terrorism are the issues for political area. Finally, the developed PLOs was evaluated by ABET accreditation system to meet an international education standard. With the international accreditation, graduates from this new developed curriculum are now given professional opportunities worldwide. The program learning outcomes (PLOs) were formulated out of a survey conducted by the program stakeholders, resulting in 10 PLOs for Manufacturing Engineering program, as shown in Table 2. The relationship between the PLOs and the ABET student's outcomes is presented in Table 3, while the relationship between the stakeholders' needs and the PLOs is shown in Table 4.

Table 1**.** Classification of power of stakeholders and impact on stakeholders

Power of stakeholders	**Impact on stakeholders**	
	High	**Low**
High	- Higher Education Commission - Industries - Thailand Council of Engineers - Prince of Songkla University - Engineering faculty	- Manufacturing engineering alumni - Industrial engineering department - Lectures
Low	- Students	- General public

It can be seen from Table 2 that the PLOs were defined into generic and specific skills with a balance proportion, where PLOs 1-5 are specific skill and PLOs 6-10 are generic skill. The PLOs of specific skills result students' competence of knowledge, while the PLOs of generic skills contribute the attitude and skill competencies. PLO4 focuses on the student's capability of digital technology which is the advanced skill of 21st century education. PLO5 is the ultimate objective of the program. Innovator is the main attribute of the program to achieve the Thailand 4.0 policy. PLO7 is the key student's attribute of Prince of Songkla University as the students demonstrate social contributions. Besides, 11 attitudes and skills are also specified for the program including; creative thinking (1st – 2nd year), implement thinking (2nd – 3rd year), innovative thinking (3rd – 4th year), system thinking (4th year), self directed (1st – 2nd year), intrinsic motivation (3rd – 4th year), adaptable (1st – 4th year), open minded (1st – 4th year), system integration (3rd – 4th year), teamwork collaboration (1st – 4th year) and digital fabrication (2nd – 4th year).

Table 2. Program learning outcomes of OBE Manufacturing Engineering curriculum

Program Learning Outcomes (PLOs)	Generic Skill	Specific Skill
PLO1: An ability to identify, formulate and solve complex engineering problems of Thailand, the southern region in particular, by applying principles of engineering, science, and mathematics		✓
PLO2: An ability to apply modern engineering principles to develop innovations in collaboration with other disciplines		✓
PLO3: An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgement to draw conclusion		✓
PLO4 An ability to exploit digital technologies to design, test, inspect, control and manage manufacturing systems		✓
PLO5 An ability to design manufacturing engineering innovations that can be commercialized or eligible for patenting		✓
PLO6 An ability to acquire new knowledge to empower lifelong self-development	✓	
PLO7 An ability to demonstrate empathy, social contribution and prioritization on benefit of mankind	✓	
PLO8 An ability to recognize ethical and professional responsibilities in manufacturing engineering situations	✓	
PLO9 An ability to communicate using different modes of delivery such as writing reports, oral presenting, and elaborating effectively and understandably for international audiences	✓	
PLO10 An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	✓	

Table 3. the relationship between the new PLOs and the ABET student's

ABET students' outcomes	PLOs									
	1	2	3	4	5	6	7	8	9	10
1. an ability to apply knowledge of mathematics, science and engineering	✓									
2. an ability to design and conduct experiments, as well as to analyse and interpret data		✓								
3. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability									✓	
4. an ability to function on multidisciplinary teams								✓		
5. an ability to identify, formulate, and solve engineering problems										✓
6. an understanding of professional and ethical responsibility			✓							
7. an ability to communicate effectively						✓				

Table 4. The relationship between the stakeholders' needs and the new PLOs

Stakeholders	Needs	PLOs									
		1	2	3	4	5	6	7	8	9	10
Higher Education Commission	Have knowledge and ability in creating innovation; Have 21st century skills; Have a professional ethics of engineering	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Industries	Have knowledge about manufacturing process design; Have skills about lifelong learning. Have actually work and motivation; Able to work with people who have different ideas; Able to communicate by English; Able to do work improvement, targeting and planning, and computer programming	✓	✓	✓	✓	✓	✓		✓	✓	✓

Thailand Council of Engineers	Have engineering knowledge and basic sciences; Able to design and analyse engineering problems; Able to develop process and determine engineering answers; Able to be professional ethics in engineering and life-long leaning; Able to do environmental and social activities	✓	✓	✓	✓	✓	✓		✓	✓	✓
Prince of Songkla University (PSU)	Vision: PSU is the university of innovation and society with academic excellence and is the main mechanism for southern and country development and gear towards leading ASEAN universities by 2027	✓	✓			✓					
	Mission: Create graduates with academic and professional competencies with integrity, discipline, pursuing intellectual, mental and public skills in the 21st century and able to apply knowledge based on practical experience	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Identity: I-WiSE (Integrity, Wisdom, Social Engagement)						✓	✓	✓		
PSU Engineering Faculty	Vision: PSU engineering faculty is the nation's leading engineering faculty in producing engineers with potential and international innovation in order to develop southern region and country.	✓	✓			✓					
	Mission: To produce engineers with good attitude creative and have international knowledge and skills.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

The mapping between the new PLOs and the new course learning outcomes (CLOs) is shown in Table 5. The The development of teaching and learning plan and courses corresponding the PLOs is discussed in the next section.

Table 5. The mapping between the new PLOs and the new CLOs

Courses	**credits**	**Curriculum program learning outcomes (PLOs)**																											
		PLO1			PLO2		PLO3			PLO4				PLO5	PLO6		PLO7		PLO8		PLO9					PLO10			
		1.1	1.2	1.3	2.1	2.2	3.1	3.2	3.3	4.1	4.2	4.3	4.4		6.1	6.2	7.1	7.2	8.1	8.2	9.1	9.2	9.3	9.4	9.5	10.1	10.2	10.3	10.4
200-112 Fundamental Mathematics for Engineer	3((3)-0-6)			●	●	●										○			○										
200-113 Fundamental Physics for Engineer	3((3)-0-6)			●	●	●										○			○										
200-114 Fundamental Chemistry for Engineer	2((2)-0-4)			●	●	●										○			○										
226-102 Mathematics for Computer Aided Design	3((3)-0-6)			●	●	●				○						○			○	○									
226-104 Fundamental Chemistry Laboratory	1(0-3-0)			●	●	●	●	●	●							○			○		●			○			○		
226-202 Mathematics for Control Systems and Engineering Analysis	3((3)-0-6)			●	●	●				○	○	○				○			●	●						●	●	●	●
200-111 Into Engineering World	2((2)-0-4)			●															●	●						●	●	●	●
200-116 Basic Engineering Programming	3((2)-2-5)			●						●	○	○	○						○	○									
200-117 Basic Engineering Drawing	2((2)-0-4)			●	●					●									○										

4.2 Teaching and Learning Plan

Differently from the traditional program, the OBE manufacturing engineering program is the backward design from PLOs to course structure and study plan. Proper selecting knowledge, attitude and skills are essential to translate the PLOs into teaching and learning courses totalled up to 138 credits. From the developed program, the 138 credits were divided into 30 credits for general education, 102 credits for specific area and 6 credits for selective subjects. For the specific area, the subjects were grouped in three main parts; basic science, basic engineering and professional area. Teaching and learning methods were defined in four years with eight semesters (Table 6), and all the courses were developed corresponding to different categories; general, interdisciplinary and disciplinary areas, as illustrated in Figure 2.

Table 6. Teaching and learning plan of OBE Manufacturing Engineering program

Year	Teaching and learning plan		
	Semester 1	**Semester2**	**Summer**
1	- General Education subjects (2 credits) - Fundamental Engineering (18 credits)	- General Education subjects (7 credits) - Fundamental Manufacturing Engineering (14 credits)	-
2	- General Education subjects (4 credits) - Fundamental Manufacturing Engineering + Industrial PrBL (17 credits)	- General Education subjects (6 credits) - Fundamental Manufacturing - Engineering + Industrial PrBL (15 credits)	-
3	- General Education subjects (3 credits) - Specific Manufacturing Engineering + Thin Sandwich (18 credits)	- General Education subjects (7 credits) - Elective subjects (6 credits) - Specific Manufacturing Engineering + Thin Sandwich (7 credits)	Practicum WBL
4	Plan A - Thick Sandwich + Industrial PrBL (7 credits) Plan B - Cooperative Education (7 credits)	Plan A - Thick Sandwich + Industrial PrBL (7 credits) Plan B - Cooperative Education (7 credits)	

Note Industrial PrBL: Industrial Project-based Learning, Practicum WBL: Practicum Work-based Learning, Thin Sandwich: Study mostly in University and sometimes in industry, Thick Sandwich: Study half in University and half in industry

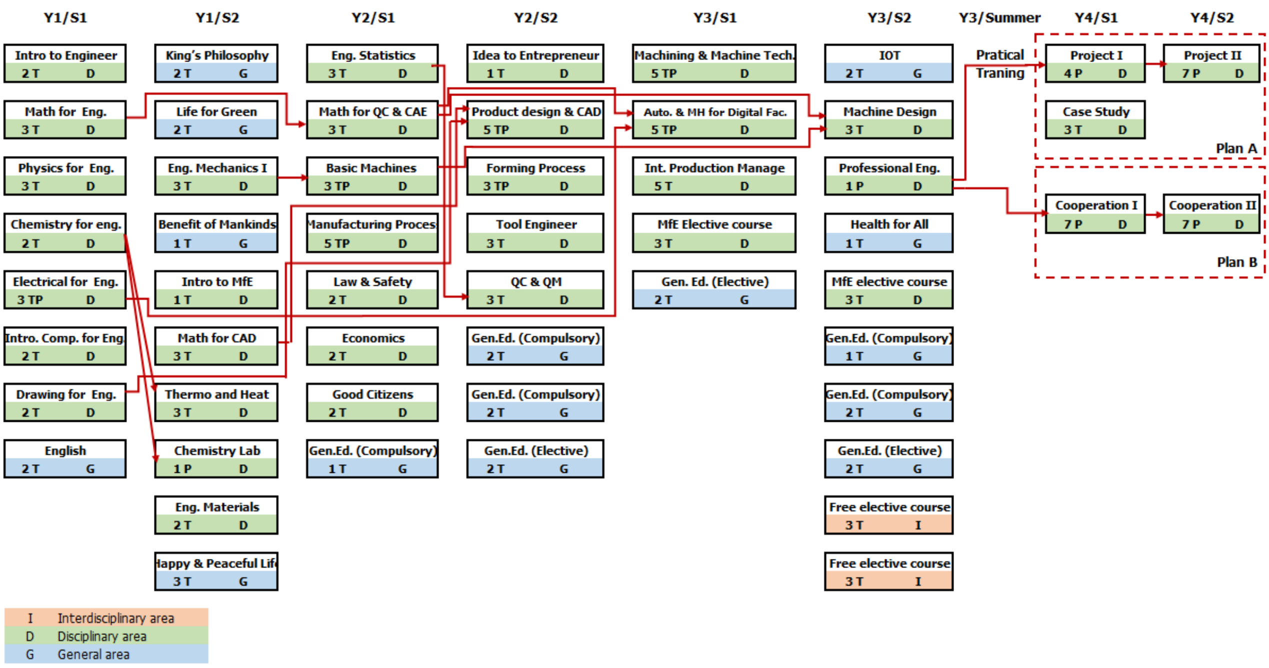


Figure 2. Teaching and learning courses of OBE Manufacturing Engineering Program

It can be noticed that general education and fundamental engineering subjects are determined in first year, whereas specific subjects of Manufacturing Engineering are defined in third year. This leads students to have fundamental knowledge before learning advanced subjects. The involvement with industries was applied from the second year by industrial project-based learning and work integrated learning (i.e. thin sandwich and thick sandwich activities). The final fourth year, students can select their preferred plan, where Plan A is thick Sandwich + Industrial PrBL and Plan B is Cooperative Education. The difference between these two plans is that students will study half in University and half in industry for Plan A, while students will have a role as employee in industries for Plan B. From this design, one year WIL are implement to encourage students gaining more practical experience. From Figure 2, the sequence of teaching and learning courses and the relationship between courses were considered in order to strengthen students' knowledge background before start learning specific/advanced subjects. For example, in order to achieve in learning the specific course of Machine Design, students need to pass fundamental courses of Math for QC and CAE, and Basic Machines. Course modules are also developed to combine related courses into one module. This can eliminate the problem of teaching the same subtopics and students can get better understanding and gain deeper knowledge. For instance, the course module of Manufacturing Process was developed to replace the courses of Manufacturing Process I, II and Manufacturing Process Laboratory I, II. All courses are planned and operated systematically from content design through assessment. Active learning techniques are prioritized in conducting classes to promote student engagement with class activities.

5 Conclusion

This paper presents the OBE curriculum design for a Manufacturing Engineering program, from Thai traditional to outcome based education. CDIO framework, ABET accreditation system and WIL concept have also been employed to conduct the OBE Manufacturing Engineering curriculum. It is apparent that 10 PLOs were developed based on the expectations of stakeholders. STEEP analysis was also applied to consider in dimensions of social, technological, economical, environmental, and political. Knowledge, attitude and skills essential in achieving the PLOs were identified and translated into courses totalled up to 138 credits. All courses were classified in to general, interdisciplinary and disciplinary areas and operated systematically as the teaching-learning sequence and the relationship between courses were taken into account. Course modules were also designed to replace related courses. With the international ABET accreditation, the developed graduates from this developed curriculum now are given professional opportunities worldwide. WIL approach was employed to design teaching-learning plan, in which students have opportunities to gain practical experiences from industries from the 3rd year study. However, the OBE manufacturing engineering curriculum has not employed for teaching students yet. This curriculum should be further analysed and developed with stakeholders' feedbacks, such as higher education commission, students and industries to achieve in expected learning outcomes of the curriculum and meet their needs.

6 References

ABET. (2017). 2018-2019 Criteria for Accrediting Engineering Programs, Retieved 20 June 2020 from https://www.abet.org/wp-content/uploads/2018/02/E001-18-19-EAC-Criteria-11-29-17.pdf

AWPA. (2014). Engineering Workforce Study. Retrieved 20 June 2020 from http://www.awpa.gov.au/publications/Documents/Engineering%20Workforce%20Study%20-%20June%202014.pdf

Ayyappan, P., Parthasarathy, R., Rajamanickam, L. and Vijayan, P. (2019). An Efficient Curriculum Design for Engineering Programs Using Outcome Based Education (OBE) Approaches, International Journal of Innovative Science, Engineering & Technology, Vol. 6(4), April 2019, pp. 81-94

Bachnak, R., Marikunte, SS., Abu-Ayyad M. and Shafaye AB. (2019). Fundamentals of ABET Accreditation with the Newly Approved Changes, 126th annual conference and exposition, American Society for Engineering Education (ASEE), June 2019

Chong, A. and Romkey, L. (2012). Evolving a Rubric for Use in Assessing Engineering Graduate Attributes in a Student Senior Research Thesis, American Society for Engineering Education, Retieved 20 June 2020 from https://pdfs.semanticscholar.org/183c/657429a078510cf87e1bcbb927b4deafce21.pdf

Crawley, E.F. (2001). The CDIO Syllabus A Statement of Goals for Undergraduate Engineering Education, CDIO organization Retieved 20 June 2020 from http://www.cdio.org/files/CDIO_Syllabus_Report.pdf

Crawley, E.F., Malmqvist, J., Lucas, W.A. and Brodeur, D.R. (2011). The CDIO Syllabus v2.0, An Updated Statement of Goals for Engineering Education, Proceedings of the 7th International CDIO Conference, , Copenhagen, June 20 – 23, 2011

Edwards D., Perkins K., Pearce J. and Hong, J. (2015). Work Integrated Learning in STEM in Australian Universities, Australian Council for Educational Research, Retieved 20 June 2020 from https://research.acer.edu.au/cgi/viewcontent.cgi?article=1046&context=higher_education

Eldeeb, R. and Shatakumari, N. (2013). Outcome Based Education (OBE) - Trend Review, Journal of Research & Method in Education, Vol. 1(2), pp. 9-11

Killen, R. (2007). Teaching Strategies for Outcomes-based Education, Second Edition. Cape Town: Juta and Company Ltd. p. 48. ISBN 978-0-7021-7680-7.

Lee, L., Lee L.S., Sripakagorn, A., Kuptasthien, N., Tien, D.B., Saad N.H., Cheah, S.M. and Leong, H. (2015). Comparative Study on CDIO Implementation in Selected ASEAN, 11th International CDIO Conference, Chengdu, Sichuan, P.R. China, June 8-11, 2015 , pp. 1-15

Lee, C.H., Lee L. and Kuptasthien, N. (2018). Design Thinking for CDIO Curriculum Development, 14th International CDIO Conference, Kanazawa Institute of Technology, Kanazawa, Japan, June 28 – July 2, 2018, pp. 88-98

Lima R.M., Dinis-Carvalho, J., Sousa, R.M., Arezes, P. and Mesquita, D. (2017). Development of competences while solving real industrial interdisciplinary problems: a successful cooperation with industry, Production, Vol. 27 No. spe São Paulo, pp. 1-14.

Mesquita, D. Lima R.M., Flores, M.A., Marinho-Araujo, C. and Rabelo, M. (2015) Industrial Engineering and Management Curriculum Profile: Developing a Framework of Competences, International Journal of Industrial Engineering and Management (IJIEM), Vol. 6 No 3, pp. 121-131.

Mesquita, D., Flores, M.A., and Lima R.M. (2018). Desarrollo del currículo en la enseñanza superior: desafíos para la docencia universitaria (Curriculum development in higher education: challenges for university teaching), Revista Iberoamericana De Educación Superior, 9(25), 42-61. https://doi.org/10.22201/iisue.20072872e.2018.25.277

MONASH University (2018). MONASH Engineering Work Integrated Learning (WIL) Retrieved 20 June 2020 from https://www.monash.edu/__data/assets/pdf_file/0004/1695721/WIL-Engineering.pdf

Pee, S.H. and Leong, H. (2006). Reformulating Engineering Education at Singapore Polytechnic, 2nd International CDIO Conference Linkoping, Sweden 13 to 14 June 2006, pp. 1-11

PSU, Industrial Engineering Department (2016). Manufacturing Engineering Program, B.Eng degree, Prince of Songkla University. Retieved 20 June 2020 from https://www.ie.psu.ac.th/images/files/filecurriculum/2561/update/MfE2559-25_08_61-Final.pdf

Spady, W. (1994). Outcome-Based Education: Critical Issues and Answers. Arlington Virginia: American Association of School Administrators. Retrieved 20 June 2020 from https://files.eric.ed.gov/fulltext/ED380910.pdf

Stiwne, E.E. and Jungert, T. (2010) Engineering students' experiences of transition from study to work Journal of Education and Work, Vol. 23(5), pp. 417-437, DOI: 10.1080/13639080.2010.515967

WEF. (2016). The Future of Jobs: Employment, Skills and Workforce Strategy for Fourth Industrial Revolution. Retieved 20 June 2020, from Geneva, Switzerland : http://www3.weforum.org/docs/WEF_Fuuture_of_Jobs.pdf

Youhasan, P., Sivanjali, M. and Sathaananthan, T. (2019) Outcome Based Medical Curriculum: Features, Standards and Challenges, Bangladesh Journal of Medical Education, Vol. 10, Issue 1, pp. 34-38.

Zou, X.T., Ko, E., Li, C. and Zhou, C. (2012). The Systematic Development of Rubrics in Assessing Engineering Learning Outcomes, The 1st IEEE International Conference on Teaching, Assessment and Learning for Engineering, Hong Kong, China, 20-23 August 2012. pp. T1A-1 - T1A-5

NPS Better predict online classroom

Patittar Nakwong[1], Apiwat Muttamara[2], *Boonlum Soontorn[3]*

[1,3] Faculty of Science and Technology, Department of Applied Science, Phranakhon si Ayutthaya Rajabhat University, Ayutthaya 13000, Thailand
[2] Faculty of Engineering, Thammasat University, Khlong Luang, Pathum Thani 12120, Thailand

Email: Patittar.n@gmail.com

Abstract

By 2020, Thailand and other countries around the world have experienced severe COVID-19 in almost every corner of the world, China, Japan or even the United States. Was also greatly affected as a result of this impact on teaching and learning management for students, which was originally a Face-to-face system, the teaching model has been changed to be an online classroom system such as Google classroom Zoom meeting Hangout skype etc. In order to evaluate the online teaching and learning model in the Thai education system therefore created a satisfaction evaluation form of 89 students in bachelor degree with online teaching. By using the Net Promoter Score (NPS) business recommendation method. The student group like a customers, by dividing the group of respondents according to a score of 0 to 10. Student groups were satisfied with traditional teaching and suggesting methods. This group is in the form of Promoter, representing 13.6 percent. For the group of students who are not satisfied with the online teaching style and do not recommend further This group is in the form of Detractor, representing minus 6.7 percent and the assessment of satisfied for traditional teaching score 75 percent, which is considered a very satisfactory level.

Keywords: Active Learning; Engineering Education; Conference Information; Project Approaches.

1 Introduction

Since the beginning of 2020, Thailand and other countries around COVID-19 have changed the universities in Thailand to use online education. In this case, the objective is to assess the current trend of online teaching styles at the bachelor degree. By evaluating the learning of students which may cause some student not have computer, internet connection and more problems, etc. Assessment of online teaching in this critical situation, (Rompho, 2020) studied the evaluation in the form of Net Promoter Score (NPS) as well as customers doing small online for evaluating transactions using the Net Promoter method before you will receive one client survey request: levels 0 ߦ 10, where 0 = none and 10 = sure. Please rate your willingness. To recommend us to others (Nicholas & Kordupleski, 2018) assessments are important both in designing online courses and as a mechanism for learning quality assurance. In this article, the issues that assess online teaching and learning are considered. There are different incentives for evaluation and strategies for meeting these needs. The UK government has a broad impact on tertiary education. Part of this effect has increased the importance of evaluation.

However, the evaluation drive is not matched by support and training for workers who should perform these processes (Oliver, 2000)

Peters (1998) Identify many differences between distance learning and traditional education. These include: Teaching 'writing' is the opposite of teaching 'speaking'. Learning 'reading' focuses on 'listening' learning.

The results from the use of technical and electronic media, including three different teaching structures, were created, which are teaching styles.

The social status of distance students is very different in terms of the decisions of students at traditional universities. Specific conditions of institutions and institutions are necessary for the development of controls and evaluations.

The latest emerging trends in E-learning assessments are reviewed and explored to address the latest topics and participation in the age of distance education. Which has been rigorously examined in identifying and detailed research projects, frameworks and modern techniques for evaluating E-learning using methods such as Blockchain, Gamification, Process Mining and MOOC (Lara, Aljawarneh, & Pamplona, 2019)

The online teaching point of view that many systems use is especially important for closed online conversations, as is learning by letter. It can be seen that this is very useful for assessors. For effective teaching and learning during this critical time, the researchers used NPS evaluation methods. To assess student satisfaction in online learning The format of the question is short, concise and easy to understand. Makes it able to evaluate the teaching model effectively

The 'Teaching and Assessment Policy' The purpose of this policy is to ensure that every teaching and evaluation program passes, especially to at-risk sub-groups. There are 3 ways to evaluate teaching (Figure 1.) (Curriculum, Teaching and Assessment, 2020)

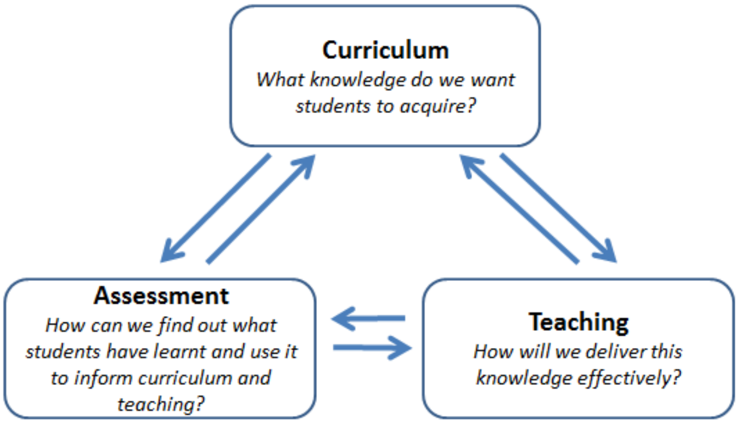


Figure 1. Curriculum, teaching and assessment linked. (Curriculum, Teaching and Assessment, 2020)

From Figure 1. Explain that the teaching and evaluation courses are inseparably linked It can be seen that when all three are in the same line, they are the most effective and highest quality learning effective for all students, regardless of the starting point. On the other hand, this should translate to all students to make good progress and achieve the best academic results. Because it gives them the best opportunity to learn.

This paper assesses the effective and problem of online learning. Based on study group satisfaction of bachelor degree 89 students and focus the requirements of the students for the effectiveness of online education

2 Net Promoter Score Definition

The first introduction by Fred Reichheld in his 2003 Harvard Business Review article is Net Promoter, which describes practices and reliability in determining customer satisfaction with company products or services (Reichheld, 2003).

Net Promoter Points are indexes from 0 to 10 that measure a customer's intentions in recommending a company's product or service to others, use it as a proxy to assess a customer's overall satisfaction with a company's product or service, and customer loyalty to the brand.

Net promoter scores are a measure of customer a loyalty that measures customers' the customer who scored 9-10 would be the promoter, 7-8 are a passively satisfied customer and 6 below would-be detractors.

For the NPS has been calculated by equation (1) (Enrollment Catalyst and Rick Newberry, 2020) and NPS guide for Figure 2.

Net Promoter Score (NPS) = % Promoters – % Detractors (1)

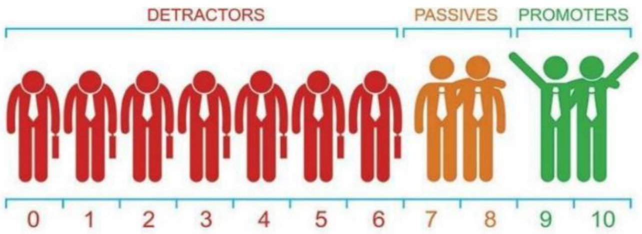


Figure 2. NPS guide. (Dinesh & Rajasekaran, 2018)

To test the connection between promoter scores and development, check the scores collected to drive organizations in many organizations. What they find is persuasion. Despite the ways in which the scores themselves migrate by most industry sponsors, net, pioneers of all things consider creating more than double the lead rate. (Dinesh & Rajasekaran, 2018)

3 Result and Discussion

In this study for our group was measuring by google form it is online assessment included 9 questions. As a results aspect of satisfaction for online learning the detailed of result shown in Table1. From the Figure 3. shows the results of the number of courses for students in 1 term. The results show the maximum of 7 subjects represent 25% and the minimum 1 subject is 4% of the total students.

Table 1. Number of courses studied in the semester

Number of course	Number of respondents
1	0
2	3
3	0
4	9
5	24
6	6
7	47

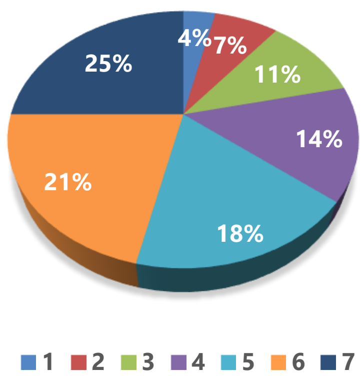


Figure 3. The result number of courses studied in the semester.

The table 2-3 as below shows the different parameters depending on which employees rated the company. The following statements are ranked on the scale 1-5 (where 1 is the least likely). This survey was conducted in Traditional education and online classrooms in which students from one department survey There are 89 students in total.

Table 2. Education structure of students group

Year	Number of respondents
1	27
2	18
3	33
4	11

Table 3. How satisfied are you with teaching in the classroom/ online class room?

Score	Class room (%)	Online classroom(%)
1	0	3.4
2	0	2.2
3	12.4	28.1
4	39.3	37.1
5	48.3	29.2

From Table 3, shown the results of satisfaction with online classroom teaching? It can be seen that most of the students are satisfied with the traditional learning with 48.3% and 29.2% of the online learning styles.

Table 4. Would you like to promote this teaching in the classroom/online course to your friends?

Score	Class room(%)	Online classroom (%)
10-9	45	31.4
8-7	23.6	30.4
6-0	31.4	38.1
NPS	13.6	-6.7

Table 4 is the comparison of the results of traditional learning/ online learning to your friends?. In order to find the NPS score from Table 4, it can be seen that promoters there are 9-10 scoring points, traditional learning accounting for 31.4% and 45% of online learning. And detractors of traditional learning is 31.4% and 38.1% online learning.

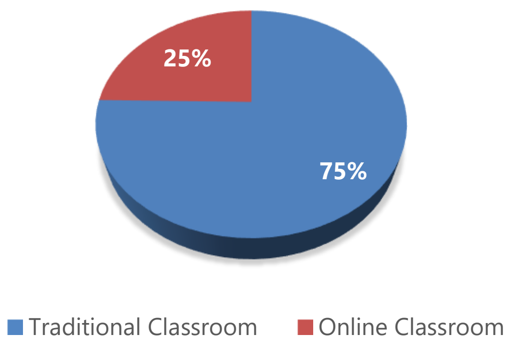


Figure 4. The result of type of teaching and learning does student want the most.

4 Conclusion

The calculation of NPS in term traditional learning is 13.6% and minus 6.7% of online learning. Finally the last one of question **"What type of teaching and learning do you want the most**?" the most of student like to study in classroom it was show that 75% (Figure 4.)

Our results indicate that traditional learning has a higher response rate. In addition, both methods have different results in terms of NPS scores for student satisfaction. Due to the general complaints of students about online lessons and the lack of teaching tools and equipment that affect students in traditional learning rather than online learning and how to improve online lessons in the future to reduce the number of teachers. Prospective studies with a larger sample size to assess the effectiveness of tools for assessing student satisfaction to be used as a way to improve online lessons in the future.

Acknowledgement

The author acknowledge support from the Faculty of Science and Technology, Department of Applied Science, major of Industrial management Engineer Phranakhon si Ayutthaya Rajabhat University.This publication is a partial outcome of project, Curriculum Development of Master's Degree Program in Industrial Engineering for Thailand Sustainable Smart Industry (MSIE4.0)" that has been funded with support from the European Commission (Project Number: 586137-EPP-1-2017-1-TH-EPPKA2-CBHE-JP). We are grateful to the Thammasat School of Engineering(TSE) for the support.

5 References

Curriculum, Teaching and Assessment. (2020, June 14). Retrieved from http://gg.gg/jmugf

Dinesh, N. & Rajasekaran, N. (2018). IMPACT OF EMPLOYEE NET PROMOTER SCORE IN ORGANISATIONAL GROWTH. *International Journal of Research and Analytical Reviews*.

Enrollment Catalyst and Rick Newberry. (2020, June 9). Retrieved from Enrollment Catalyst: http://gg.gg/jjibv

Lara, J. A., Aljawarneh, S., & Pamplona, S. (2019). Special issue on the current trends in E-learning Assessment. *Journal of Computing in Higher Education, 32*(1), 1-8. doi:10.1007/s12528-019-09235-w

Nicholas, I. F., & Kordupleski, R. E. (2018). What is Wrong with Net Promoter Score.

Oliver, M. (2000). Evaluating online teaching and learning. *Information Services & Use, 20*(2-3), 83-94. doi:10.3233/isu-2000-202-304

Peters, O. (1998). Learning and Teaching in Distance Education: Analyses andInterpretations from an International Perspective. *Education + Training, 41*(8), 384-386. doi:10.1108/et.1999.41.8.384.3

Rajasekaran, N., & Dinesh.N, a. (2018). HOW NET PROMOTER SCORE RELATES TO ORGANIZATIONAL GROWTH. *International Journal of Creative Research Thoughts 6*.

Reichheld, F. F. (2003). The one number you need to grow. Harvard business review, 81(12), 46-55.

Rompho, N. (2020, June 10). *Nopadol's Story*. Retrieved from http://gg.gg/jmafg.

Global PBL: Cross-cultural educational project for engineering students

Helena V. G. Navas[1], Hiroshi Hasegawa[2], Dai Watanabe[2], Anak Khantachawana[3], Anabela C. Alves[4]

[1]UNIDEMI, Department of Mechanical and Industrial Engineering (DEMI), NOVA School of Science and Technology (FCT NOVA), Universidade NOVA de Lisboa, 2829-516 Caparica, Portugal
[2]Department of Machinery & Control Systems, College of Systems Engineering and Science, Shibaura Institute of Technology, Fukasaku 307, Minuma-ku, Saitama-shi, Saitama 337-8570, Japan
[3]Department of Mechanical Engineering, Faculty of Engineering, King Mongkut's University of Technology Thonburi, 126 Pracha Uthit Rd, Bangmod, Thung Khru, Bangkok 10140 Thailand
[4]ALGORITMI R&D Center, Department of Production and Systems, School of Engineering, University of Minho (UMinho), 4800-058 Guimarães, Portugal

Email: hvgn@fct.unl.pt; h-hase@shibaura-it.ac.jp; dai-wata@shibaura-it.ac.jp; anak.kha@kmutt.ac.th; anabela@dps.uminho.pt

Abstract

Project-Based Learning (PBL) has been the active learning methodology used in a Cross-Cultural Engineering Project (CEP) that it is an educational project between Shibaura Institute of Technology (SIT) from Japan, NOVA School of Science and Technology (FCT NOVA), Universidade NOVA de Lisboa from Portugal and King Mongkut's University of Technology, Thonburi (KMUTT) from Thailand. This partnership occurred since July 2017, so three successful editions were achieved. The editions last nine days and were held in mid-July. The venue of the event was the Caparica Campus of the NOVA School of Science and Technology (FCT NOVA). The hard core of course participants are students from SIT (Japan), KMUTT (Thailand) and FCT NOVA (Portugal). Students from the Chulalongkorn University (Chula. Univ.) and Chiang Mai University (CMU) from Thailand and from University of Navarra of Spain had also participated in some editions of the event. More than 100 students, 20 teaching assistants and 10 teachers were involved on this global PBL on the three editions. The students were organized in interdisciplinary and international four or five teams of different graduate and undergraduate years, of different universities. Each team had to work in a contemporary problem related with Ecology, Energy, Eco-tourism, Community development among others. This paper presents the results of such experience, pointing out the benefits for the students and for the teachers. A discussion about the competencies acquired by the students is presented. Some challenges are also addressed.

Keywords: Engineering education, global PBL, cross-cultural experience, competencies, problem-solving skills.

1 Introduction

That we live in a global world could not be more true than today given the current pandemic situation. This epidemic started in a Chinese city and it spread in less than three months to the entire world, stopping it by the fear of this infectious. Since COVID-19 epidemic was declared as a pandemic at 11 of March 2020 (WHO, 2020), the efforts were united to face this pandemic and international multidisciplinary teams are working together to find a vaccine.

Nevertheless, the market globalization of goods, services and resources have been putting some challenges to the engineering education for a long time as reported by many authors and reports (Alves et al., 2013; ASME, 2012; Graham, 2012; King, 2012; Lucena et al., 2008; Matsumura & Tanabe, 2019; Melsa, 2007; National Academy of Engineering, 2005; UNESCO, 2010, 2015). Despite this fact, international engineering education systems and organizations continue working at different rhythms and under different curricular structures (Alves et al., 2013; Lucena et al., 2008). To know and discuss these differences it is important to bring engineering educators from different countries to work together in doing common research (Borrego & Bernhard, 2011; Lima et al., 2019; Mesquita et al., 2019) or promoting common educational cross-cultural projects.

One such educational project is the Cross-Cultural Engineering Project (CEP) that is based on Project-Based Learning (Kongwat et al., 2020; Navas, 2017, 2018; Yamashita & Hasegawa, 2020) and it is the focus of this paper. This project is undertaken by three universities from Portugal, Japan and Thailand. It provides a rich and meaningful experience for teachers and, most important, students. This paper discusses such benefits and challenges for teachers and students. Mainly it discusses what competencies students acquire when involved in such global PBL environment (gPBL).

Project-Based Learning (PBL) is, by their own nature and roots (Dewey, 1916; Kilpatrick, 1918), a suitable environment to promote key competencies referred by Council of the European Union (2018) as lifelong learning competencies. These are: 1) Literacy; 2) Multilingual; 3) Mathematical, science, technology and engineering; 4) Digital; 5) Personal, social and learning to learn; 6) Citizenship; 7) Entrepreneurship and; 8) Cultural awareness and expression (2018, p. 15). These contribute equally to a successful life in society, can be applied in many different contexts and in a variety of combinations and are supportive to each other, overlapping in some situations.

Competencies implies knowledge (facts and figures, concepts, ideas and theories which are already established and support the understanding of a certain area or subject); skills (ability and capacity to carry out processes and use the existing knowledge to achieve results) and attitudes (disposition and mind-sets to act or react to ideas, persons or situations) (Council of the European Union, 2018; Rychen & Salganik, 2000). These key competences embed critical thinking, problem solving, teamwork, communication and negotiation skills, analytical skills, creativity, and intercultural skills that are the most reported for the 21st century (Kang, 2019; The Economist, 2015; UNESCO, 2016; World Economic Forum, 2015).

Another important definition of competency is presented in Matsumura and Tanabe (2019) work. Competency is an action tendency and decision-making style derived from one´s experience that is related to the ability to bring out the best in oneself and others. It involves the ability to behave and act in a way that promotes mutual communication with others as a working adult in society. Three main skills support this competency definition: teamwork (relating and collaborating with others and team management); personal (self-control, self-confidence and behavior control) and problem-solving (problem identification, planning and implementing solutions). Matsumura and Tanabe (2019) discussed how education system in Japan has been assessing generic skills which they divide in two aspects: literacy (knowledge application ability) and competency (action/decision making tendency). These generic skills are assessed using the Progress Report on Generic Skills (PROG). PROG has been also used to measure the achievement of international PBL referred above, the CEP.

By developing an open-ended project in a PBL context, students collaborate in teams and organize themselves to pursuit project objectives concretized in deliverables. To achieve this, these teams manage resources, time and cost, accomplishing tasks and milestones and solving problems. By actively participating on these activities and they will acquire the competencies referred. PBL has been implemented in many universities around the world (Alves & Leão, 2015; Davies et al., 2011; Guerra et al., 2017; Jollands et al., 2012; Kokotsaki et al., 2016; Lima et al., 2017; Mills & Treagust, 2003; Pereira & Barreto, 2016; Powell & Weenk, 2003), from the engineering first years (Alves et al., 2019; Lima et al., 2007) to final years in projects with companies (Dinis-Carvalho et al., 2017; Lima et al., 2015). Nevertheless, cross-cultural PBL experiences as well as cultural dimension impact on PBL are more difficult to find (Mohd-yusof et al., 2013).

PBL is also an active learning methodology suitable to provide the needed competences to pursuit a Society 5.0 (Ferreira & Serpa, 2018; Keidanren, 2018; Komiyama & Yamada, 2018; Pereira et al., 2020). According to a publication in the World Economic Forum meeting *“People will be expected to exercise rich imaginations to identify a variety of needs and challenges scattered across society and the scenarios to solve them, as well as creativity to realize such solutions by using digital technologies and data. Society 5.0 will be an Imagination Society, where digital transformation combines with the creativity of diverse people to bring about "problem solving" and "value creation" that lead us to sustainable development. It is a concept that can contribute to the achievement of the Sustainable Development Goals (SDGs) adopted by the United Nations.”* (Nakanishi, 2019). This concept, originated from Japan, is a strategy to deal with the impact of an ageing population (Pereira et al., 2020).

This paper is divided in five sections. The first section presents a brief background on the themes of the research presented in this paper and the objectives. The second section presents the research methodology. Section three introduces the context and gPBL teams organization. The results are presented in the section four. Lastly, section fifth draws some concluding remarks.

2 Research methodology

The defined objectives for the paper are fulfilled by presenting the teams outcomes related with learning outcomes established for the gPBL. The key competences developed by the students are discussed at the light of the outcomes results and teachers observations and experience. For the study presented in this paper, it was used the skills embed in the key competences proposed by the Council Recommendation on Key Competences for Lifelong Learning (Council of the European Union, 2018), as referred in section 1.

It is important to notice that CEP sponsors have done previous researches and measurements of this gPBL using the PROG measurement system. Comparison of gPBL attendant and non-attendant Japanese students showed very positive results to the attendees, mainly, to their development of teamwork skills (relating with others and team management) and personal skills (self-control) (Matsumura & Tanabe, 2019).

3 Global PBL context and organization

Since July 2017, three editions of Global PBL have been held at NOVA School of Science and Technology (FCT NOVA), University NOVA of Lisbon. All editions were organized by Shibaura Institute of Technology (SIT) from Japan, FCT NOVA from Portugal and King Mongkut's University of Technology, Thonburi (KMUTT) from Thailand (Figure 1). The CEP is based on Global Project Based Learning through the problem solving experience (Navas, 2017).

Figure 1. Location of the three universities involved in the gPBL

3.1 Context

The venue of the event in the three editions discussed in this paper is the Caparica Campus of the NOVA School of Science and Technology (FCT NOVA), University NOVA of Lisbon. The hard core of course participants are students from SIT (Japan-JP), KMUTT (Thailand) and FCT NOVA (Portugal-PT). Students from the Chulalongkorn University (Chula. Univ.) of Thailand, from the Chiang Mai University (CMU) of Thailand (TH) and from University of Navarra of Spain (SP) have also participated in some editions of the event. The editions last nine days and are held in mid-July. The Table 1 presents the numbers for the three editions.

Table 1. Characterization of the three last editions

	Event days	No. students	Number of groups	Teaching assistants	Professors
2017	11-19 July	17	3	3 (PT, JP, TH)	4 (PT, JP, TH)
2018	10-18 July	28	5	7 (PT, JP, TH)	4 (PT, JP, TH)
2019	9-17 July	37	6	7 (PT, JP, TH)	5 (PT, JP, TH)

All activities are taught and directed by Professors and Teaching Assistants (TA). Professors act as an assumed investor to project. They make various kinds of comments and suggestions in the Design Review (DR). TAs advise the teams to coordinate with the local staff, to support the management of teams. Comments from various points of view among lecturers are allowed. Basic stance is to pay respect to students' ideas and opinions. The lecturers should not force the students to follow their comments (Navas, 2018).

It is expected that students learn in practice to work with the several methodologies such as Attractive Quality, Kano Model, Kando Quality, Quality Function Deployment (QFD), TRIZ, Lean A3, etc. At the end of the Cross-cultural Educational Project (CEP), students should be able to do:

- Goal setting
- Assessment planning
- Budget planning
- Schedule planning for activities

The CEP enables students:

- To acquire the synthetic problem solving capability to be internationally attractive
- To acquire concepts and technologies on "Systems thinking", "Systems Method (Engineering Method)", and "Systems Management (Project Management)"
- To acquire a capability of work as a member of an international and/or interdisciplinary team

The assessment components are:

1. Design review result
    - Teamwork
    - Personal
    - Problem-solving
2. Final Presentation result
    - Outcome assessment considering:
        - Work in multi-culture and interdisciplinary team
        - Leadership
        - System thinking and engineering

These assessments are measured using the PROG system scales. It is used an assessment grid where components 1 and 2 are ranked. The CEP staff team, normally, set-up awards to be assigned to the first three places.

3.2 PBL teams organization

All teams are composed five to six graduate students and undergraduate students. Each team is made up of the students from several countries and universities. Students have to communicate in English, even if they use freely various devices and services, such as electronic dictionaries, smartphones and the Internet. Teams were formed based on their nationalities and on the questionnaire for team forming, which was prepared by professors and TAs. The Figure 2 illustrates the practical process of the Global PBL.

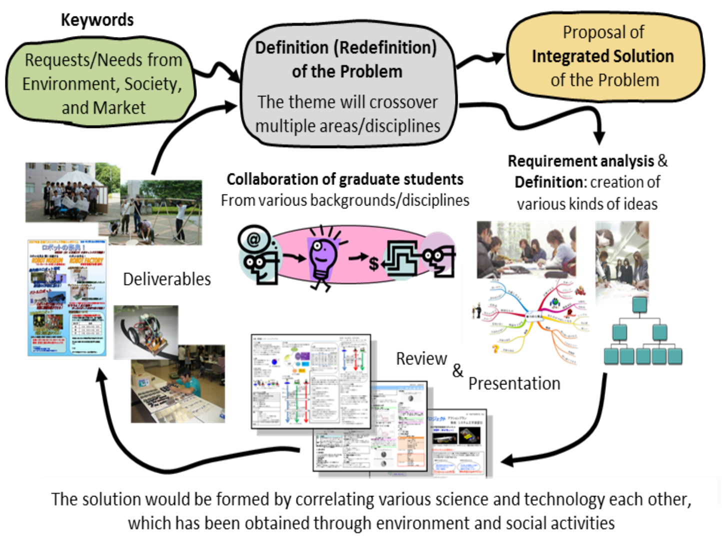


Figure 2 – Practical Process for Global PBL

In Global PBL, unexpected problems faced by people very frequently in the real world, will be induced by intention as an improvisation education (Navas, 2017; Yamashita & Hasegawa, 2020). This "Oh my God" experience should trigger the improvement of competency and it is detailed explained in Yamashita and Hasegawa (2020). Each team is requested to reconstruct the process of solving the problems by rescheduling. Improvisation education is performed to obtain creatively adaptation skill to unexpected changes in a project. All through the project, students are expected not only to make a plan but also make a design, implementation and a fieldwork about a pre-defined theme.

Some keywords are referred for setting the theme: Ecology, Energy, Eco-tourism, Community development, Service, Mobility, Welfare and medical system, Disaster prevention, Multi-language communication, User experience, Innovation, Education system, Global leadership, Unexamined Patent, Others (student's idea). As an examples, the last year the themes of the teams were: Wearable transportation IC system, Train safety; Fun time Fun Life, Ocean Waste Removal and Alternatives to air conditioning on cars.

The definition of the problem and its solution is made using various methods, thinking processes and systematic communication tools, such as Brainstorming, KJ Method, Mind map, etc.

4 Results

This section presents some results of competencies developed by gPBL attendees in the teachers opinion and experience. These are obtained by matching teams outcomes results (design review and final presentation) with the competencies definition provided in section 1 and some PROG results retrieved pre-, during and post gPBL (Matsumura & Tanabe, 2019). Additionally, these were supported by the observations and experience of the CEP staff coordination team. Table 2 presents such results through some evidences and examples.

Table 2. Characterization of the three editions

Competencies	Knowledge	Skills	Attitudes
Literacy	New methodologies	New technical and social skills	Greater confidence and security in knowledge
Multilingual	Improved knowledge of English	Understanding conversations and speaking skills in English.	Initiative to communicate with foreign partners

Mathematical, science, technology and engineering	Attractive Quality, Kano Model, Kando Quality, QFD, TRIZ, Lean A3, Idea Creation Support System; System Thinking and Engineering	Problem-solving, ideas generation, creativity, apply engineering methodologies to solve interdisciplinary problem	Proactivity, explore other tools, creativity
Digital	Be aware of new tools to communicate	Digital tools use (e.g. videos)	Initiative to use different tools, to share information
Personal, social and learning to learn	Plan a project and activities, plan, distribute individual and team tasks, establish a contact with a company, public presentation	Negotiate and solve conflicts, initiative to present a topic and answer to questions	Initiative to develop prototypes; communicate, how to act in public, friendship culture, backup by encouraging members when they are negative
Citizenship	Informal aspects of citizenship, consider and accept different values	Transmit country values	Feeling of national pride and wanting to transmit national values to foreign partners
Entrepreneurship	Manage a project with a company and collaborate in a multidisciplinary team	Build the products prototypes, mobilize resources; leadership	Stimulus and motivation to make the project, create a positive atmosphere for the team
Cultural awareness and expression	Culture from other countries, understand the differences and respect them	Work in multicultural teams and environments	Culture exchange, motivational change

If the knowledge could be best learned through traditional classes and this project could bring some novelties that will need to be practiced in the professional work, the skills and attitudes are mostly developed through projects and others active learning methodologies (Alves et al., 2018; Council of the European Union, 2018). Particularly, the skills and attitudes related to cultural issues are burst in this kind of project.

5 Conclusions

This paper discussed the competencies developed by students in gPBL environment to the light of the life-long learning key competences recommended by European Council. Some of these are coincident with generic skills assessed by PROG measurement system in Japan. Mainly, the teamwork, personal and problem-solving framed as competency for PROG system have been ranked with high scores. Nevertheless, more than these are obtained, as the examples and evidences presented in Table 2 revealed. The challenges to work in a different country in a multidisciplinary team could be "simulated" in this gPBL bringing many benefits, being the main one the preparation of better professionals capable to work in a global work market. Even for the teachers this is a challenge, that when surpassed becomes a great benefit. Nevertheless, it is of general opinion that the difficulties were more related to the theme selection than with cultural issues. The awareness of the "different" cultures gave to the students an openness mind-set, which contribute to the best fit integration and help each other understanding. It would be important as future work to deepen these, probably, by doing a questionnaire or using a PROG similar measurement system to assess the students competencies that attended to this gPBL.

Acknowledgments

The FCT NOVA's author acknowledges Fundação para a Ciência e a Tecnologia (FCT - MCTES) for its financial support via the project UIDB/00667/2020 (UNIDEMI).

The SIT's authors gratefully acknowledge the JSPS KAKENHI. This work was supported by JSPS KAKENHI Grant Number 19H01739.

The UMinho author acknowledges Fundação para a Ciência e Tecnologia within the R&D Units Project Scope: UIDB/00319/2020.

6 References

Alves, A.C., Kahlen, F.-J., Flumerfelt, S., & Manalang, A. B. S. (2013). Comparing engineering education systems among USA, EU, Philippines and South Africa. *ASME International Mechanical Engineering Congress and Exposition, Proceedings (IMECE)*, *5*. https://doi.org/10.1115/IMECE2013-63254

Alves, Anabela C., & Leão, C. P. (2015). Action, Practice and Research in Project Based Learning in an Industrial Engineering and Management Program. *ASME 2015 International Mechanical Engineering Congress and Exposition, Volume 5: Education and Globalization*, V005T05A013. https://doi.org/10.1115/IMECE2015-51438

Alves, Anabela C., Leão, C. P., Moreira, F., & Teixeira, S. (2018). Project-Based Learning and its Effects on Freshmen Social Skills in an Engineering Program. In *Human Capital and Competences in Project Management*. InTech. https://doi.org/10.5772/intechopen.72054

Alves, Anabela Carvalho, Moreira, F., Carvalho, M. A., Oliveira, S., Malheiro, M. T., Brito, I., Leão, C. P., & Teixeira, S. (2019). Integrating Science, Technology, Engineering and Mathematics contents through PBL in an Industrial Engineering and Management first year program. *Production*, *29*(x), 0–0. https://doi.org/10.1590/0103-6513.20180111

ASME. (2012). *Vision2030: Creating the Future of Mechanical Engineering Education*. *September 2012*. http://files.asme.org/asmeorg/Governance/StrategicManagement/IAB/23752.pdf

Borrego, M., & Bernhard, J. (2011). The Emergence of Engineering Education Research as an Internationally Connected Field of Inquiry. *Journal of Engineering Education*, *100*(1), 14–47. https://doi.org/10.1002/j.2168-9830.2011.tb00003.x

Council of the European Union. (2018). *Proposal for a Council Recommendation on Key Competences for Lifelong Learning*.

Davies, J., e Graaff, E., & Kolmos, A. (2011). *PBL across the disciplines: Research Into Best Practice*. Aalborg Universitetsforlag.

Dewey, J. (1916). *Democracy and Education. An introduction to the philosophy of education*. Free Press.

Dinis-Carvalho, J., Fernandes, S., Lima, R. M., Mesquita, D., & Costa-Lobo, C. (2017). Active Learning in Higher Education: developing projects in partnership with industry. *Proceedings of INTED2017 Conference*, 1695–1704.

Ferreira, C. M., & Serpa, S. (2018). Society 5.0 and Social Development: Contributions to a Discussion. *Management and Organizational Studies*, *5*(4), 26. https://doi.org/10.5430/mos.v5n4p26

Graham, R. (2012). Achieving excellence in engineering education: the ingredients of successful change. In *The Royal Academy of Engineering* (Vol. 101, Issue March). http://epc.ac.uk/wp-content/uploads/2012/08/Ruth-Graham.pdf

Guerra, A., Ulseth, R., & Kolmos, A. (2017). *PBL in Engineering Education* (A. Guerra, R. Ulseth, & A. Kolmos (eds.)). SensePublishers. https://doi.org/10.1007/978-94-6300-905-8

Jollands, M., Jolly, L., & Molyneaux, T. (2012). Project-based learning as a contributing factor to graduates' work readiness. *European Journal of Engineering Education*, *37*(2), 143–154. https://doi.org/10.1080/03043797.2012.665848

Kang, S. Y. (2019). *To build the workforce of the future, we need to revolutionize how we learn*. World Economic Forum. https://www.weforum.org/agenda/2019/09/to-build-the-workforce-of-the-future-we-need-to-revolutionize-how-we-learn-wecome-to-digital-learning-2-0/

Keidanren. (2018). *Society 5.0: co-creating the future*. www.keidanren.or.jp/en/policy/2018/095_outline.pdf

Kilpatrick, W. H. (1918). The project method. *Teachers College Record*, *19*(4), 319–335.

King, C. J. (2012). Restructuring Engineering Education: Why, How And When? *Journal of Engineering Education*, *101*(1), 1–5. https://doi.org/10.1002/j.2168-9830.2012.tb00038.x

Kokotsaki, D., Menzies, V., & Wiggins, A. (2016). Project-based learning: A review of the literature. *Improving Schools*, *19*(3), 267–277. https://doi.org/10.1177/1365480216659733

Komiyama, H., & Yamada, K. (2018). *New Vision 2050*. Springer Japan. https://doi.org/10.1007/978-4-431-56623-6

Kongwat, S., Watanabe, D., Mochizuki, K., Koike, R., Navas, H., & Hasegawa, H. (2020). Finding Attractive Solutions based on Idea Creation Support System for Cross-cultural Engineering Project. *2020 JSEE (Japanese Society for Engineering Education) Annual Conference International Session*.

Lima, R. M., Mesquita, D., Dinis-Carvalho, J., & Sousa, R. M. (2015). Promoting the Interaction with the Industry through Project-Based Learning. *Seventh International Symposium on Project Approaches in Engineering Education*.

Lima, Rui M., Dinis-Carvalho, J., Sousa, R. M., Alves, A. C., Moreira, F., Fernandes, S., & Mesquita, D. (2017). Ten Years of Project-Based Learning (PBL) in Industrial Engineering and Management at the University of Minho. In A. Guerra, R. Ulseth, & A. Kolmos (Eds.), *PBL in Engineering Education* (pp. 33–51). SensePublishers. https://doi.org/10.1007/978-94-6300-905-8_3

Lima, Rui M., Mesquita, D., Sousa, R. M., Monteiro, M. T. T., & Cunha, J. (2019). Curriculum Analysis Process: analysing fourteen Industrial Engineering programs. *PAEE/ALE2019*, 92–101.

Lima, Rui M, Carvalho, D., Flores, A., & Van Hattum-Janssen, N. (2007). A case study on project led education in engineering: students and teachers perceptions. *European Journal of Engineering Education*, *32*(3), 337–347. https://doi.org/10.1080/03043790701278599

Lucena, J., Downey, G., Jesiek, B., & Elber, S. (2008). Competencies Beyond Countries: The Re-Organization of Engineering Education in the United States, Europe, and Latin America. *Journal of Engineering Education*, *97*(4), 433–447. https://doi.org/10.1002/j.2168-9830.2008.tb00991.x

Matsumura, N., & Tanabe, A. (2019). The Development of PROG, and Performance Assessment of Performance of International PBL with PROG. *2019 JSEE Annual Conference International Session Proceedings*.

Melsa, J. L. (2007). Educating Engineers for a Global World. *Journal of JSEE*, *55*(31–36).

Mesquita, D., Salimova, T., Soldatova, E., Atoev, S., & Lima, R. M. (2019). What can be recommended to engineering teachers from the analysis of 16 European teaching and learning best practices? *Proceedings of the SEFI 47th Annual Conference*, 770–779.

Mills, J. E., & Treagust, D. F. (2003). Engineering education - is problem-based or project-based learning the answer? *Australasian Journal of Engineering Education*, *3*, ISSN 1324-5821. https://doi.org/10.1108/13552540210420989

Mohd-yusof, K., Arsat, M., Borhan, M. T., Graaff, E., & Kolmos, A. (2013). PBL Across Cultures. In *4th International Symposium on Problem Based Learning*.

Nakanishi, H. (2019). *Modern society has reached its limits. Society 5.0 will liberate us*. World Economic Forum Meeting. https://www.weforum.org/agenda/2019/01/modern-society-has-reached-its-limits-society-5-0-will-liberate-us

National Academy of Engineering. (2005). Educating the Engineer of 2020: Adopting Engineering Education To the New Century. *National Academies Press*. https://doi.org/10.1109/EMR.2009.4804343

Navas, H. (2017). "Global PBL" na FCT NOVA - "through the problem solving experience." *Inovação & Empreendedorismo*, *85*(4).

Navas, H. (2018). Global PBL 2018 na FCT NOVA. *Inovação & Empreendedorismo*, *95*(8).

Pereira, A. G., Lima, T. M., & Charrua-Santos, F. (2020). Society 5.0 as a Result of the Technological Evolution: Historical Approach. In T. Ahram, R.Taiar, S. Colson, & A. Choplin (Eds.), *Advances in Intelligent Systems and Computing* (pp. 700–705). Springer, Cham. https://doi.org/10.1007/978-3-030-25629-6_109

Pereira, M., & Barreto, M. (2016). PBL in school of Engineering of Lorena at the University of São Paulo: Lessons learned and challenges. In Rui Manuel Lima, E. de Graaff, A. C. Alves, A. Menezes, D. Mesquita, J. Dinis-Carvalho, L. Bettaieb, N. van Hattum-Janssen, N. Costa, R. M. Sousa, S. Fernandes, & V. Villas-Boas (Eds.), *Proceedings of the PAEE/ALE'2016, 8th International Symposium on Project Approaches in Engineering Education Education (PAEE) and 14th Active Learning in Engineering Education Workshop (ALE)* (pp. 174–181).

Powell, P., & Weenk, W. (2003). *Project-Led Engineering Education* (Vol. 53, Issue 9). Lemma Publishers. https://doi.org/10.1017/CBO9781107415324.004

Rychen, D. S., & Salganik, L. H. (2000). *Definition and selection of Key competencies*. https://www.oecd.org/edu/skills-beyond-school/41529556.pdf

The Economist. (2015). *Driving the skills agenda: Preparing students for the future*.

UNESCO. (2010). *Engineering : Issues Challenges and Opportunities for Development*. http://unesdoc.unesco.org/images/0018/001897/189753e.pdf

UNESCO. (2015). *Rethinking education: Towards a global common good?*

UNESCO. (2016). *Education 2030: Incheon Declaration and Framework for Action for the implementation of Sustainable Development Goal 4*. http://uis.unesco.org/sites/default/files/documents/education-2030-incheon-framework-for-action-implementation-of-sdg4-2016-en_2.pdf

WHO, W. H. O. –. (2020). *Coronavirus disease 2019 (COVID-19). Situation Report 51.* https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200311-sitrep-51-covid-19.pdf?sfvrsn=1ba62e57_10

World Economic Forum. (2015). *The skills needed in the 21st century*. New Vision for Education - Unlocking the Potential of Technology. https://widgets.weforum.org/nve-2015/chapter1.html

Yamashita, M., & Hasegawa, H. (2020). Efficiency of individual competency in teamwork under unexpected situation in Project-Based Learning. *Proceedings of INTED2020 Conference 2nd-4th March 2020, Valencia, Spain*, 2033–2040.

Development of Automated Guided Vehicles for a Smart Factory: A Project-Based Learning Experience

Yasiru Shikshitha Malshan Benaragama[1], Pisut Koomsap[1]

[1] Department of Industrial Systems Engineering, Asian Institute of Technology, Pathumthani, Thailand

Email: fluxes94@gmail.com, pisut@ait.asia

Abstract

Manufacturers are facing a challenge from customer demands of product variety in several small batch sizes that desperately need a flexible material handling system. This challenge stimulated the idea of developing a flexible material handling system to support student learning in an Erasmus+ Curriculum Development of Master's Degree Program in Industrial Engineering for Thailand Sustainable Smart Industry (MSIE4.0) funded by the European Commission. It also became a Master thesis on managing a fleet of automated guided vehicles (AGVs). This paper discusses the learning experience gained over the project timeline. Several activities have been done both academic and non-academic throughout this journey of project-based learning, and from identifying the problem statement to the delivery of five in-house AGVs and their management system. Prior to the design of the five AGVs, a small prototype was built and a network was tested for proof of concept. Furthermore, a set of experiments were conducted to ensure repeatability and reproducibility can be achieved. Many more activities including making a bill of materials and contact vendors were done once it was time for full-scale development. Challenges encountered along the journey and our way of overcoming these challenges are also discussed.

Keywords: PBL, Thesis, AGVs, Smart factory, Material handling systems.

1 Introduction

As industries move forward to the Industry 4.0 era, the demand for huge batch sizes will vary and the concept of focusing on each order as a unique event is introduced (Ghadiri, 2007). To adapt to these new trends, the factories must adapt to varying demands from customers, by improving its flexibility in handling small batch sizes in an efficient way. For an industry to be flexible enough, there are various factors to be considered. Among these factors, the importance of having a flexible material work flow for short production cycles as well as just in time supply chains in an industrial manufacturing environment can be shown (Künemund et al, 2014). Therefore, material handling systems within the factory plays an important role in improving the flexibility of a factory. One common practice in material handling system is to use automated mobile robots to do the transportation. These robots are generally called as Automated Guided Vehicles (AGVs). Usage of these AGVs in a manufacturing system environment offers an efficient and a flexible material handling system which will result in an increase in production output of the manufacturing process (Esmaili, 2007).

It is clear that there is much room for improvement in the field of material handling systems for Industry 4.0 era. Even though AGVs are the ideal candidate for building a flexible material handling system for industries, there are doubts about its application to a smart factory, simply because the current concepts behind existing AGVs are technologically inferior compared with the technological developments achieved by other aspects when we focus on meeting the requirements for Industry 4.0 (https://ottomotors.com/blog/industry-4-0-flexible-agv). But, by redesigning the AGVs, there is still potential for the AGVs to be applicable for the future of industry.

The first author had the opportunity to be in a team involved in building a Smart Learning Future Factory, related to the Master's Degree Program in Industrial Engineering for Thailand Sustainable Industry (MSIE4.0) was funded by the Erasmus+ Curriculum Development program. This enabled in bringing forth concepts and ideas of AGV design and development to a real-world Smart Factory, by designing and developing 5 prototype AGVs specifically built for the Smart Factory at AIT (Asian Institute of Technology, Thailand). The developed prototype AGVs were used in the Master Thesis of the first author, on "Design and Development of a Hybrid

Fleet Management System for Automated Guided Vehicles", and the algorithm developed for the Thesis is applied in the Smart Factory at the time of writing this article. For the years to come, these prototype AGVs and the infrastructure built around them will help engineering students to learn and develop skills related to Industry 4.0.

2 Identification of requirements

Upon receiving the opportunity to be a part of the team that built the Smart Future Learning Factory at AIT, the first author was assigned to work on the Material Handling System that was to be built to the Smart Factory. The requirements of the team leader were specified. The Material Handling system should be flexible, the control of the MHS should be remotely accessible from anywhere in the world and the MHS should be a learning platform for IE students to learn from. Having received full freedom to carry out concept development and after careful study of what need to be done in order to meet the specified requirements, an initial concept was developed. The idea of using Automate Guided Vehicles (AGVs) was proposed to the team. After a careful feasibility study, the team leader requested a scaled-down prototype of the concept AGV to be built and tested.

3 Design learning experience

After receiving approval for the proposed concept, it was time to design the scaled-down prototype of the AGVs. The initial AGV prototype design phase began after research was done on existing AGVs. Different AGV types were researched upon and their pros and cons were identified. Decisions on what sort of navigation method (Fixed path or free ranging) to be used was researched upon. Research done on using camera vision for free ranging capability received a negative feedback (Jian et al, 2006), where the problems associated with using camera vision was pointed out. Knowledge on why cameras are not favourable in gathering relevant data for applications involving transport solutions (Miljković et al, 2013) further solidified the stance in not using camera vision for AGV navigation. Upon researching on whether to use centralized or decentralized control (Künemund et al, 2014), researchers have pointed out the difficulties related to the operation of a centralized fleet of AGVs (Svestka & Overmars, 1998). After developing a sensible work plan, the small prototype AGV was developed and put to extensive testing (figure 1). Experiments were conducted in various aspects of the AGV in order to prove the proposed concept was a feasible one, and that it will meet the required specifications.

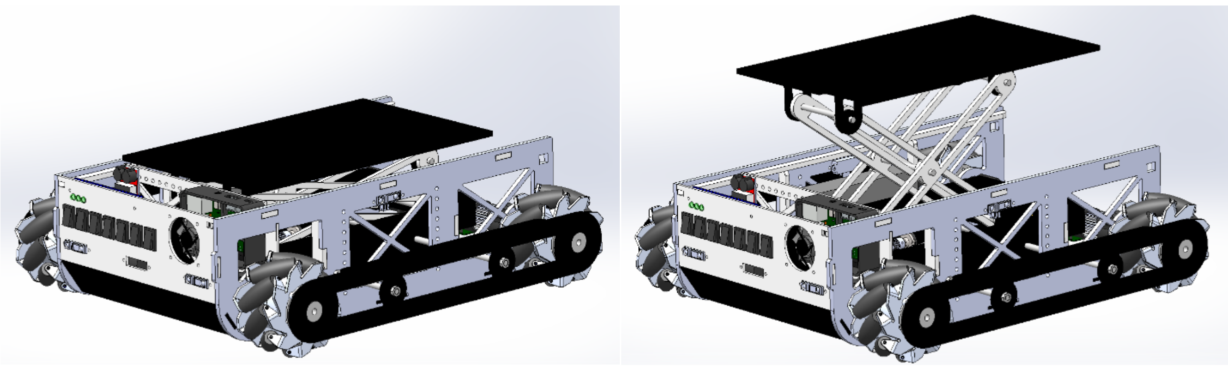


Figure 1: The initial prototype CAD drawing built to check the feasibility of operation in the factory floor

After seeing the potential of the proposed system and that the concept was feasible, reliable, repeatable and reproduceable upon implementation to the smart factory, green light was received to move ahead with the development of the full scaled AGVs. The scope of the project was changed in order to develop five AGV units. After re-evaluating the design specifications according to the experience gained by the scaled-down prototype, the CAD design of the full-scaled AGV began. Adhering to the required payload capacity, the required dimensions and other relevant data, the CAD drawing was completed (figure 2).

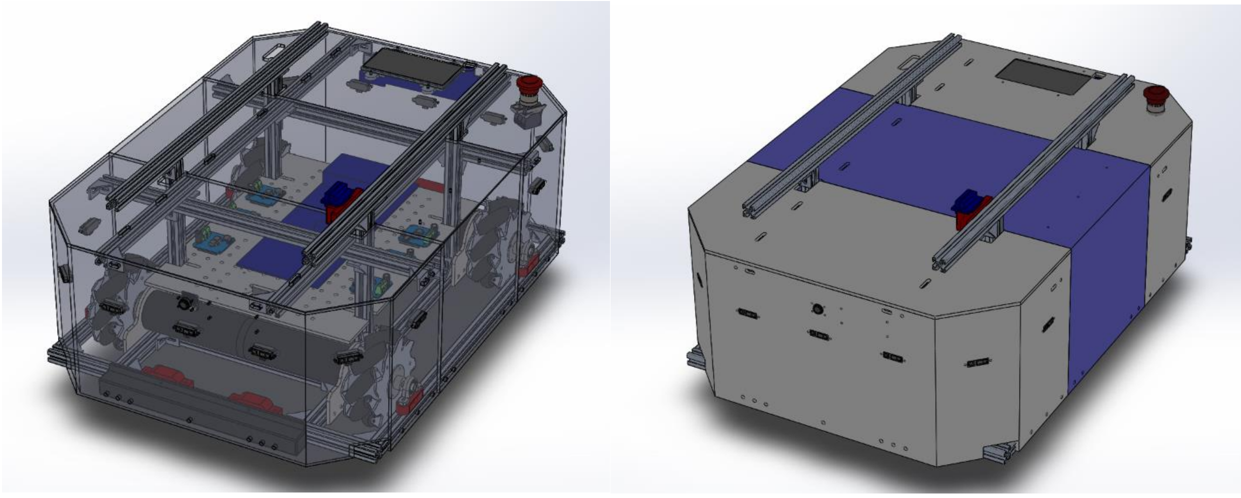


Figure 2: The final designed CAD drawings of the full scaled AGVs

The next step in the design phase was the electronics of the AGVs. A printed circuit board was designed specially for the AGVs. By doing this, all the electronics of the AGV was securely fastened to one circuit board which will avoid unnecessary wiring being done on AGVs.

4 Project management learning experience

By this time of the development phase, the design of the final AGV and the PCB (Printed Circuit Board) was finalized. All the major components needed for both the AGV and the PCB were decided upon and it was time to move on with the purchase of needed components. Due to the requirement of doing one-time purchases from a vendor, the team leader advised to perform the orders methodically, to avoid possible re-orders. Due to this reason, a comprehensive list of materials was created on the purchase items for both the AGVs, PCBs and all other required items. This list of materials was grouped and clustered according to the availability for different vendors, for the ease of purchasing. The cost estimation for the entire project was created upon request and was submitted to the team leader.

The list of material was sent to multiple vendors in order to identify the most suitable vendor who provided the best value for money. After contacting the vendors and checking the relevant information such as estimated date of delivery, the purchases were made according to the urgency of the said items. Some items were not available domestically. Hence, these purchases were given a higher priority to avoid delays associated with delivery. Permission was taken from the team leader to make purchases from overseas as soon as possible. The next most urgent items related to the mechanical structure were then purchased, followed by the electronic components.

The very first items to be received were items related to the mechanical structure. The aluminium frame for the five AGVs were quickly built and tested for strength. Thanks to the timely purchases, the PCBs which was shipped from China was delivered just as the electronic items were delivered. Hence, the time spent in waiting for the rest of the items to be delivered were well spent in completing the PCBs. At the end of this phase, the PCBs were tried and tested and was ready to be fixed to the AGVs.

The next delivery was the mecanum wheels and the motors, which was ordered from the same vendor. By this time, the main components of the AGV were ready to be assembled (figure 3). The progress was shown to the team leader and the initial tests revealed that the AGVs were performing as expected in the Smart Factory.

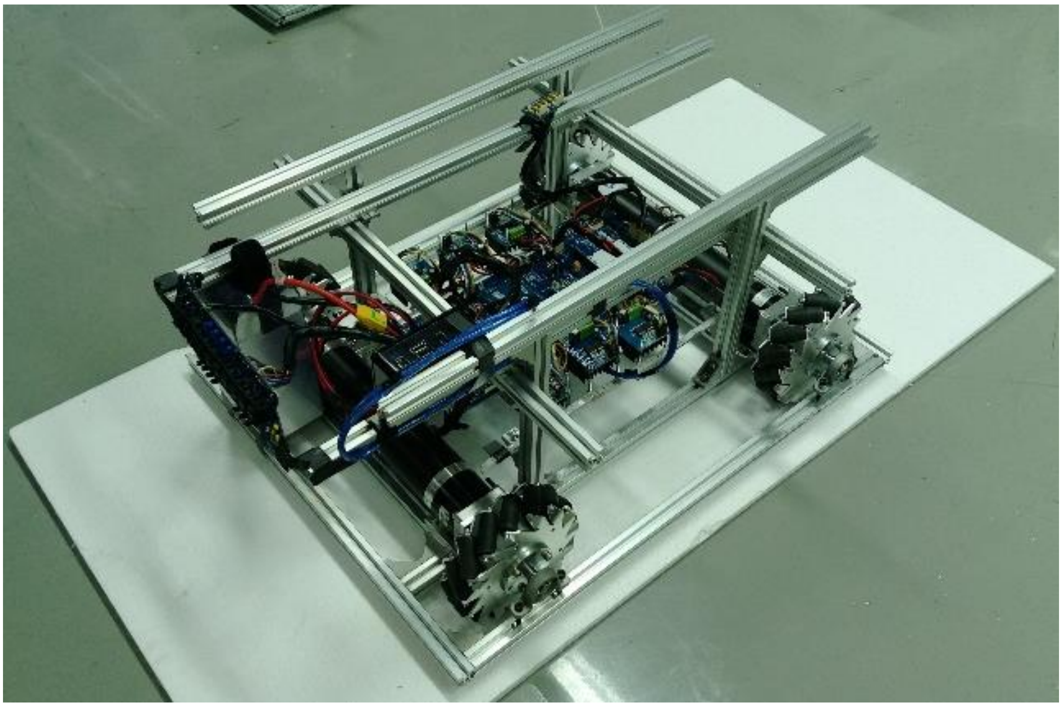


Figure 3: The AGV in its aluminium frame with the electronics assembled.

The shipment from United States took much longer than expected. These were the Magnetic Guide Sensors and their accessories to be used in fixed path AGV navigation. But the time spent waiting was well utilized by testing the AGV fleet management algorithm developed by the first author, which was to be used in the Smart Future Learning Factory.

Finally, after receiving all the components, assembling them and after extensive testing carried out to ensure a reliable performance, the outer acrylic plastic body was put to production. The outer plastic body was delivered within a week, and was fixed to the AGVs. Finally, the AGVs got the appearance of a mobile robot (figure 4).

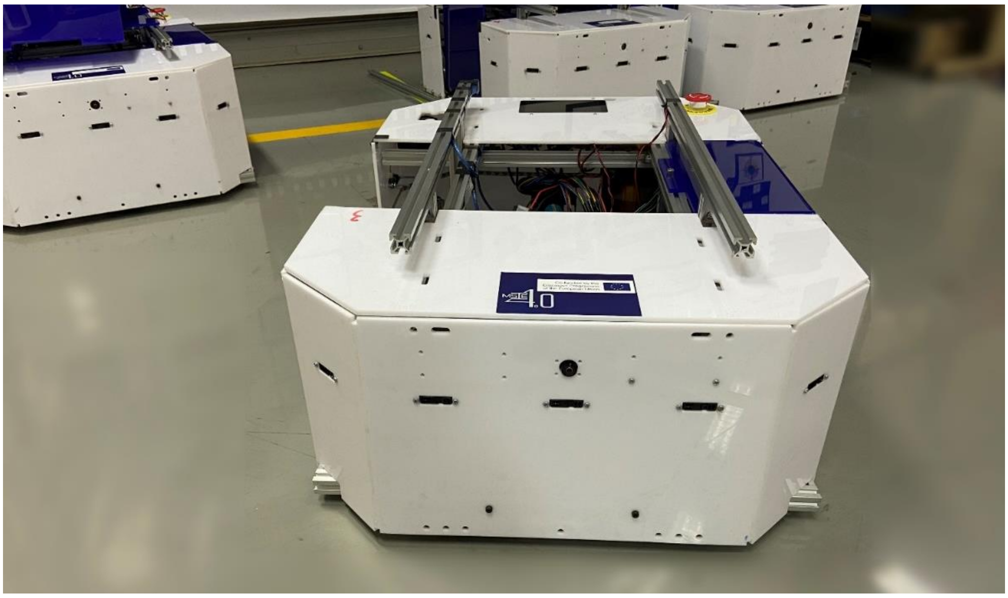


Figure 4: A completed AGV at the end of the development.

5 Implementation learning experience

Extensive testing was done from the now operational AGVs. Tests on accuracy and repeatability of navigation were conducted. The AGVs were tuned in order to get maximum accuracy possible. During these tests, the navigational flexibility of the mecanum wheels were also tested. The mecanum wheels offered much more manoeuvrability than traditional wheels. They helped the AGV navigate sideways and rotate on the spot beside the normal navigational methods. Therefore, by using these tests, an algorithm was developed which offered accurate, robust and flexible navigational capability to the AGVs.

The next phase was to develop a reliable communication platform. The AGVs communicated via standard Wi-Fi, and so, the AGVs connected to the existing Local Area Network (LAN) of the Laboratory. By doing so, the communication links with the main control computer was made easy and fast without the need of purchasing additional communication hardware.

By the mid of March, the five full-scaled AGVs were ready to be deployed on the Smart Future Learning Factory. Modifications were made to the factory floor in order for the AGVs to do its navigations. The AGVs were ready to be linked with the Hybrid Fleet management system. Table 1 shows the dates and milestones of the project.

Table 1. Milestones and important dates.

Date	Milestones
October 1, 2019	Initial design sketches for the AGV
October 4, 2019	Beginning of the CAD design
October 9, 2019	Creating the Bill of Materials
October 16, 2019	Finalizing the CAD design
October 18, 2019	Initial design of the PCB
November 1, 2019	Finalizing the List of Parts and Bill of Materials
November 2, 2019	Finalizing the PCB design
November 3, 2019	Initial sketchup of algorithm and coding
November 13, 2019	First successful communication link-up using TCP-PI protocol
November 18, 2019	Begin work on JavaScript coding
November 22, 2019	Recieving the PCBs. Started PCB soldering
December 03, 2019	Start building the mechanical framework for the AGVs
December 23, 2019	Finished the build of the mechanical frameworks for all 5 AGVs
January 02, 2020	Start assembling the basic electronics assembly for all 5 AGVs
January 15, 2020	Finished assembling the basic electronics for all 5 AGVs
January 16, 2020	First day of controlling multiple AGVs simultaneously
February 2, 2020	Initial design of the Graphical User Interface for the main server
February 11, 2020	The arrival of the final components for the AGVs, the magnetig guide sensors and its pheripherals
February 18, 2020	Fixing the Acryllic bodies to the AGVs.
March 4, 2020	Optimizing the communication links
March 12, 2020	Deplyment of all 5 AGVs simultaneously on the factory floor
March 17, 2020	Initial AGV fleet management algorithm development
March 22, 2020	Completion of the AGV fleet management algorithm
April 2, 2020	Optimizing the Digital Inertial Measuring system for increased navigational accuracies
April 6, 2020	Final completion date of improving all the AGV algorithms
April 22, 2020	AGVs are deployed in the Smart Factory successfully.

The AGVs had a fast, robust and a very resilient bi-communication platform from which information was shared between the AGVs and the computer. The cloud robotics platform was an ideal solution to integrating wireless links between multiple units (Aniruddha Singhal et al, 2017). Research was carried out on possible methods of AGV fleet management. Research done on how to handle robots in a public environment was referred (Causse

& L. H. Pampagnin, 1995), since the AGVs will operate on a factory floor where humans will also work. Also, challenges that arise in managing multiple robots in a constricted environment was also looked at (R.Alami et al, 1998) to gain knowledge on how to approach the development of the algorithm. Possible methods of localization were researched upon. Methods such as using navigation signs in order to locate the robots (Jian, 2006) and usage of image sign tags replacing magnetic tags (Lu, 2001) were compelling methods. But, finally the use of RFID tags placed on the floor to act as the method of AGV localization was carried out.

The final AGV fleet management algorithm had the capability of directing the AGVs to workstations situated in the smart factory and deliver items from the source to the destination. Due to the capability of the AGV to do a hybrid navigation, where it switches between fixed path navigation at the vicinity of each workstation and switches to free ranging navigation on its way to the destination, the AGVs had the best of both worlds, the excellent navigational accuracy of a fixed path system with the flexibility and ease of modifications offered from free ranging systems.

When developing the decentralized operation, the necessary machine-to-machine communication, their important protocols and relevant information was researched upon (Clark et al, 2003). It was a necessity to build up a dynamic database of information where each AGV can read and write data. This database act as the information hub from which the AGVs will store all the important information such as AGV status, current position, etc.

6 Challenges encountered along the journey

The path to development of the prototype AGVs was filled with unexpected challenges, obstacles. But the entire project was successfully completed by solving one problem at a time. The biggest problem encountered was the great unevenness of the factory floor. The floor not so slippery and smooth, ideal for mecanum wheels. But it was extremely uneven that the first prototype AGV had so much trouble in travelling straight. From the tests done on the prototype, it was clear that this problem will affect to the full-scaled AGVs as well. Hence, a digital gyroscope with a high rate of data retrieval was used along with a dedicated microcontroller for it. By this way, any unwanted changes in orientation of the AGV when it is operating will soon be detected and necessary steps will be taken instantaneously.

7 Conclusion and the learning experience gained from the project

The learning experience gained from this project is so immense that by the end of the project, skills in both academic and non-academic sides was achieved. Knowledge on Information and Communication technology and many other fields of engineering such as designing PCBs, experience in mechanical engineering, experience in electrical and electronics engineering, experience in computer programming was gained. Apart from these academic knowledges gained, knowledge on how to act responsibly from a working point of view, experience in contacting vendors and placing orders and dealing with payments and deliveries and delays and many more life skills were achieved.

Acknowledgements

This work is the outcome of project "Curriculum Development of Master's Degree Program in Industrial Engineering for Thailand Sustainable Smart Industry (MSIE 4.0)" that has been funded with support from the European Commission (Project Number: 586137-EPP-1-2017-1-TH-EPPKA2-CBHE-JP). This publication reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

8 References

Alami, R., Fleury, S., Herrb, M., Ingrand, F. and Robert, F., "Multi-robot cooperation in the MARTHA project," in IEEE Robotics & Automation Magazine, vol. 5, no. 1, pp. 36-47, March 1998, doi: 10.1109/100.667325.

Causse, O. and Pampagnin, L. H., "Management of a multi-robot system in a public environment," Proceedings 1995 IEEE/RSJ International Conference on Intelligent Robots and Systems. Human Robot Interaction and Cooperative Robots, Pittsburgh, PA, USA, 1995, pp. 246-252 vol.2, doi: 10.1109/IROS.1995.526168.

Clark, C. M., Rock, S. M., and Latombe, J., "Motion planning for multiple mobile robots using dynamic networks," 2003 IEEE International Conference on Robotics and Automation (Cat. No.03CH37422), Taipei, Taiwan, 2003, pp. 4222-4227 vol.3, doi: 10.1109/ROBOT.2003.1242252.

Jian, L. U., Hiroyasu, I. & Kyoko, H., (2006) A Hybrid Vision Method for Autonomous Guided Vehicle Navigation

Khanmohammadi, S., Ghadiri, H. and Jahedmotlagh, M. R., "Modelling of helper robots in manufacturing systems using Petri Nets," *2008 IEEE International Joint Conference on Neural Networks (IEEE World Congress on Computational Intelligence)*, Hong Kong, 2008, pp. 1692-1697, doi: 10.1109/IJCNN.2008.4634025.

Mehdi, E., "Intelligent path planning of AGV systems." *Tabriz university* (2007).

Miljković, Z., Vuković, N., Mitić, M. & Babić, B. (2013) New hybrid vision-based control approach for automated guided vehicles

Singhal, A., Aniruddha & Pallav, Prasun & Kejriwal, Nishant & Choudhury, Soumyadeep & Kumar, Swagat & Sinha, Rajesh. (2017). Managing a fleet of autonomous mobile robots (AMR) using cloud robotics platform. 1-6. 10.1109/ECMR.2017.8098721.

Svestka, P. & Overmars, M. H., (1998) Coordinated path planning for multiple robots. In: Robotics and Autonomous Systems 23

Wissing, M., Kuenemund, F., Hess, D. and Roehrig, C., "Hybrid Navigation System for Mecanum Based Omnidirectional Automated Guided Vehicles," *ISR/Robotik 2014; 41st International Symposium on Robotics*, Munich, Germany, 2014, pp. 1-6.

COVID 19 and academia community cooperation: skills development fostering diversity, inclusion and equal opportunities

Ana Teresa Ferreira-Oliveira[1], Ana Sofia Rodrigues[2]

[1] CISAS, Escola Superior de Tecnologia e Gestão, Instituto Politécnico de Viana do Castelo, Rua Escola Industrial e Comercial de Nun´Alvares, 4900-347, Viana do Castelo, Portugal
[2] CISAS, Escola Superior Agrária, Instituto Politécnico de Viana do Castelo, Rua Escola Industrial e Comercial de Nun´Alvares, 4900-347, Viana do Castelo, Portugal

Email: ateresaoliveira@estg.ipvc.pt; sofia@ipvc.pt;

Abstract

This paper intends to discuss the development of skills in higher education in the area of inclusion, equal opportunities and special educational needs associated with COVID 19. It is mainly a theoretical reflection with qualitative data that inform the review. The paper intends to present the state of legislative mandates in Portugal and the articulation with European recommendations and higher education regarding inclusion. It also focus on the understanding of the impact of COVID 19 in social organizations and how can higher education institutions help to develop skills in this reality, therefore increasing university-social organizations cooperation. Social organizations were interviewed through email and qualitative results are presented. In addition, international imperatives will be presented and their articulation with skills development in higher education in Portugal. Formal future implementation towards inclusion in Higher Education Institutions is key and 1) fostering skills, 2) adapting curriculla, 3) training faculty members, 4) teaching and learning more problem solving in practice, more work-based learning, more service-learning and 5) deep cooperation with social organizations, are key factors towards fostering an implementation of inclusion in Higher Education Institutions. It is important to ensure that effective and urgent European solutions are found for responses to the pandemic in the area of adult education in inclusion, equal opportunities and educational needs in all areas but also towards development of policies of inclusion in higher education.

Keywords: Skills development; inclusion; equal opportunities; special educational needs; covid-19; university social organizations cooperation

1 Introduction

The COVID 19 pandemic has brought about considerable changes in our educational systems and major economic disruptions. The OECD Interim Economic Assessment (2020) emphasizes that coronavirus containment efforts have involved widespread quarantines and restrictions on mobility and work travel. The impacts of such restrictions are significant, including direct disruption to global supply chains, weaker final demand for imported goods and services, and the wider regional decline in international tourism and business travel. Therefore, the growth prospects are very uncertain and, currently, there are no precise assumptions for the future regarding the economy and employment. The relevance of this article has therefore been increased by the current global context. The paper intends to present the state of legislative mandates in Portugal and the articulation with European recommendations and higher education regarding inclusion. It also focus on the understanding of the impact of COVID 19 in social organizations and how can higher education institutions help to develop skills in this reality, therefore increasing university-social organizations cooperation.

2 Skills development in higher education in the area of inclusion, equal opportunities and special educational

Skills development in this area is even more crucial when economies face recession and the need for rapid adaptation, flexibility and problem solving - although skill development cannot be considered a panacea for such severe conditions, it can however, making a difference for the consortium by navigating these dire circumstances and trying to increase the chances of the consortium facing the pandemic with more capable responses such as the possibility of the project in question. According to data from the latest OECD report of OECD - Tackling Coronavirus COVID 19) | Contributing to a global effort: COVID-19: Protecting people and societies, the Coronavirus COVID-19 pandemic presents specific challenges for well-being people with disabilities, particularly in the dimensions of education, health and social life. The pandemic has introduced a very deep stress in the lives of people with disabilities, drastically altering their routines and significantly modifying the way they manage their daily lives. The United Nations in its latest report entitled "Pandemic COVID 19 and People with Disabilities" says that people with disabilities generally have more health care needs than others - both standard and disability-related needs - and therefore are more vulnerable to the impact of low quality or inaccessible services than other audiences. Although having a disability is unlikely to expose people to an increased risk of coronavirus, many people with disabilities have specific underlying conditions that make the disease more dangerous for them, including its social and individual development effects. In addition, the European Disability Forum in its open letter to the leaders of the European Union: Covid-19 - Inclusive Response to Disability, states that investment in the provision of services and support in this public is crucial and, consequently, maximum European solidarity is necessary to guarantee strengthening services. According to this letter, as is well known, health and social care systems are constantly underfunded across the EU. Investment in these services is essential and urgent to ensure that they can cope with the rising costs associated with the crisis. This contingency plan accelerated the transformation of the labor market and marked social support institutions as essential to the survival of a country in crisis. The interdependence of the population and these institutions makes the relevance of this investment in training, knowledge sharing and awareness raising within this theme evident. Mckinsey's latest April report entitled "Thinking about the next normal but making it work" demonstrates the need for organizations to find a balance between what they did before and what needs to happen in the new normal. The future is not what we thought it would be just a few months ago and according to the report it is important to assume that organizations should not assume that everything will be as it was before. It is crucial to find new ways to respond to the new problems that the pandemic poses. It is important to re - imagine the challenges that the future presents us. With the Coronavirus pandemic (COVID 19) collaboration, flexibility of solutions and inclusion need more than ever to be worked on and the financing of this project would make it possible to develop a very valid set of responses in the area of adult education that would allow to build responses to this pandemic more effectively. The Mckinsey report focuses on the need to deconstruct the usual traditional organizations and to design new non-traditional teams.

In 2017, the Portuguese State ended the lethargy regarding initiatives that focus on the inclusion of students with SEN in higher education. Order No. 10734/2017 creates the Working Group on Special Needs in Science, Technology and Higher Education (GT-NECTES, 2017), which makes a report with 67 recommendations. Of the indications made by the GT-NECTES, the highlight is the granting of a scholarship for people who prove they have 60% or more disability (Dec. Lei No. 8584/2017), which in the 2018/2019 academic year came to benefit around 400 students, and the Inclusion Desk creation project allocated. It is recommended to make essential information available in physical formats such as Braille, extended characters or simple language, as well as interpretation for Sign Language. Following Directive 2016/2102, it is a priority to make processes such as: registration, notifications and receipt of credentials, applications, interactive forms, as well as all types of information supporting the respective processes accessible - it is important to diagnose, carry out usability studies with users with some type of functional limitation and rectify the interactive interfaces and support information. It is also recommended that HEIs define welcoming practices, involving and valuing the student community / student associations in supporting students with special needs, either through peer group programs (mentored) or through volunteer programs. It is urgent to include in the HEIs a diagnosis of the study of measures for the implementation of specific teleworking or distance learning conditions for students or

workers with disabilities and accessibility of work materials and the electronic assessment system for workers with special educational needs. As mentioned by Claeys-Kulik, Jorgensen & Stober (2019) the lack of awareness between university and the community on issues of diversity and inclusion is an ongoing challenge, followed by a lack of funding and other resources, and the difficulty of identifying target groups.
The paper intends to present the state of legislative mandates in Portugal and the articulation with European recommendations and higher education regarding inclusion. It also focus on the understanding of the impact of COVID 19 in social organizations and how can higher education institutions help to develop skills in this reality, therefore increasing university-social organizations cooperation.

3 Method

3.1 Procedure and participants

This paper intends to present a research with three social organizational that work in inclusion, equal opportunities and special educational area. Qualitative data were collected in April 2020. The goal was to understand the impact of COVID 19 in their organizations and how could the higher education institutions help to develop skills in this reality. Social organizations were invited to participate in the research. The criterion used in these selection was the proximity with the university and involvement in previous common projects. The interviews focused on two key topics: current situation of social organization regarding their limitations on service and contributions of higher education institutions on competence development. Interviews were implemented through email. Qualitative results were analyzed using Bardin content analysis.

4 Results

Results from the social organization on neuromotor disability area informs that the time of confinement has, without a doubt, consequences for the physical and mental well-being of its users. More than 2 months without direct therapeutic intervention (with the maintenance of guidelines via telephone to the user or caregiver), will in the future be reflected in more motor stebacks and therefore more needs for support products or more complex adaptations. Professionals have demonstrated their ability to adapt, but face-to-face contact in the neuromotor area is essential. They are all anxious to return from the classroom activity. This being a new situation worldwide, there are practices in the field that have been shown to be more efficient in this situation. Therefore, relating to topic of contributions of higher education institutions on competence development this participant refers that universities can be very relevant in the exchange of experiences (benchlearning) and knowledge exchange, including with other countries in order to try to minimize the consequences for our users for so long without direct intervention. The faster they could articulate with other realities, the more quickly we will implement new strategies.

Results from the social organization on autism area reports that they have faced successive challenges in the context of this pandemic. Therefore, relating to the topic of contributions of higher education institutions on competence development this participant refers that universities would leverage innovation and institutional development and strengthen partnerships. The recipients of the organization's action are people with Autism Spectrum Disorder, clients that they describe as being the fringes of the most vulnerable population. Considering for instances the capacity and competences for the adoption of individual protection measures. Even this capacity to understand the need in these population are often compromised. In this sense, the access that this population has to the necessary care and support is small and compromises their current and future quality of life. The organization's technical team has been developing new intervention methodologies that, at the same time, guarantees public health, trying to minimize the required physical isolation, which implies changes in resources and conditions in the organization itself. All efforts will be made to maintain the inclusion and equal opportunities of people with Autism Spectrum Disorder. At this moment it is assumed by this organization that the role of higher education institutions on competence development is very relevant and crucial for the training of our professionals.

The social organization in the area of visual impairment was forced, in this context of prevention and containment of the pandemic, to suspend its in-person activity, which has had a significant impact on the daily management of social response and on the relationship between employees, users, families and community partners. Visually impaired people have been particularly affected, seeing their dependence on others growing and exacerbating the fear associated with this threat to public health. Touch is essential in the relationship that these people establish with the world around them, making compliance with the rules for preventing coronavirus infection very difficult. Social isolation also tends to be experienced more intensely, especially in the case of users who do not master the new information and communication technologies. The public's already usual vulnerability is, of course, exacerbated. The technical team has developed its activity based on remote communication with users, which constrains the support provided and the quality of the relationship established. Interlocution with other professionals and services has been extremely important, helping to solve the problems that, at each moment, users are confronted. The resumption of face-to-face activity is already being prepared, but they anticipate great difficulties in view of the type of work developed and the characteristics of the response, developed in the natural contexts of people's lives and with a strong involvement of families and other community resources. Compliance with social detachment proves to be especially challenging and the role of universities could be the new practices to be developed and are yet to be developed and implemented. University-social cooperation is crucial for learning and developing towards more effective European responses.

5 Discussion and Conclusions

Claeys-Kulik, Jorgensen & Stober (2019) stated that the lack of awareness between university and the community on issues of diversity and inclusion is an ongoing challenge, followed by a lack of funding and other resources, and the difficulty of identifying target groups. This report, which considers the education of professionals necessary, the training of administrative teams and teams of teachers and researchers, with a view to raising the level of awareness and providing tools and concrete approaches to deal with diversity. Ultimately, this will promote inclusiveness in the learning, teaching and research environments. Part of this relevance would be to continue moving the discourse on diversity from a challenge to be solved under previous conditions of quality and excellence. Several leading European universities have already explicitly assumed this position, as they realize that, by ensuring equitable treatment, they immediately improve their learning environment and their research. Universities should intend to take this step and continue to improve its learning and research environment and in its exploration and dissemination plan, to argue precisely the significant improvement of its teaching and learning processes. Universities should develop alternative curricula fully integrated with the special needs of the social organizations. This particular result, which according to our knowledge to date, is scarce in the context of higher education in Portugal, would allow Universities to advance in terms of training and promoting equal opportunities. IPVC, for instances, intends to increase the active cooperation projects between with social organizations allowing for greater synergistic exchanges between mutual needs, achieving more beneficial joint solutions for the area of disability, increasing the likelihood of transferring the positive results towards skills development and the efficiency of the learning outcomes. When designing these alternative curricula, universities should take into account the technical infrastructure of the Virtual Learning Environment (VLE), which should guarantee the accessibility of learning materials and the electronic assessment system for students with special educational needs. Universities should have the responsibility to provide students with adequate library resources (ie an electronic library service) and any necessary training as an institutional responsibility. Study programs should include virtual laboratories designed to ensure the acquisition of specific learning outcomes. According to Heiman and Precel (2003) practice in teaching and developing skills in disabled learners is very relevant. Regarding academic strategies students with learning disabilities they preferred additional oral explanations or visual explanations, whereas nondisabled students preferred more written examples. Additional effort should be made by universities to tackle these demanding's regarding inclusion of students with special needs in higher education. Skills development appears to be more relevant and during examinations, the students with special needs had difficulty concentrating and were concerned about lack of time. Wray and Houghton (2019)showed that government policy (in UK) hadn´t such a relevant effect on HEIS practice, however the study made clear the efforts made by faculty members to support disabled students. These efforts were based on values associated with providing an equitable experience for all students. Faculty members were able to exercise discretion

responding to disabled students without significant influence from institutional managers, national legislation or broader policy discourse. Therefore, there is a long journey to overcome regarding policies and afterwards implementation on higher education institutions. Wray and Houghton (2019)show that faculty members are tackling with success and human values disabilities in higher education, however more is needed.
Formal future implementation towards inclusion in Higher Education Institutions is key and 1) fostering skills, 2) adapting curriculla, 3) training faculty members, 4) teaching and learning more problem solving in practice, more work-based learning, more service-learning and 5) deep cooperation with social organizations, are key factors towards fostering an implementation of inclusion in Higher Education Institutions.

6 Conclusion

It is relevant that higher education projects involve different stakeholders with different and relevant roles in the area of inclusion, equal opportunities and special educational needs. This will allow to create a direct impact on regional political measures, assuring also the participation of the main regional decision-makers. It is important to ensure that effective and urgent European solutions are found for responses to the pandemic in the area of adult education in inclusion, equal opportunities and educational needs in all areas but also towards development of policies in higher education. Also, Higher Education Institutions that work thoroughly these issues should develop formal future implementation towards inclusion fostering skills, adapting curriculla, training faculty members, teaching and learning more problem solving in practice, more work-based learning, more service-learning and increase cooperation with social organizations, key factors towards fostering an implementation of diversity in Higher Education.

7 References

Claeys-Kulik, A., Jorgensen, T. Stober, H. (2019) Diversity, Equity and Inclusion in Higher Education Institutions: Results from the INVITED Project. in Royo, C. & Mariaud, H. European University Association asbl, Geneva, Switzerland.

Collins, A., Azmat, F., & Rentschler, R. (2018). "Bringing everyone on the same journey": revisiting inclusion in higher education. Studies in Higher Education, 44(8), 1475–1487. doi:10.1080/03075079.2018.1450852

Grupo de Trabalho para as Necessidades Especiais na Ciência, Tecnologia e Ensino Superior (GT-NECTES) (2017). Acedido em https://www.portugal.gov.pt/download-ficheiros/ficheiro.aspx?v=50f006ee-9f56-4348-8675-60d2e536544f

Heiman, T., & Precel, K. (2003). Students with Learning Disabilities in Higher Education. Journal of Learning Disabilities, 36(3), 248–258. doi:10.1177/002221940303600304

Rao, Shaila. "Faculty attitudes and students with disabilities in higher education: a literature review." College Student Journal, vol. 38, no. 2, 2004, p. 191+. Accessed 15 June 2020.

Mckinsey's report "Thinking about the next normal but making it work" https://www.mckinsey.com/featured-insights/leadership/from-thinking-about-the-next-normal-to-making-it-work-what-to-stop-start-and-accelerate

Mike Wray & Ann-Marie Houghton (2019) Implementing disability policy inteaching and learning contexts – shop floor constructivism or street level bureaucracy? Teaching in Higher Education, 24:4, 510-526, DOI: 10.1080/13562517.2018.1491838

OECD Interim Economic Assessment (2020) http://www.oecd.org/economic-outlook/may-2020/

OECD report of 4 May 2020, OECD - Tackling Coronavirus COVID 19) | Contributing to a global effort: COVID-19: Protecting people and societies, the Coronavirus COVID-19 www.https://www.oecd.org/coronavirus/en/

United Nations report entitled "Pandemic COVID 19 and People with Disabilities" https://www.un.org/development/desa/disabilities/covid-19.html

COVID-19: Transition to Online Problem-based Learning in Robotics – Challenges, Opportunities and Insights

Marietjie Havenga

Unit for Self-Directed Learning, North-West University, Potchefstroom, South Africa

Email: marietjie.havenga@nwu.ac.za

Abstract

This research in progress reports on the challenges, opportunities and insights gained regarding an introductory robotics course during a rapid transition to an online learning environment during the COVID-19 lockdown. The Fourth Industrial Revolution is a major driving force for change across the globe. It is characterised by developments, such as 3D printing, artificial intelligence and robotics. As a result, there is a need to prepare students to develop specific skills for future demands. The aim of the course is to introduce fourth-year Computer Science Education students to robotics while employing problem-based learning online as teaching–learning approach. Opportunities are provided for the development of essential skills, such as cooperative problem solving and self-directed learning. The robotics course comprises various topics, such as a historical overview, ethical considerations, as well as the requirement of students to program Lego© Mindstorms robots online using relevant software and simulation programs. In the study, some tasks were completed individually while others had to be done in teams. A qualitative methodology was used. Data collection consisted of the lecturer's self-reflective notes as well as students' weekly reflective sheets regarding their responsibilities and activities, and the submission of a comprehensive portfolio regarding all programming codes, pictorial evidence of robot simulations and short video recordings of team collaboration. All students' data were submitted on the university's learning platform or course management system as well as on a cloud. The data were analysed manually. Based on the reflections and feedback, the lecturer gained insight into the online teaching and learning of robotics. Further, results indicate that students developed essential skills as they were challenged with online learning.

Keywords: Computer Science Education Students; Online Learning; Problem-based Learning; Robotics.

1 Introduction

The first reported outbreak of coronavirus disease (COVID-19 or SARS-CoV-2) was in Wuhan, China in December 2019. Although the origin of this severe acute respiratory syndrome virus is not known, the global impact thereof is unprecedented (Del Rio & Malani, 2020). Currently, the global infection of the coronavirus pandemic exceeds 11.7 million and 540 000 deaths have been reported (7 July 2020). Further, there is no vaccine currently available, testing is insufficient and it appears to be possible that some individuals may even be "asymptomatic" carriers of the virus (Del Rio & Malani, 2020, p. 1339). As a result, most countries declared a so-called "quarantine" or "lockdown" period to implement particular protocols with the aim to prevent the rapid spreading of the virus with resultant infection and possible death of individuals. Moreover, the lockdown affects all levels of humankind. For example, many universities and schools closed due to an emergency call from heads of state. Such a call has a critical impact on students' learning. This required a rapid transition from full-time learning to online learning during lockdown without losing the benefits of active and responsible learning.

Learning should be driven by using appropriate pedagogies and approaches where students are actively involved, curious and searching for innovative answers to open-ended problems (Yiannoutsou, Nikitopoulou, Kynigos, Gueorguiev, & Fernandez, 2017). Problem-based learning (PBL) is an approach that encapsulates student-centred learning, active participation and high-level thinking (Savery, 2015). At the core of PBL is the drive to solve unknown, open-ended or vague problems in collaboration and to think about solutions in new ways. However, due to the abovementioned limitations imposed by the COVID-19 lockdown, the challenge was to explore how to apply PBL in an online environment to introduce full-time Computer Science Education students to robotics. Consequently, the aim of this research was to report on the challenges, opportunities and insights gained regarding an introductory robotics course due to a rapid transition to online PBL.

2 Context and related work

This section outlines the online learning environment and PBL as well as the learning of robotics.

2.1 Problem-based practice

Mohd-Yusof (2017, p. 18) notes that the PBL approach can challenge both the lecturer and the student, as the lecturer is not "going to teach everything that students need to learn". Lecturers need to formulate suitable and authentic problems, guide students to understand the PBL approach, facilitate for active learning and team cooperation, and scaffold students to address challenges and support for metacognitive and critical thinking (Mohd-Yusof, 2017). Likewise, students should clarify and understand nuances of the problem, clearly formulate learning goals, conduct research, explore challenges, and come up with innovative solutions to an ill-defined problem (Baloche & Brody, 2017; Savery, 2015). The aim is not only to solve the problem in hand but also to develop self-directed learning (SDL) skills and essential attributes for the future to address unknown problems and challenges in integrated disciplines that affect society.

2.2 Online problem-based learning

Applying PBL in an online environment is not trivial. Abdullah and Kian (2019) applied PBL where industry experts were involved in online scaffolding to assist engineering students in developing essential high-order skills for the workplace. Valiente et al. (2019) used an online simulation tool (circuit simulation applet in Java) to enhance engineering students' learning of electronics. However, Blayone, Van Oostveen, Barber, DiGiuseppe, and Childs (2017) put forward a social-constructivist model with relevance to PBL and inquiry-based learning in online contexts. The Fully Online Learning Community model (FOLC) accentuates the construction of knowledge (*knowing)*, development of competencies to solve complex problems together (*acting)*, and a community that relates to transformative learning, which involves trust, openness, exploring of different views, collaboration and feedback, among others (*being)* (Blayone et al., 2017; Gray, 2016). (Note that the words in brackets and in italics indicate alignment of aspects of FOLC with the three elements of curricula as mentioned by Kolmos (2017) in the context of transition to a PBL curriculum). FOLC endorses social presence (SP) and cognitive presence (CP) as means of responsible and shared experiences to accomplish joint tasks online. SP relates to the ability of a student to be involved and interacting purposefully in an online community of learning while CP involves an individual constructing meaning in authentic settings through online environments (Blayone et al., 2017). In addition, Blayone et al. (2017) highlight that "successful collaborative learning" occurs at the intersection of SP and CP where learners develop essential competencies to address "critical inquiry" (Blayone et al., 2017, p. 4). Schultze and Brooks (2019, p. 709) concur that SP involves the existence of "being there" in a virtual world, to be committed to act and become deeply involved. Such learning is in particular a challenge in subjects with a practical component, for instance Science, Engineering, Technology and Computer Science.

2.3 Online learning of robotics

One of the fields of specialisation, related to the Fourth Industrial Revolution (4IR), is robotics. Schwab (2016, p. 10) gives prominence to the 4IR and refers to the "growing harmonization and integration of so many different disciplines and discoveries", and mentions robotics among others. Using robots may have an effect on supply chains and all sectors to perform an array of tasks involving precision, time and quality and could add value to society (Schwab, 2016). Consequently, there is a need that individuals should be exposed to robotics, particularly in the education sector. In 2019, the South African Minister of Basic Education announced the development and implementation of a new curriculum in 2021–2022 in schools regarding "Coding and Robotics" (IOL, 2019). To stay informed, lecturers decided to prepare Computer Science Education students for demands that might arise in the future, such as robotics. As a result, Computer Science pre-service education students should gain knowledge and skills to plan activities and to assemble and program robots.

Avello, Lavonen, and Zapata-Ros (2020) outline the relationship between coding and robotics and computational and creative thinking. Computational thinking is essential for the development of particular skills, and involves the understanding of problem scenarios, the development of computer programs and digital competences, as well as human activities involved in collaborative problem solving. Based on their research, Avello et al. (2020, p. 1) noted, "computational and creative thinking are related to find efficient and good solution to problems". Likewise, Pollak and Ebner (2019) emphasise computational thinking in terms of understanding the problem context, application of relevant skills, strategies (e.g. break down a problem in manageable sections) and computational tools. In an online learning environment, some tools can be used to assist in the learning of robotics. All of these have different approaches, for example:

- LEGO Mindstorms EV3 is software to program third-generation robots and enables an individual to connect and control the LEGO EV3 brick using USB, Bluetooth or Wi-Fi (Figure 1);
- LEGO Digital Designer is simulation software used to design and build a robot (Lego) (Figure 2);
- CoderZ provides a visual code editor with an EV3 online simulator (CoderZ, 2019) (Figure 3a, 3b); and
- Ev3_scratch uses Scratch code in the browser to command the EV3 robot to move over Bluetooth.

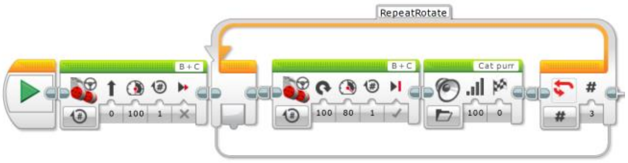


Figure 1. Mindstorms EV3 visual code segment.

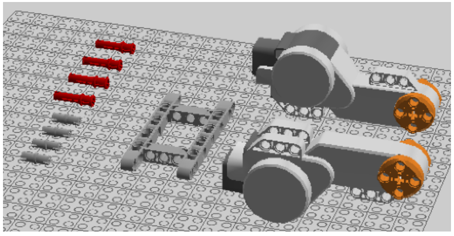


Figure 2. LEGO Digital Designer simulation software.

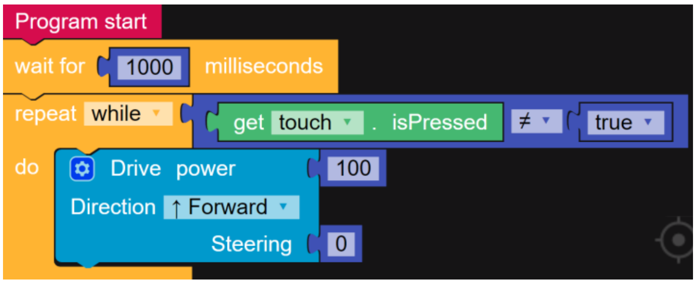


Figure 3a. Visual code editor in CoderZ.

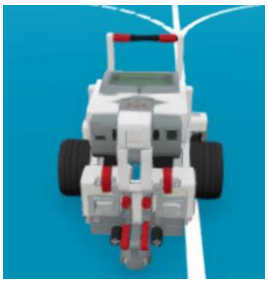


Figure 3b. EV3 online simulator in CoderZ.

Due to the rapid transition from full-time to online learning without losing the benefits of active and responsible learning, using appropriate environments for an introduction to robotics was imperative. The following research question directed this research: What are the challenges, opportunities and insights associated with a rapid transition to an online problem-based learning (PBL) environment for robotics?

3 Empirical Research

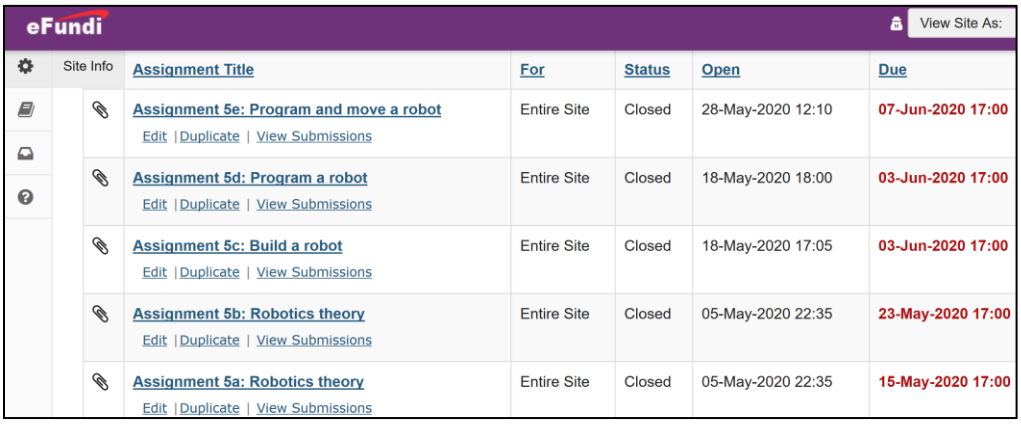
This section outlines the participants, the online learning management system (LMS) as well as data collection and analysis procedures.

3.1 Participants

Fourth-year Computer Science Education students participated in this research. The population consisted of three full-time students only. Although, this was an excellent opportunity to introduce and implement robotics using an online PBL approach, the aim was to refine activities for a larger population of distance students (using online learning) who will be introduced to robotics in another course in the next semester.

3.2 Online learning management system (LMS)

The lecturer (author) restructured the course to enable students to achieve the outcomes using online PBL. The students were required to manage and upload their assignments (PBL robotics tasks) on the eFundi university learning management platform (developed by Sakai) (Figure 4). In addition, students used WhatsApp to share information (social and cognitive presence) and the lecturer provided additional support regarding some challenges that students experienced with the simulation programs (teacher presence). Particular robotic scenarios were ‘drivers’ for active learning and group work that required problem solving, critical thinking and innovation while employing the PBL approach. Further, opportunities were provided for cooperative problem solving and the development of SDL. Students participated in an online learning community using Zoom (online discussion through a cloud-based platform) and submitted their assignments on eFundi as PDF files to enable online assessment using electronic marking tools. Figure 4 outlines the time schedule and due dates on eFundi.



Assignment Title	For	Status	Open	Due
Assignment 5e: Program and move a robot Edit | Duplicate | View Submissions	Entire Site	Closed	28-May-2020 12:10	07-Jun-2020 17:00
Assignment 5d: Program a robot Edit | Duplicate | View Submissions	Entire Site	Closed	18-May-2020 18:00	03-Jun-2020 17:00
Assignment 5c: Build a robot Edit | Duplicate | View Submissions	Entire Site	Closed	18-May-2020 17:05	03-Jun-2020 17:00
Assignment 5b: Robotics theory Edit | Duplicate | View Submissions	Entire Site	Closed	05-May-2020 22:35	23-May-2020 17:00
Assignment 5a: Robotics theory Edit | Duplicate | View Submissions	Entire Site	Closed	05-May-2020 22:35	15-May-2020 17:00

Figure 4. eFundi learning management system.

3.3 Problem-based tasks and student activities

PBL tasks and students’ responsibilities were worded as follows: you need to work individually on some tasks while others are group work. Download the LEGO Mindstorms software as well as the CoderZ simulator program. Study the YouTube videos (some links were given by the lecturer) to assist you in using these programming environments. (Note, with the rendering problem of robotics parts, students could not complete Assignment 5c online using Lego Digital Designer [Figure 2]).

- *Task 5d: LEGO Mindstorms environment* (similar to Figure 1). Each student needed to do the programming on his or her own to get used to the software environment. In this case, the task was worded as follows, “[m]ove the robot until the light sensor identifies the green line, then turn 90 degrees left, move forward until an obstacle is detected … ” Since you do not have a real robot (EV3 brick), you need to visualise the movements and test your programming code. After completion, all students should work together as a team. Use a platform, such as Zoom, to share your work. Each student uploads his or her code. Select among yourselves the task with the ‘correct’ programming code. Then brainstorm and elaborate on the code to perform particular movements on which your team has decided. Explain in a Word document the approach and/or steps that you have followed to test the programing code. Continuously reflect on and evaluate your final programming code.

- *Task 5e: CoderZ simulator* (similar to Figure 3a and 3b). Each student needs to program and move his or her own robot using the simulator. This is an open-ended problem. After completion of your program, cooperate in a team. Each student uploads his or her video on WhatsApp. Subsequently, your team needs to select the ‘best’ example and add some functionality. Collaborate on WhatsApp, justify your modifications and copy the screen prints (evidence of conversations and images) into Word. Continuously reflect on and evaluate your final programming code.

- Do the following in both tasks 5d and 5e:
    - Make video recordings of your programming efforts using your mobile phone. In addition, make screen prints of the programming code (diagrams).
    - After finalising these tasks, each student must complete the weekly reflective sheet template (comprising questions on responsibilities, cooperation, commitment, time management, addressing of challenges and peer assessment).

- Copy the programming code (screen print) to a Word document and number each task consecutively. Include the explanation of your program, testing approach and the steps that you followed as well as additional programming tasks, weekly reflective sheets and images, and submit these as a PDF file on eFundi. Also submit your short video recordings as zipped files. Note that time slots are set for each PBL task.

- Reflective questions: scan the QR code as a link to Google Docs and complete a short questionnaire regarding your experiences, team cooperation, approaches and insight on the online programming of robots.

3.4 Data collection an analysis

Date collection involved the PDF documents comprising programming code, explanation of the testing approach and steps, additional programming tasks, weekly reflective sheets, images, additional reflections on Google Docs and short video recordings. Data were manually analysed and some themes emerged.

4 Results and discussion

This section presents the results and addresses the research question. Table 1 outlines the themes that emerged from the results. Participant numbers are indicated in brackets. Quotations are reproduced verbatim and unedited.

Table 1. Themes that emerged from the results.

Theme	Students' feedback
Team work	"My group and I discussed and assisted each other when we were not sure of something as well as to reassure each other and motivate each other to continue to find a solution and the right way into doing something. We worked fairly well together … so the pace of discussion went well." (P1) "During this discussion, we had to make changes to the code, to allow the robot to work properly. All members were engaged and involved." (P2)
Challenges	"Only problems we really faced … as 2 of the 3 people in the group did not have the same version in Mindstorms …"(P1) "Programming without a robot is difficult to work with trial and error and to understand the type of programming at the beginning." (P3) "I kept trying to find new and better ways to program the code the way I wanted." (P2)
Reflection	"I personally think that we have achieved our own personal aims as well as group aims … we discussed … the videos and what we researched as well as programmed." (P1) "I really enjoyed doing this assignment. It is very nice that we need to work together as a team to improve on our work." (P2) "As a team, we have achieved our goals of programming the robot and doing what was required." (P3) "We used other 'parts' of code to get the robot to turn. We also decided on a different modification so that the colour sensor problem was not an issue anymore … This has been very insightful and I hope to do it with the learners in my class some day." (P2)

	"It was easier to think practically about the movements of the robot. We started with an easier application/software and built ourselves up to CoderZ. If we had immediately started with CoderZ, I would have been a lot more confused." (P2) "PBL - students will remember the work alot better if they have to solve the problems, instead of being spoon fed. They will also enjoy it more and be able to explore more. [...] It was something new and something I would never get the chance to do in any other subjects." (P2) "That programming a robot is very fun and interesting to do. It challenged me to think out of the box." (P3)
Approach	"We first spoke about our programs, using whatsapp [...] use my programming, to work on as a team, seeing that my computer was the only one with the latest version of the LEGO Mindstorm application. On zoom, we went through each instruction [...] We asked questions about whether the correct blocks were used and whether they were being measured correctly." (P2) "We had a ZOOM meeting to go through the program to see what works and what doesn't." (P3)
Evaluation	"We all agreed that the above programming was correct." (P2) "Yes, our team has achieved its aims. We discussed the programming and came up with the best possible solution to the programming problem." (P2)
Time	"Our team is progressing at a good pace. We talk about and determine deadlines for our assignments, meetings, discussions etc. and each member sticks to it." (P2) "We are progressing very well and we are ahead of schedule." (P3)
Resources	"Many YouTube tutorials watched to do the programs and to learn how to code." (P3)

The following question is addressed in this section: What are the challenges, opportunities and insights associated with a rapid transition to an online PBL environment for robotics?

Results indicate that students experienced several *challenges*. For example, they had to get used to the programming environment, some members did not have the same Mindstorms version, and initially it was difficult to do coding without a robot (Mindstorms EV3 brick) as they had to understand the programming code and the resultant robot movement. As a result, participants studied YouTube videos to assist them. Participants approached the problems as follows: they discussed the programs using WhatsApp to comment on one another's coding. Thereafter, they used Zoom, discussed each instruction and asked questions regarding the use of the correct programming blocks and their functionality. During Zoom meetings, students changed the programming code to ensure that the robot worked properly.

Regarding *opportunities*, participants experienced working in problem-based teams as positive in the sense that all members attended the meetings online, they were committed, shared their knowledge, improved their programming and contributed to the development of the final code. Further, they assisted each other, reassured and motivated each other to find a solution and worked well together. One student remarked, "I personally think that we have achieved our own personal aims as well as group aims." The team progressed at an acceptable pace and they were able to submit their assignments before the deadline.

Moreover, participants reflected before, during and after programming tasks. Students did some research, studied videos and worked through the requirements before commencing with the assignments. One participant said, "[d]uring this discussion, we had to make changes to the code, to allow the robot to work properly." The outcomes were achieved and students assessed each other with average marks as follows: Participant 1 (9/10), P2 (10/10), and P3 (8/10).

In accordance with the FOLC model (see 2.2), examples of the construction of knowledge (*knowing)*, cooperative solving of problems (*acting)* and community of practice (*being)* were identified where students collaborated online to address robotics tasks (Table 2).

Table 2. Application of the FOLC model in the online learning of robotics.

Principle	Selected examples
Construct knowledge	"We asked questions about whether the correct blocks were used and whether they were being measured correctly." "We discussed the programming and came up with the best possible solution." "PBL - students will remember the work alot better if they have to solve the problems, instead of being spoon fed. They will also enjoy it more and be able to explore more." (cognitive presence)
Cooperate in solving problems	"We had a ZOOM meeting to go through the program to see what works and what doesn't" "I personally think that we achieved our own personal aims as well as group aims." (social presence). "This has been very insightful and I hope to do it with the learners in my class some day."
Form a community of practice	"My group and I discussed and assisted each other … reassure each other and motivate each other to continue to find a solution." "We worked fairly well together."

The lecturer developed some *insights* regarding the rapid transition from full-time to online learning:

- It is essential that full-time students should continue with the course online without losing the benefits of active and responsible learning.
- The lecturer should plan properly, provide clear expectations, and problems should be crafted for students in an online environment.
- Teacher's presence is essential. The lecturer should facilitate, guide and assist students.
- Social and cognitive presence is crucial, particularly in an online PBL environment.
- Technical issues may be a challenge to ensure that all members use the same software; therefore, the lecturer should test the software on different platforms before students commence with the tasks.
- Members need to be actively involved in functioning teams where all contribute to solve the robotics problems in hand.
- Students should be committed and have to consider online learning as an opportunity for a community of practice.
- Compliance to PBL principles in an online learning environment is not trivial and students should be assisted in this regard.
- PBL as student-centred approach provides for the sharing and critical evaluation of ideas (*knowledge*).
- Online PBL activities should be student-driven and should involve active participation (*acting*).
- To counteract isolation, it is essential to provide for online collaboration (e.g. using Zoom or Microsoft Teams) in the sense of being present in enhancing one another's learning (*being*).

5 Conclusion

The current research considered the challenges, opportunities and insights gained regarding an introductory robotics course due to a rapid transition to online PBL. Results indicate that, although students experienced some challenges, they were also exposed to new opportunities to collaborate online. Certain insights emerging from the rapid transition from full-time to online learning were gained to enhance responsible and active learning when introducing robotics to students. Limitations involved that only three students participated. Future research may involve the development and/or use of various platforms to optimise online PBL.

6 References

Abdullah, A. H., & Kian, N. T. (2019). Modeling factors for industry experts' intention to participate in online scaffolding. *International Journal of Engineering & Technology, 8*(1.8), 73-76.

Avello, R., Lavonen, J., & Zapata-Ros, M. (2020). Coding and educational robotics and their relationship with computational and creative thinking. A compressive review. *Revista de Educación a Distancia, 20*(63), 1-21.

Baloche, L., & Brody, C. M. (2017). Cooperative learning: Exploring challenges, crafting innovations. *Journal of Education for Teaching, 43*(3), 274-283.

Blayone, T. J., Van Oostveen, R., Barber, W., DiGiuseppe, M., & Childs, E. (2017). Democratizing digital learning: theorizing the fully online learning community model. *International Journal of Educational Technology in Higher Education, 14*(1), 1-13.

CoderZ. (2019). CoderZ. Retrieved from https://gocoderz.com/

Del Rio, C., & Malani, P. N. (2020). COVID-19—new insights on a rapidly changing epidemic. *Jama, 323*(14), 1339-1340.

Gray, A. (2016). *The 10 skills you need to thrive in the Fourth Industrial Revolution.* Paper presented at the World Economic Forum.

IOL. (2019, Mar 25). School robotics, coding roll-out from grades R to 9 next year. *Cape Times.* Retrieved from https://www.iol.co.za/capetimes/news/school-robotics-coding-roll-out-from-grades-r-to-9-next-year-20076838

Kolmos, A. (2017). PBL Curriculum Strategies: From Course Based PBL to a Systemic PBL Approach. In A. Guerra, R. Ulseth, & A. Kolmos (Eds.), *PBL in Engineering Education* (pp. 1-12). Rotterdam: Sense Publishers.

Lego. (2020). Lego Ditigal Designer. Retrieved from https://www.lego.com/en-us/service/help/products/themes-sets/digital-designer/about-lego-digital-designer-408100000007854

Mohd-Yusof, K. (2017). Sustaining Change for PBL at the Course Level: Taking the Scholarly Approach. In A. Guerra, R. Ulseth, & A. Kolmos (Eds.), *PBL in Engineering Education* (pp. 13-32). Rotterdam: Sense Publishers.

Pollak, M., & Ebner, M. (2019). The Missing Link to Computational Thinking. *Future Internet, 11*(12), 1-13.

Savery, J. R. (2015). Overview of problem-based learning: Definitions and distinctions. In A. Walker, H. Leary, C. E. Hmelo-Silver, & P. A. Ertmer (Eds.), *Essential readings in problem-based learning: Exploring and extending the legacy of Howard S. Barrows* (pp. 5-15). West Lafayette, IN: Purdue University Press.

Schultze, U., & Brooks, J. A. M. (2019). An interactional view of social presence: Making the virtual other "real". *Information Systems Journal, 29*(3), 707-737.

Schwab, K. (2016). *The Fourth Industrial Revolution*. New York: Crown Business.

Valiente, D., Payá, L., Fernández de Ávila, S., Ferrer, J., Cebollada, S., & Reinoso, O. (2019). *Active Learning Program Supported by Online Simulation Applet in Engineering Education.* Paper presented at the Proceedings of the 9th International Conference on Simulation and Modeling Methodologies, Technologies and Applications. SCITEPRESS-Science and Technology Publications, Lda.

Yiannoutsou, N., Nikitopoulou, S., Kynigos, C., Gueorguiev, I., & Fernandez, J. A. (2017). Activity plan template: a mediating tool for supporting learning design with robotics. In M. Merdan, W. Lepuschitz, G. Koppensteiner, & R. Balogh (Eds.), *Robotics in Education. Research and Practices for Robotics in STEM Education* (Vol. 457, pp. 3-13): Springer.

Science clubs and scientific and technological fairs: encouraging girls in exact sciences, engineering and information technology

Laurete Zanol Sauer[1], Isolda Gianni de Lima[1], Odilon Giovannini[1], Valquíria Villas-Boas[1]

[1]University of Caxias do Sul, Caxias do Sul, Brazil

Email: lzsauer@ucs.br, iglima@ucs.br, ogiovannini@gmail.com, vvillasboas@gmail.com

Abstract

This work is the report of an educational experience carried out as part of the actions of the project "Encouraging Girls in Science, Engineering and Information Technology" (EM&CT), under development at the University of Caxias do Sul (UCS). Through various activities promoted by UCS with five elementary and high schools, located in the region covered by UCS, the project has, among its main objectives: to contribute significantly to scientific and technological development and innovation in the schools of the region, and to encourage participation and training of female students for careers in exact sciences, engineering and information technology. Among the central actions of the project are the creation of a Science and Astronomy club and the promotion of scientific and technological fairs in each one of the co-executing school. In 2019, students of the co-executing schools, in their Science and Astronomy Clubs, developed projects that were presented at the fairs held at their schools. Subsequently, these research projects were presented selected works were presented at the Scientific and Technological Fair of Serra Gaúcha (MOSTRASEG), held at UCS. The results obtained showed that, in the way activities were promoted, participation, with projects carried out by students, in the referred events is one of the possibilities to achieve the proposed objectives.

Keywords: Science and Astronomy Clubs; Scientific Fairs; Project-based Learning; University-K12-Community Integration

1 Introduction

Proposing teaching and learning methodologies that aim to arouse students' interest in science is a way to promote a taste for scientific and technological areas. It is possible to awaken the scientific curiosity of young people through new pedagogical environments in their school context, avoiding the reproduction of information from traditional classes, which more prepare students to do well in tests and less involve them in the process of learning and in the emotion of the discovery. Particularly, attracting girls to science has been also an apprehension for many researchers concerned with gender issues and the importance of female participation in science, technology engineering and mathematics (STEM) (Rasmussen & Hapnes, 1991; Anderson, 1994; NSF, 1998; Blickenstaff, 2005; Du & Kolmos, 2009; Tessari & Villas-Boas, 2013; Dasgupta & Stout, 2014; González-González et al, 2018; Sauer et al, 2020).

In Brazil, the process of insertion of women in scientific and technological careers occurred in the same proportions as in other countries of the world, however, during much of the twentieth century there was still a great prejudice related to women's aptitude or even to their intellectual abilities to pursue these careers (Tessari & Villas-Boas, 2013).

In this context, incentive programs and valorisation of female participation in STEM are presented as a solution through which this scenario may have possibilities to be reversed. In the last decade, the National Council for Research and Development (CNPq) has launched a considerable number of public calls aimed at supporting projects intended to stimulate the promotion of scientific fairs and the education of women for careers in Exact Sciences, Engineering and Information Technology in Brazil.

This paper reports, actions related to the creation of science clubs and scientific and technological fairs of a project approved in the last public call of CNPq, and that is underway at the University of Caxias do Sul, a community institution of higher education located in the southern region of Brazil. This project, called "Encouraging Girls in Science, Engineering and Information Technology" (EM&CT), is developed in partnership with five public elementary and high schools in the region of the university and is coordinated by a team of instructors that has been promoting for over ten years various activities to encourage young students in the field of Exact Sciences and Engineering. The main objective of this study is to determine the progress achieved by the female students participating in the project, particularly with regard to science clubs and fairs, and to collaborate with these results for STEM education in Brazil and for engineering education at the level of basic education, awakening vocations and talents.

2 The Project EM&CT

All the actions of this project were proposed with the intention of valuing the school as a strategic and important space for the promotion of good pedagogical practices, to approximate the elementary and high schools and the university, to encourage female students from these schools to careers in Exact Sciences, Engineering and Information Technology, and to combat the dropout of female undergraduate students from the university, which occurs mainly in the early years, creating opportunities for them to act as scholarship holders for research and extension projects. Despite this project being conceived for girls, boys are also welcomed to participate in the activities.

Among the central actions of the project, we would like to highlight the creation of a Science and Astronomy club and the promotion of scientific and technological fairs in each one of the co-executing school.

The methodology of planning and carrying out the project actions involves the joint action of the participants of the university and the co-executing schools. This team, which comprises 13 faculty and five undergraduate students from the university, along with five teachers and 15 students from the co-executing schools, is responsible for carrying out activities at the Science and Astronomy club and to promote a scientific and technological fair in each co-executing school. These activities reach an estimated population of approximately 1,000 students from the co-executing schools.

In order to achieve the proposed objectives, the activities related to the Science and Astronomy club and to the scientific and technological fair were conceived considering active learning strategies and methods, in particular, project and problem based project (Savin-Baden & Howell-Major, 2004; Graaff & Kolmos, 2007; Bell, 2010; Villas-Boas et al., 2016; Merritt, 2017; Beier et al, 2019), in order to establish connections between the basic knowledge of the Exact and Natural Sciences and the practical applications to solve real problems of students' daily lives.

The activities, in this project, are intended to make knowledge accessible as it promotes the development of the autonomy of those involved in the process, as well as it seeks to promote the knowledge building and to promote interdisciplinary posture and practice.

3 Science Clubs

A science club is a pedagogical space for scientific studies in a perspective of building and producing knowledge, presenting strong integration with the community, and finding its participants involved in an atmosphere of cooperation and solidarity (Pires *et al*., 2007). In this project, these clubs were designed to be created and managed at each co-executing school by the responsible teacher and fellow students of the project under the guidance of the coordinating team from the university. The activities carried out at each Science and Astronomy club take place during overtime and focus on studying, solving complex problems, developing projects and debates on topics involving science and technology. In this context, the club is the place where the "members" expose their ideas, their curiosities and seek to build knowledge, collaboratively, and using the scientific methodology. At the Science and Astronomy clubs, girls and boys developed questions, delineated a project, and were guided through research under their teacher's supervision. In project-based learning, the students' choice for what they want to research in their projects is the key element of this approach. Teachers supervise each step of the process and approve each project theme before the student starts to develop it. Students with similar research questions are advised to work cooperatively, thus nurturing 21st century collaboration and communication skills and honouring students' individual learning styles or preferences (Bell, 2010).

The Science and Astronomy Clubs are active in the co-executing schools of the EM&CT project and present the following history and current scenario:

- at Farroupilha school, the creation of the Science and Astronomy Club was encouraged by the EM&CT project team and is in its implementation phase, with the goal of fully integrating itself into the school's activities of 2020. In 2019, the school team, involved in the project, declared that it was touched by the others and started to carry out three projects, among which one of the projects managed to participate in the Scientific and Technological Fair of Serra Gaúcha (MOSTRASEG), an event to be described in section 4.2. We consider this an advance and merit of the EM&CT project, whose teacher representative of the school declared that they had never developed projects with scientific methodology.
- at Tancredo Neves school, the Science and Astronomy Club was created successfully in 2019 and as an EM&CT project activity. The school managed to implement several actions and projects, including organizing the school's own Scientific Fair and participating with a project in MOSTRASEG.
- at the Melvin Jones school, a space that served as a warehouse for scrap materials was revitalized. The scholarship holder teacher, together with the scholarship girls and other volunteer students, selected and labeled usable materials for use in the Science and Astronomy Club. Initially, in the new space, the workshops promoted by the EM&CT project were held, and shortly thereafter, work with projects, among which, ten participated in MOSTRASEG.
- at the Elisa Tramontina and João Pilati schools, the Science and Astronomy Clubs were already active, having been created before their participation in the EM&CT project.

During 2019, in addition to carrying out the projects under the guidance of teachers, the following workshops were held at the aforementioned Science and Astronomy Clubs: Astronomy; Preparation of alcoholic tincture, from fresh plants; Solid waste; Exploring smartphones; Information systems in digital media and Computational thinking and Robotics. These workshops were all promoted by the EM&CT project, and guided by UCS teachers to be applied to students from co-executing schools.

Figures 1 and 2 show images of students working in their Science and Astronomy Clubs.

Figure 1. Science Club at Melvin Jones School

Figure 2. Science Club at Elisa Tramontina School

4 Scientific and Technological Fairs

The scientific and technological fair, organized in each co-executing school of the EM&CT project, is an activity in which students present research projects developed throughout the year. The fair has among its main objectives (Barcelos, Jacobucci & Jacobucci, 2010): to awaken or develop a taste for research and experimentation; develop students' creativity and critical thinking; develop students' social habits and attitudes and a sense of responsibility; develop students' specific skills, interests and competences; in addition to integrating the community with the school.

To achieve these objectives, students are involved in carrying out projects, guided by teachers participating in the Continuing Education Course, promoted by the EM&CT project, in which one of the objectives is to promote skills in research methodology. The scientific and technological fair is organized and coordinated, in each co-executing school, by the scholarship holder teacher, assisted by students from the Science and Astronomy Clubs.

4.1 Scientific Fairs in the co-executing schools

The schools' scientific fairs, promoted considering the objectives already mentioned, intend to provide students with access to the scientific community, through research. Although the projects presented are not innovative, considering the social reality in which each of the schools is inserted, the incentive and support for carrying out research projects, throughout K-12, can be seen as a first step towards the formation of researchers at the basic level, who may become, in the future, researchers of fundamental questions for the progress of Science and Technology. As one of the results of the Science and Astronomy Clubs to be highlighted, entrepreneurship can already be observed in students in the final years of elementary school and, even more, in high school.

The development of scientific fairs in each of the schools is always a reason for great expectations and satisfaction on the part of all those involved (school community, students and teachers), as it is a time when all the projects, carried out and supervised in stages, are presented in their final version. During students' explanations, while presenting their work, one can perceive the commitment, the challenges faced and the evolution to reach the objectives that they set out to achieve. Indeed, each student also recognizes his own evolution and demonstrates its personal satisfaction. Research often creates a perspective for the future of young people who had no perspective at all, and also opens horizons and makes the student realize that she/he is capable of much more than she/he believes, much more than society imagines and all of this going through the paths and challenges that science presents her/him.

The scientific fair is the moment when it is possible to observe skills such as oral communication, student engagement and motivation. These skills are the result of the work developed with project-based learning. When attending a presentation, for which the student is responsible, it is evident her/his dedication and enthusiasm to publicize her/his work and her/his achievements with the project. It is also visible that the teacher's interaction and encouragement are fundamental for the student to recognize her/his full potential.

Created to be spaces for discussions on topics related to science, technology, society and the environment, the Science and Astronomy Clubs promote the development of projects on these topics, in addition to other scientific issues, considering that they are not isolated from the social, environmental, economic and political context. In 2019, considering the productions of the four Science and Astronomy Clubs referred to in session 3, we had the involvement of approximately 135 teachers, who guided about 422 projects, with the approximate participation of 1519 students, on the most varied themes involving different areas of knowledge and, addressing a wide diversity of research questions, such as environmental, social, health and economics, science and technology, regional culture, history, entrepreneurship, among others. Figures 3 and 4 show scenes from the Scientific Exhibitions that took place in two of the co-executing schools.

Figure 3. Scientific fair at João Pilati school

Figure 4. Scientific fair at Elisa Tramontina school

The students expressed interest and involvement with the scientific fair, both for the social interaction among colleagues, school and family, and for the opportunity to present something that they developed and produced, resulting in success in carrying it out.

The testimony of the scholarship holder teacher of one of the co-executing schools summarizes one of the main achievements of the scientific fair, validating the above assumptions: "*my greatest professional accomplishment took place today. The students were all engaged, all in search of knowledge, presenting themselves for all the community. It was an unforgettable moment. I believe that this is education. Teachers very enthusiastic about the projects and in questioning the students to evaluate the projects. Students from other schools are coming to appreciate students' projects, making them feel valued for their studies. Ex-teachers and ex-alumni helping and valuing the presentation of projects by students*".

Table 1 shows the 37 best projects from the Science and Technology Clubs of the co-executing schools, approved to participate in MOSTRASEG. In Table 1, the name of the projects for each school is separated by semicolon. These projects were developed by a total of 63 girls and 26 boys.

Table 1. Best Projects from co-executing schools.

School	Projects
Tancredo de Almeida Neves	MoveT, a universe of possibilities.
Melvin Jones	Automotive Protection; Medicinal Plants: a study through the construction of a website; Piezoelectricity: piezoelectric uses; Pets: application development aimed at the residents of Caxias do Sul; Totalitarian Governments; Rare diseases: concepts and Brazilian legislation; Depression of adolescents in the XXI century; Science Club: a possible space; The influence of art on the development of mentally chalenged children
João Pilati	Plastics and microplastics; The use of chatbots based on Artificial Intelligence for information; Vaccination: Problem or solution?; Weight sensor; Guide for the visually impaired; Biodegradable plastic.
Elisa Tramontina	Study for the development of organic paint to reduce environmental impacts and reuse of food; Study on the use of technologies in the school environment and their integration with current teaching methodologies; Study of alternative replacement of industrial glue components by tree sap for greater safety and resistance; Who are they?; Study of the use of hovenia dulcis as a way of analyzing the impact of exotic plants on our environment; Study of the replacement of paraffin present in candles with vegetable wax and cooking oil; The study of the influence of sound waves on the development of plants; Alternative treatment for wastewater from the washing machine and its relationship with fluid mathematics (phase II); Study of a method of producing a pencil from the vane; Carlos Barbosa in a matter of welcoming exchange students; Incorporation of manihot esculenta peel in the manufacture of incenses that are less aggressive to the environment and its role in the health of Indian women; Study of a method of creating a winch to reposition of dead people; Art gift study: research on the concept of thinking associated with the right and left brain; Medicine alarm clock: an alternative to help organize medicines for the elderly; Depression: 21st century science; Study of the feasibility of extracting cannabidioids from ruta graveolens for possible control of Parkinson's tremors; Use of araucaria angustifolia seed husks as a composite in wood agglomerates and MDF panels; Feasibility study of the use of peanut shell in the production of wood substitute panels; Use of lauric acid to fight acne.
Farroupilha	Learning deficit of high school students in Portuguese and Mathematics

4.2 MOSTRASEG

MOSTRASEG is an annual scientific and technological regional fair for students in 9th through 12th grades from cities close to Caxias do Sul, where is located the University main campus. At MOSTRASEG, students have a chance to show others their projects about their own scientific investigations and compete against the young scientists from other schools. To participate in MOSTRASEG, the research projects developed by the students are selected from their school's science fairs. The team project is formed by no more than three students who are guided by their teachers.

In September of 2019, the 11th MOSTRASEG occurred, and it was the biggest edition to date with 150 projects and more than 350 students from 26 schools. The female participation was 60% of total and 65% of the projects had one girl in the team at least.

Each project at MOSTRASEG are assessed by two researchers of UCS, and at least one of the evaluators works on the same field of the project. The evaluators receive the projects one week before the fair starts for a previous assessment. Then, in the two days of fair, the evaluators walk by the exhibition court and interview the project team for the final assessment. MOSTRASEG is a free event and all community is welcomed.

Figure 5 and 6 show the fair court with the students presenting their research projects.

Figures 5 and 6. Images of MOSTRASEG.

4.3 Co-executing schools' projects that received a prize at MOSTRASEG

The projects awarded in MOSTRASEG, by students from co-executing schools, are listed in Table 2.

Table 2. Projects that received a prize at MOSTRASEG.

Prize	Project	School
Sustainability, Renewable energy and environment	Study of the use of *hovenia dulcis* as a way of analyzing the impact of exotic plants on our environment	Elisa Tramontina
Digital Technologies	The use of chatbots based on Artificial Intelligence for information	João Pilati
2nd place Elementary School	Guide for the visually impaired	João Pilati
3rd place High School	Incorporation of *manihot esculenta* peel in the manufacture of incenses that are less aggressive to the environment and its role in the health of Indian women	Elisa Tramontina
1st place High School	Study of the feasibility of extracting cannabidioids from *ruta graveolens* for possible control of Parkinson's tremors	Elisa Tramontina

4.4 Working with the feedback

After MOSTRASEG ended, a week later, an evaluation meeting of the projects that were developed in science clubs by scholarship holder students from co-executing schools was held at UCS. This activity was conducted by instructors of the EM&CT team with the aim of discussing and clarifying the items in the MOSTRASEG evaluation form, and to encourage self-assessment of the work, as a way of reflecting on aspects of improvement of new research projects to be carried out. in school science clubs.

At the first moment of this meeting, the scholarship girls from each school, accompanied by the scholarship holder teachers, got to know the MOSTRASEG evaluation form, discussed and recorded their doubts and understandings of the aspects that were evaluated. One by one, the following items were highlighted and proposed to be examined: field notebook, bibliographic binder, work exhibition panel, oral presentation, research relevance, applicability, application of scientific methodology and research report; exactly as they appear in the evaluation form used by UCS instructors who constitute the group of project evaluators.

The second moment was an exchange of ideas among all participants in the meeting. The scholarship girls reported what they understood about the evaluation items and presented questions to clarify their doubts. The scholarship holder teachers also participated, collaborating with explanations and inquiring about points that were unclear. The discussions were mediated by the instructors of the EM&CT team, who expanded and deepened clarifications for the doubts presented.

Then, as a third step, a self-assessment was proposed: the scholarship girls analyzed their own project and assigned a score from zero to ten for each item, as shown in the evaluation form, and wrote a brief opinion as a justification. for the assigned score.

In the fourth moment and final activity of the meeting, the scholarship girls reviewed their materials (field notebooks, panel photos, bibliographic binder and research report) seeking to analyze, identify and share aspects to be improved in their records, aiming at the next editions of MOSTRASEG.

Still, regarding this activity of evaluating the projects developed and presented by the scholarship girls at MOSTRASEG, we highlight its importance due to the active participation strategy adopted for its development. In addition, as it was promoted after MOSTRASEG, this activity allowed the girls to reflect on what they experienced in the entire process of developing and presenting their projects. With that, and with the interactions promoted, they were able to assign meaning to the aspects evaluated in their projects. Finally, the girls identified that they could improve their performances, as EMC&T fellows and while acting in the Science and Astronomy Clubs of their schools, suggesting that they can become science researchers.

5 Final Remarks

One of the guiding principles for the creation of science clubs is research as the process that, integrated into the school's daily routine, guarantees the suitable appropriation of reality, as well as projects possibilities for intervention. It combines the social character with the protagonism of the researchers (FREIRE, 1980), making them critical and reflective. With this same view, Demo (2000) justifies that, when going through the research process, the student has the opportunity to develop critical thinking, exercise reflection, becoming producer of knowledge and not just a transfer of information, in fact, with regard to research as a pedagogical principle, we highlight that: [...] research promotes the development of scientific attitude, which means contributing, among other aspects, for the development of conditions to interpret, analyze, criticize, reflect, reject closed ideas throughout life, learn, seek solutions and propose alternatives, enhanced by investigation and for the ethical responsibility assumed in the face of political, social, cultural and economic issues. [...] a conception of scientific investigation that motivates and guides action projects, aiming at improving the community and the common good (KÜLLER, 2011).

In this context, the EM&CT project structured this proposal that seeks to overcome the fragmentation of programs and actions, aiming at the creation of science clubs, as spaces for carrying out research and projects. All of this, taking place in a school where young people develop a culture through protagonism in transformative activities, with the possibility of exploring their vocational interests or professional options, their perspectives on life and social organization, thus exercising their autonomy in formulating and rehearsing the realization of their life and society projects (KÜLLER, 2011).

As for the contribution of the study developed and presented here to the practice of basic education teachers/educational practitioners, it is worth pointing that all these activities were developed with five teachers in the Continuing Education Course, already mentioned, whose main objective has been to involve teachers from the co-executing schools as the main ones involved in the continuity of the actions that are being promoted in the project. In addition to the continuity of actions, it is intended that these teachers are multipliers of the ideas and actions that have been promoted with other students and with other teachers and managers of their schools. The course has been developed in line with the offer of the project's activities, but expanding the discussion on the theoretical aspects that underlie them, considering scientific, technological and pedagogical knowledge. Other editions of this course are being scheduled to assist teachers/educational practitioners from other schools in the region.

With activities like this, the school can, in addition to teaching, exercise the role of encouraging 21st century participation, teamwork, proactivity, creativity, collaboration and communication skills.

6 References

Anderson, V. (1994) How engineering education shortchanges women, *Journal of Women and Minorities in Science and Engineering, 2*, 99-121.

Barcelos, N. N. S.; Jacobucci, G. B.; Jacobucci, D. F. C. (2010).Quando o cotidiano pede espaço na escola, o projeto da feira de ciências “vida em sociedade” se concretiza. *Ciência & Educação, 16(1)*, 215-233.

Beier, M. E., Kim, M. H., Saterbak, A., Leautaud, V., Bishnoi, S., & Gilberto, J. M. (2019). The effect of authentic project-based learning on attitudes and career aspirations in STEM. *Journal of Research in Science Teaching*, *56*(1), 3-23.

Bell, S. (2010). Project-based learning for the 21st century: Skills for the future. *The clearing house*, *83*(2), 39-43.

Blickenstaff, J. C. (2005). Women and science careers: leaky pipeline or gender filter? *Gender and education*, *17*(4), 369-386.

Dasgupta, N., & STOUT, J. G. (2014). Girls and Women in Science, Technology, Engineering, and Mathematics STEMing the Tide and Broadening Participation in STEM Careers. *Policy Insights from the Behavioral and Brain Sciences*, *1*(1), 21-29.

Demo, P.. Pesquisa: princípio científico e educativo. 12 ed. São Paulo: Cortez, 2006.

Du, X. & Kolmos, A. (2009). Increasing the diversity of engineering education–a gender analysis in a PBL context. *European Journal of Engineering Education*, *34*(5), 425-437.

Freire, P. *Conscientização: teoria e prática da libertação*. São Paulo: Moraes, 1980.

González-González, C. S., García-Holgado, A., de los Angeles Martínez-Estévez, M., Gil, M., Martín-Fernandez, A., Marcos, A.& Gershon, T. S. (2018, April). Gender and engineering: Developing actions to encourage women in tech. In *2018 IEEE Global Engineering Education Conference (EDUCON)*, 2082-2087.

Graaff, E. & Kolmos, A. (Eds.). (2007). *Management of Change: Implementation of Problem-Based and Project-Based Learning in Engineering*. Roterdam: Sense Publishers.

Küller, J. A. (2011). Protótipos curriculares de Ensino Médio e Ensino Médio integrado: resumo executivo. *Série Debates ED–Unesco*, (1).

Merritt, J., Lee, M. Y., Rillero, P., & Kinach, B. M. (2017). Problem-based learning in K–8 mathematics and science education: A Literature review. *Interdisciplinary Journal of Problem-Based Learning*, *11*(2). doi: 10.7771/1541-5015.1674.

National Science Foundation. (1998) *Women, Minorities and Persons with Disabilities in Science and Engineering*. Arlington, VA: NSF, p. 99-338,.

Pires, M.G.S. (2007). Motivações e expectativas de alunos/as do ensino fundamental na participação de um Clube de Ciências. *VI Encontro Nacional de Pesquisa e Educação em Ciências*, Florianópolis.

Rasmussen, B.&Hapnes, T. (1991) Excluding women from the technologies of the future? A case of the culture of computer science, *Futures*, *10*, 1107-1119.

Sauer, L. Z., Reis, C. E. R., Dall’Acua, G, Lima, I. G., Giovannini, O. & Villas-Boas, V. (2020, April). Work-in-Progress: Encouraging Girls in Science, Engineering and Information Technology. In *2020 IEEE Global Engineering Education Conference (EDUCON)*, 28-32.

Savin-Baden, M.; Howell-Major, C. (2004). *Foundations of Problem-based Learning*. McGraw-Hill Education, New York.

Tessari, L. D.&Villas-Boas, V.(2013) A Participação Feminina nos Cursos de Engenharia da UCS: A História e o Papel das Atividades de Divulgação Científica. *InAnais do XLI Congresso Brasileiro de Educação em Engenharia - Educação em Engenharia na era do conhecimento*. Brasília: Editora ABENGE.

Villas-Boas, V., Martins, J. A., Giovannini, O., Sauer, L. Z., Booth, I. A. S. (Eds.). (2016)*Aprendizagem Baseada em Problemas: estudantes de ensino médio atuando em contextos de Ciência e Tecnologia*. 1. ed. Brasília: Editora ABENGE.

Implementing Problem-Based Learning Model for Elevator Spare Part Procurement Planning in a Group of Airport Buildings

Tanutta Klongakara, Wuttinan Nunkaew

Department of Industrial Engineering, Thammasat School of Engineering, Thammasat University, Thailand

Email: tanuttak@gmail.com, nwuttinan@engr.tu.ac.th

Abstract

This paper proposes a framework of elevator spare part procurement planning decision in a group of airport buildings based on a Problem-based Learning (PBL) model. According to the lack of experience of newly graduated engineers in this field, they could not efficiently determine procurement planning concerning the yearly budget and several related factors. By organising a group of brainstorming team and applying the PBL model, newly graduated engineers have practised on procurement planning and discussed with a team of senior engineers who have more experiences in this field. The main discussion process has great benefits not only for junior engineers but also for senior engineers who can get some new points of view to creating the solution. The crucial criteria for elevator spare parts procurement planning, obtained from group brainstorming meetings and the PBL model, have been listed as the cost of spare parts purchasing, the lifetime of spare parts, the delivery lead times, and the warehousing management. These criteria were concluded in the procurement framework resulting in an enhanced performance of procurement planning as well as the reduction of workflow.

Keywords: Problem-Based Learning; Elevators Spare Parts; Brainstorm; Procurement Framework.

1 Introduction

Over the past few years, everyone has been keeping an eye on the tourism industries. The recent increase of tourists is a good guarantee of the growth of this sector. Airports of Thailand company limited (AOT), the state-owned enterprise, has operated as a state-commerce service provider for aviation business services. According to AOT's report (2018) and its overall business performance, the increase in the number of flights has also resulted in the increasing number of passengers utilizing the airports. Don Mueang International Airport (DMK) is one of the airports operated by AOT and provides facilities, high-efficiency technology and international standard security systems, this increases the ability of the airport to provide the airlines and passengers with uninterrupted services and high-quality operations. The preparation of the accessible equipment is a key responsibility of the maintenance department. Crucially, the equipment maintenance tasks require systematic planning. Maximising management means achieving the maintenance goal which is the ability to maintain the good condition of equipment and prevent damage, to provide them with the availability for service at all times, to prolong the service life, and to minimise cost. With regard to the elevator equipment, the spare parts inventory needed for maintenance process should be ready for emergency situations such as the case of elevator failure which could happen any time.

The maintenance department has many responsibilities such as planning of maintenance strategy, warehouse control, inventory management and procurement of spare parts. The equipment of elevators are quite complex because they have more details to pay attention to than other industrial machines (Moeuf, Pellerin, Lamouri, Tamayo-Giraldo, & Barbaray 2018). The maintenance department operates 24 hours daily and the staffs need to have proper maintenance preparation which would enable them to work against the clock to meet the strict deadline. Other important issues are the difficulties of the work since the equipment can be complex and various in kinds. Moreover, their lifetimes are different. There are various models and brands of the equipment and the government’s procurement processes are time-consuming and comprise of many steps. Therefore, the maintenance requires those who are specialised or experienced to work in this field since they are familiar with the nature of the work to make proper and efficient decisions with regard to the elevator maintenance process. Since the demand of new graduated engineers with several skills are higher than the past, the newly graduated engineers should take the opportunity to learn from their seniors and expert teams to gain different skills needed in the industry (ERASMUS+ CBHE PROJECT, 2019). According to the empirical study from Singha, Devikaa, Thiedeb, & Singh (2019), the skills that the newly graduated engineers need the most are expertise skills relating to fast learning abilities. The process of spare parts procurement planning from maintenance viewpoints can be improved by using new technologies of equipment such as a new remote maintenance system (Yamashita, Nakamura, Sakai, Fukata, & Sekine, 2017). This new device can utilise technology to help the equipment work more efficiently. However, in the case of elevator maintenance in the airport, the elevator parts are usually old and in need of changes. Maintenance tasks need an approval from the department of state budget in advance which can be time consuming. For all of these reasons, the maintenance team should aim to develop the skills of new graduated engineers by applying some PBL steps which focus on the results of the learning process and problem analysis to speed up the procurement planning process and to create criteria framework from the application of the PBL model.

2 Maintenance Strategy for Spare Part Planning

Several complex factors can be found within the procurement planning process. Maintenance team should concern as much as they can to cover all of the factors that affect the procurement plan. Complex maintenance tasks often involve the replacement of old parts with more modern parts to make the device work more efficiently. It is usually project-based and the problem would not recur. The most common maintenance strategy is preventive, subdividing the maintenance tasks under the right maintenance strategies. Parts are usually not be replaced until they are unable to operate (breakdown). Under preventive maintenance strategies, the goal is to replace parts before the failure and this depends on the policy of the team and the types of machine in question. The subdividing of maintenance tasks is the right choice for deteriorating parts such as electronic device for deteriorating-resistant parts. It is especially useful to follow preventive maintenance strategies. Arts (2013) refers to the maintenance guidelines and states that the internal device maintenance is different from the maintenance caused by customer usages in which the maintenance tasks often require many resources. The most important resources are:

- Experts, technicians, engineers or other trained professionals
- Tools and device
- Spare parts

Maintenance strategy is crucial with regard to the spare parts planning. Maintenance strategies determine when parts or equipment must be changed or maintained. In this subsection, we focus on maintenance/replacement decisions. Our case study suggests that the replacement of specific parts is more efficient than changing the entire body of the machine. Figure 1 provides an overview of maintenance strategies (Arts, 2013).

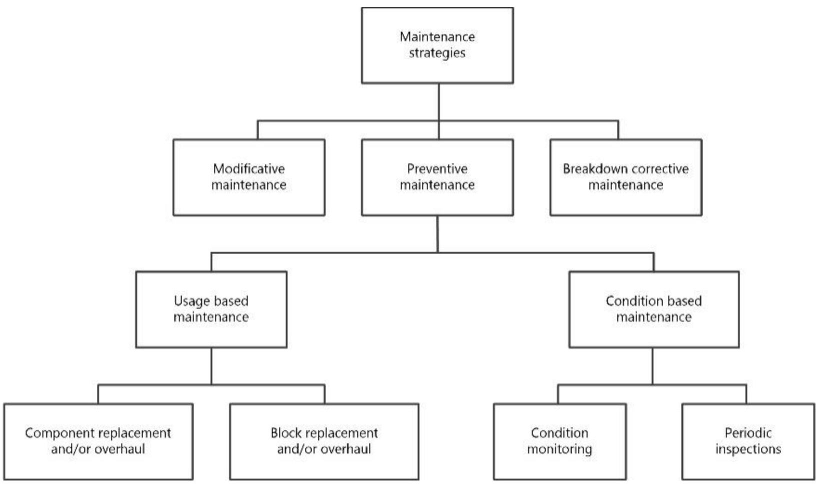


Figure 1. An overview of maintenance strategies.

In addition to choosing the right maintenance strategy for the policy and equipment, it is important to choose the right as well as experienced persons to make decisions in the process since the task requires expertise. Since the experts and senior teams are aware of this problem, they search for ways to teach useful skills to newly graduated engineers while at the same time finding the problems within elevator spare part procurement planning process by creating a framework of spare parts decision-making steps. (Driessen, Arts, Van Houtum, Rustenburg, & Huisman, 2015). The creation of this framework is done by experts and senior teams who are responsible for the planning procurement process such as the maintenance engineers, the inventory control team, the purchase team, and the high-level managers who are the final decision-makers. The team meeting has been joined by those who participate in the decision concerning the purchase of spare parts. These comprise of:

- Maintenance Manager, being on duty for 18 years, taking care of the budget of the whole department and making purchasing approvals before the decisions arrive at the unit of finance and accounting,
- Senior Mechanical Engineer, being on duty for 10 years, supervising the normal maintenance work and approving the job offers from Senior Maintenance operator,
- Site Operation Manager, being on duty for 28 years, responsible for controlling the budget for procurement, proposing procurement and controlling of spare parts,
- Finance and Accounting Manager, being on duty for 13 years, approving the procurement budget for maintenance work,
- Senior Maintenance Operator, being on duty for 30 years, following the preventive and emergency maintenance plans and working on the inventory issues.

As shown in this process flow diagram (Figure 2), the delay in the procurement process occurs during the procurement planning step which requires the highly experienced and skillful staffs as listed above to make purchasing decisions. In this case, It is not enough to pass on knowledge from experts to new staffs in order for the latter to be able to take full responsibility for the work instead. This is due to the complex nature of spare parts which vary in types. In order to avoid any problem within the procurement process, only those who have thorough mechanical knowledge of elevator systems as well as those with long working experience within the finance department could perform these procurement planning tasks.

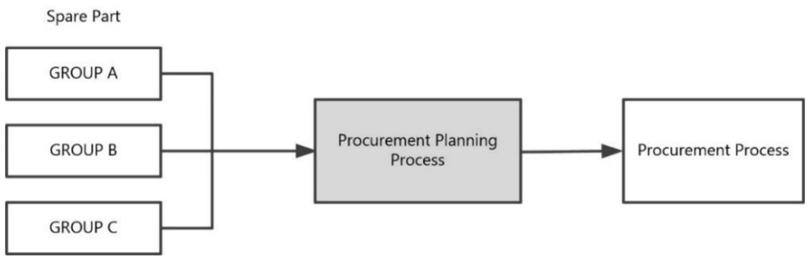


Figure 2. The overall procurement process flow diagram.

3 Inventory Management

Determining the needs of spare parts is an important action that leads to successful operations and prevents the shutdown of machine service. In the case of improper inventory storage such as a storage with insufficient parts, this could badly affect the operation. This also indicates ineffective purchasing plans. In general, when considering the obtainment of each spare part, there are several factors that one must take into account. The factors are summarized as follows:

- Number of usages of each machine model
- Machine life
- The number of spare parts usages in the past
- The number of spare parts inventories
- Spare parts supply period
- Working conditions of other machines that are necessary for the operation

The whole supply chain depends on the flow process of materials and information. The main concept of the

SCMs is about the cooperation and the reduction of inventory in the chain system. The continual planning can be divided into the flow of process. Figure 3 shows a form of inventory management in which the components of the chain operate independently and the data is transferred at the level of adjacent links (Krzyżniak S., 2005).

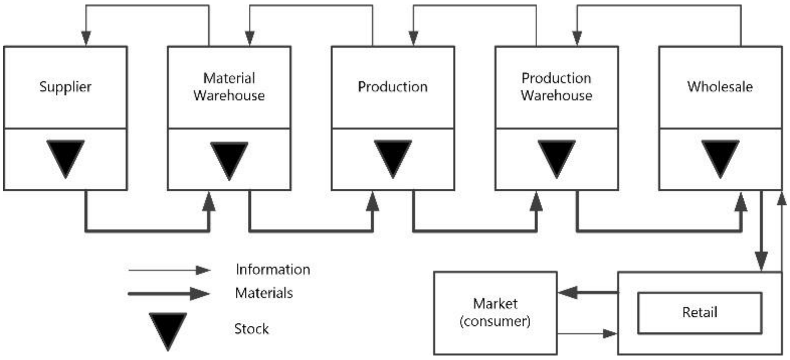


Figure 3. Streams in inventory management.

The arrows in Figure 3 clearly indicate the links between each process, giving the information about the nodes displayed in the order-size dependent on retailers' audits. The same demand levels are repeated as shown in the order from other departments in the chain, and each link is only for their own benefit. The close relationship between suppliers and customers leads to a specific inventory level being maintained on each process. This is kept in the "ready to ship" section in order to meet the demand of customers at all times. Therefore, the safety stock is necessary for mitigating risk of stockouts caused by uncertainties in the demand while the independent creation of each process is caused by the creation of excess inventory throughout the supply chain. In order to commit to the high-standard level of customer service, most companies must control the cost and other overhead expenses, having appropriate warehouse management and adequate stock of spare parts. The accumulation of the overhead cost in each process of supply chain comes from the manufacturer, the supplier, the wholesaler or retailer who strive to take appropriate measures to anticipate their product demand. At the same time, each process has its own role in supporting the main objective which is the assurance of achieving maximum customer service level. In this step, several questions arise from the issues of the limitation of demand and from the demand analysis. The answers to these questions will help adjust the company's operations to be in accordance with the real demands and help forecast forward to predict the costs that may incurred due to the warehouse overstocking of unsold products. Kot, Grondys, & Szopa (2011) have mentioned the existence of predictive techniques which exist in the advanced IT systems used for warehouse management. In this case, however, one cannot apply these techniques for the operation in some limited areas. The reason for controlling the level of spare parts is not only about the issue of the inventory cost but also about the management of spare part inventory.

At the present, the processes of the procurement of elevator spare parts are grouped according to the physical and functional parts of each item. There are 3 groups as followed:

- Group A is a group of the main parts which have the characteristics and main functions of propulsion system, with high value and long-lasting service life. They are made to order. Usually, there is a plan to change these parts according to their service life cycle to prevent the breakdown of devices (BM, Breakdown Maintenance) such as the main rope, the main controller, and the buffer.
- Group B is a group of moving parts with normal use. They have a short lifespan and average market price. These items can be replaced where the replacement plan is in accordance with the maintenance history. These parts include the door chain and the door sensor.
- Group C is a group of parts which have the characteristics of being in direct contact with the users. They are usually cheap in price but can greatly affect the safety of the users. They are used very frequently and have the more frequent replacement cycle. The spare parts are installed when necessary according to the daily check. These parts include lighting device and floor buttons.

The diverse types of inventory of elevator parts means that the management requires an expertise and the right decision for procuring a list of spare part that can be used when needed as the delay in obtaining the parts could affect the image and the level of service of the airport.

4 PBL Model

Problem-based learning (PBL) is the common method of teaching that helps solve complex real-world problems. It is a tool that promotes the learners to learn concepts and principles as opposed to direct presentations of facts and concepts, Alves et al., (2016) said that the problem was solved by challenges faced to it. The PBL model can be applied to develop problem-solving skills, critical thinking skills, and communication skills. In addition, it provides opportunities for working in groups, searching and evaluating materials for research purposes, and lifelong learning (Duch, Groh, & Allen, 2001).

PBL could be integrated into any learning situation. The qualitative approach for several data concerned by collective techniques for example focus group, interview, literature review or specialist's opinion. You also can use PBL creating evaluation lists and the main topics connecting these various uses are real-world issues. The key success is using focus group technique with include a brainstorm process. Investigation of details in factors and problem process is more interactive and share a point of view which involves the roots of problem. Therefore, PBL has adapted to renew in upper level education and provide a case study assessment of learning (Christie & de Graaff, 2017).

According to Duch, Groh, & Allen (2001), any type of research can benefit from PBL method. While the main concerns will vary among disciplines, there are some characteristics of PBL that this research can adapt in the case study. By following PBL method, the arguments chosen for the discussions should require newly graduated engineers to make rational decisions and develop logical thinking, connecting what are being discussed with their past experience and knowledge. The problems discussed should be complex enough so that the newly graduated engineers must work together as a team to solve them. A main concept or idea is to be chosen for the discussion, which will be followed by the assignment or homework that are assigned to them. The ideas and problems under consideration are that of the real-world situations. It is important to develop the aspects of storytelling or other creative practices as to increase the motivation of the new engineers in solving the problems. More complex problems will challenge them to work harder. All the available resources should be used. The problems discussed need to be introduced step-by-step so that new engineers can specifically identify the issues that would lead them closer to their goals. (Ribas, 2009) Experts and seniors should help guide the new engineers by using the problem-solving model during the meeting. Both group discussions and small group work should be reported. The final step is for the new engineers to identify important resources and learn to use these resources themselves. Nevertheless, it will be useful if the seniors help identify some resources and lead them at the beginning.

Steps of Problem-Based Learning are described as follows: (Center for Teaching, 2020). Step 1: Exploring the problems, learning the concepts, principles, and necessary information as well as new skills regarding the proposed topic. Step 2: Within a group meeting, creating a list of what they already know about the situation. Step 3: Defining the problems, putting them in a scope of what is already known, and informing what the new engineers expect to learn. Step 4: Researching on the information and find resources that will help create compelling arguments. Step 5: Checking other solutions for possible actions and look for better solutions, determining and testing possible hypotheses. Step 6: Offering and supporting the selected solution, with the conclusions being clearly identified and supported, along with relevant information and evidence. Step 7: Checking the performance, an important step in developing your problem-solving skills. Students must evaluate their performance and make some improvements for future problems. These steps which are applied during the on-site work and the insights from the analysis will help the new engineers to understand things better by having a meeting with the experts. This allows them to share ideas together (Hernández et al., 2015).

5 Research Methodology

The newly graduated engineers should be self-taught to understand the work processes. On the first day, the company's general knowledge and the special knowledge relevant to the job will be informed. It is the responsibility of the senior team and yourself. There are clear steps which can be studied on the e-learning platform or from face-to-face meetings. In this case, the PBL procedure goes into effect with the annual purchasing and planning solution as shown in Figure 4.

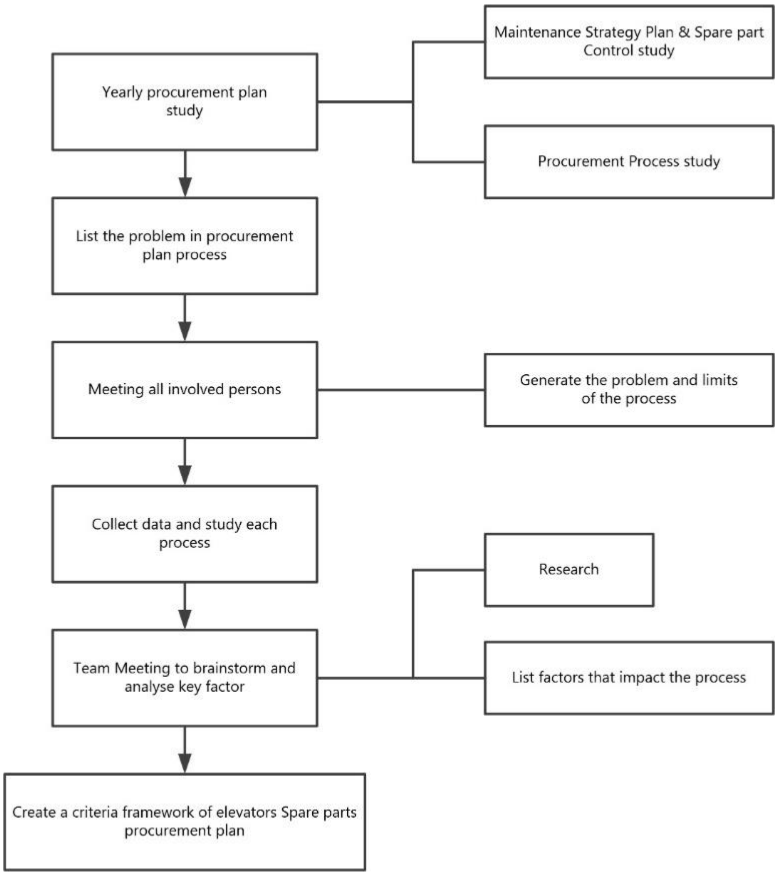


Figure 4. The work procedures.

The first step in the procedures is that of the introduction of the framework and scope of each sector's responsibilities with regard to the whole process. The new engineers are informed of how the procurement process is done, as well as on how the yearly procurement plan is created. Within the maintenance sector, the seniors are responsible as the instructors of the newly graduated engineers who are taught on the site following the concept of on-the-job training (OJT) since more benefits can be reaped from such practice due to the availability of equipment and other useful resources needed for an effective learning. After this stage, the senior engineers would encourage the newly graduated engineers to identify problems and search for possible obstacles that could derive from the procurement process. Those who have questions with regard to what they have learned at the beginning will have a chance to ask for clarifications and then move the meeting onto the next stage, in which the junior engineers will hear from their seniors the evaluation of problems gathered from the previous stage. The seniors will give suggestions, identify existing limitations, and clarify on some points that are not clear from the beginning. This significantly reduces the time of the whole learning process. Due to the fact that some aspects of the work have limitations and problems that require specific ways to resolve them, the new engineers can learn a lot from the expertise of the seniors who are more experienced. After gaining some feedbacks, if the new engineers have some more questions to ask, they will be given the time to research and study more before moving on to the next stage which is that of a group discussion. In this stage, all will brainstorm and find key factors within the procurement process as to create the criteria framework which is to be used as a tool in improving the spare parts procurement process. The effective outcome of the meeting can be created with the participation of those who have experienced the real-world working situations as well as the new engineers who might possibly add some interesting insights that are not normally acknowledged by the senior engineers.

5.1 Process Work Flow

From the problem analysis process during the meeting, the main problem which can be observed is the delay in the procurement planning of elevator spare parts. The meeting provided the opportunity for new engineers to participate in solving the problems and exchanging ideas by adapting PBL model and learning from real-world problems. According to the brainstorming session, one issue suggested that the problem of the planning and decision-making process concerning the purchase of spare parts can be time-consuming. Many factors should be taken into consideration and the insights from the experts in this field can be useful for helping the new engineers gain expertise in this matter. From the meeting, a new engineer suggested that a procurement factors criteria framework should be created to reduce the working time spent by those who work in the sector. This framework can be used in the future teaching session so that the new engineers will be able to work more efficiently.

5.2 Criteria Framework

In the brainstorming session and group discussions including the managers, the senior engineers, and newly graduated engineers, resulted in the framework and planning of the procurement of elevator spare parts. The important criteria for the planning for the purchase of elevator spare parts are summarised in Table 1.

Table 1. Criteria framework for elevator's spare part procurement planning

Criteria	Definition	Factors	Definition
Cost of spare parts purchasing	Price of Spare parts which is the direct cost of company.	Standard price / market price	Spare part price is found in market or last price within 2 years.
		Warranty	The spare part warranty period is confirmed by buyer to guarantee their product. To deal with our company, warranty period at least 1 year, followed by a term of reference.
		Number of spare parts	Number of parts installed/ the purchasing volume
A lifetime of spare parts	Spare part life span from manual and usage life times when start use.	Frequency of elevators use	Elevator locations impact the frequency of the usage which inturn affects the life-span of the parts
		The chage of spare parts in maintenance period plan	Spare part purchasing without concern about spare part condition. Changing follows maintenance plan.
Delivery lead times	Delivery time starts from the time contract is signed till the arrival of the spare parts	Manufacture production plan	Type of production and warehouse strategy of manufacture (made to order or ready to ship)
Warehousing management	The management of spare parts by the maintenance team (buyer)	Budget	Budget for the purchase of spare parts each time
		Spare parts and their effects on elevator safety	Types of spare parts that affect the safety of the users
		Urgent demand	Sellers must have the safety stock Urgent demand in case breakdown of equipment/ its effect on spare part delivery

The criteria framwork which affects the procurement planning process can be categorised into 4 groups which are the cost of spare part purchasing, a lifetime of spare parts, the delivery lead time, and warehousing management. Each group has its own factors, all of which determine the nature of the complex and important planning process. So far, only those with experiences in this field or the experts are able to take into consideration all of the dimensions of these related factors. They make decisions within the spare parts procurement planning using statistical data analysis which means mistakes are unlikely to occur. However, this criteria framewotk, which is the result of the utilisation of PBL steps, greatly facilitated the brainstorming session and increased its efficiency. The maintenance team has asked the new engineers to apply this criteria framework on the case study. The result was that they could now understand all the dimensions of the problems and all the factors which must be taken into account, leading to the speed-up of the procurement planning process.

6 Conclusion and Recommendation

The on-site problem-solving process can be applied by the PBL steps which are useful both for the experts, the seniors, and the new engineers who are given opportunities to share their knowledges and experiences. According to the analysis, the presented criteria framework mentioned in this research can be utillized as a tool to facilitate and enhance the quality of planning process concerning the procurement of elevator's spare parts. The proposed framework can also be applied to similar cases such as elevator equipment, the cost of spare parts procurement, spare part lifetime, shipping lead time, and warehouse management. In addition, the learning process based on the PBL steps is also effective at solving more complex problems and can be adapted to new situations.

For the further study, an Analytic Hierarchy Process (AHP) and a Fuzzy Analytic Hierarchy Process (FAHP) will be utilized to enhance the operational planning issues such as specific expertise and personal experience which are related to quality factors.

Acknowledgement

This publication is the partial outcome of the project "Curriculum Development of Master's Degree Program in Industrial Engineering for Thailand Sustainable Smart Industry (MSIE4.0)" that has been funded with support from the European Commission (Project Number: 586137-EPP-1-2017-1-TH-EPPKA2-CBHE-JP). The authors also would like to acknowledge the support from the Thammasat School of Engineering, Thammasat University, Thailand.

This publication reflects the views only of the authors, and the commission cannot be held responsible for any use which may be made of the information contained therein.

Co-funded by the Erasmus+ Programme of the European Union

7 References

Airports of Thailand Public Company Limited (2018). *2018 Annual Report*. Retrieved from http://aot.listedcompany.com/misc/AR/20190108-aot-ar-2018-en.pdf

Arts, J. J. (2013). *Spare parts planning and control for maintenance operations*. Eindhoven: Technische Universiteit Eindhoven. doi:10.6100/IR760116

Alves, A., Sousa, R., Moreira, F., Carvalho, M. A., Cardoso, E., Pimenta, P., ... & Mesquita, D. (2016). Managing PBL difficulties in an Industrial Engineering and Management program. Journal of Industrial Engineering and Management, 9(3), 586-611. Doi: 10.3936/jiem. 1816

Christie, M., & de Graaff, E. (2017). The philosophical and pedagogical underpinnings of Active Learning in Engineering Education. *European Journal of Engineering Education, 42*(1), 5-16. doi:10.1080/03043797.2016.1254160

Center for Teaching. (2020). *Steps to a problem-based learning approach*. Retrieved from https://teach.its.uiowa.edu/sites/teach.its.uiowa.edu/files/docs/docs/Steps_of_PBL_ed.pdf

Driessen, M., Arts, J., van Houtum, G. J., Rustenburg, J. W., & Huisman, B. (2015). Maintenance spare parts planning and control: A framework for control and agenda for future research. *Production Planning & Control*, 26(5), 407-426. doi:10.1080/09537287.2014.907586

Duch, B. J., Groh, S. E., & Allen, D. E. (2001). *The power of problem-based learning: A practical "how to" for teaching undergraduate courses in any discipline*. Stylus Publishing, LLC..

ERASMUS+ CBHE PROJECT, *Curriculum Development of Master's Degree Program in Industrial Engineering for Thailand Sustainable Smart Industry, WP 1 - Gap Analysis, Outcome 1.4 Analysis of needs of industry and students*. Retrieved from https://msie4.ait.ac.th/outcome-1-4-analysis-of-needs-of-industry-and-students/

Hernández, C., Ravn, O., & Valero, P. (2015). The Aalborg university PO-PBL model from a socio-cultural learning perspective *Journal of problem based learning in higher education., 3,* 16-35. doi:10.5278/ojs.jpblhe.v0i0.1206

Kot, S., Grondys, K., & Szopa, R. (2011). Theory of inventory management based on demand forecasting. *Polish journal of management studies*, 3, 147-155.

Krzyżniak S., *Podstawy zarządzania zapasami w przykładach*, Biblioteka Logistyka, Poznań 2005, p.10,11, 17.

Moeuf, A., Pellerin, R., Lamouri, S., Tamayo-Giraldo, S., & Barbaray, R. (2018). The industrial management of SMEs in the era of Industry 4.0. *International Journal of Production Research*, 56(3), 1118-1136. doi:10.1080/00207543.2017.1372647

Ribas, A. (2009). Aprendizaje basado en problemas en la educación superior. Colombia: Editorial Universidad de Medellín

Singha, R., Devikaa, C. H., Thiedeb, S., & Singh, K. (2019). Research-based learning for skill development of engineering graduates: An empirical study. *Procedia Manufacturing*, 31, 323-329. doi:10.1016/j.promfg.2019.03.051

Yamashita, K., Nakamura, M., Sakai, R., Fukata, H., & Sekine, H. (2017). Remote Maintenance System and New Maintenance Service for Elevators Enabled by New IoT Service Platform. *Hitachi Review*, 66(3), 248-253.

(Krzyżniak S. 2005)

Awareness and expectation of industrial engineering students on competences required toward Industrial revolution 4.0

Chayanid Sutthasri[1], Yannakorn Suebsawat[1], Anintaya Khamkanya[1*]

[1] Department of Industrial Engineering, Thammasat University, Thailand

Email: chayanid.sut@dome.tu.ac.th, yannakorn.sue@dome.tu.ac.th, kanintay@engr.tu.ac.th*

Abstract

Industrial revolution 4.0 has already changed the way industrial engineers work. Several skills needed to support Industrial 4.0 technology, such as data analytics and industrial automation, have been shifting from an optional skill to a minimum required skill. In this paper, the competences required by industry for the future workforce were addressed in a survey for industrial engineering students at Thammasat University. Students were asked to evaluate their current competence levels and to define their expected competence levels of the required skills. The result reveals that the competence levels increase significantly from first-year students to fourth-year students. However, there appear to be gaps between current competence levels of the fourth-year students and industry needs. It is also interesting to note that the expected competence levels from industry needs and from students' expectation, regardless of enrolled year, is significantly indifferent.

Keywords: Industrial 4.0; Industrial Engineering; Engineering Education; Curriculum Development.

1 Introduction

As many of us are aware, the industrial revolution 4.0 (I4.0) has now become a global megatrend. In this new industrial revolution, machines, computers, and robots will be performing and will be replacing many of human jobs. The university needs to reform the way of teaching, as well as, to redesign the curriculum, so that graduates can lead the adoption of Industrial 4.0 technology strongly. In the context of Thailand industry, there are studies on the awareness and strategic planning for handling changes on I4.0 of companies in Thailand (Korkueasuebsai, 2019; Pingwong, 2019; Rohitratana and Kumpirarusk, 2019). However, there is only one on-going research in Thailand focused on the development of curriculum for preparing the workforce to tackle the I4.0 revolution. (MSIE4.0 project, 2020)

This study aims to identify the perception of industrial engineering (IE) students on the competences needed from industry under the context of Industry revolution 4.0 (I4.0). This crucial information will be used to redesign the curriculum to meet industry needs. The survey was focused on the students from the bachelor degree program in industrial Engineering at Thammasat University (TU), Thailand, which was established in 1990. The department offers programs in industrial engineering for bachelor degree (B.IE), master degree (M.IE), and doctoral degree. There are currently 226 undergraduate students and 98 graduate students enrolled in all programs. The current curriculum of bachelor degree is the version of the academic year 2018-2023. It is a requirement from the government that a curriculum must be revised every five years or less. Although the concept of I4.0 has been incorporated in the current curriculum, the insights on a specific set of competences needed from industry point-of-view has not yet been considered in the curriculum revision before.

According to the report published on the MSIE4.0 project website regarding what competences that industry needs, there are 32 competences that industrial engineers should equip after completing the master degree in industrial engineering. The competences are defined based on three main technologies of I4.0, which are big data, sensor, and mobile device. These technologies were then used to identify the list of competences required on three application areas, including production technology, product development and IT-based integrated system. The report suggests that the most important outcome for MSIE graduates is to be able to provide better solutions for various industry practical problems using big data technology in the domain of production technology, as shown in Figure 1.

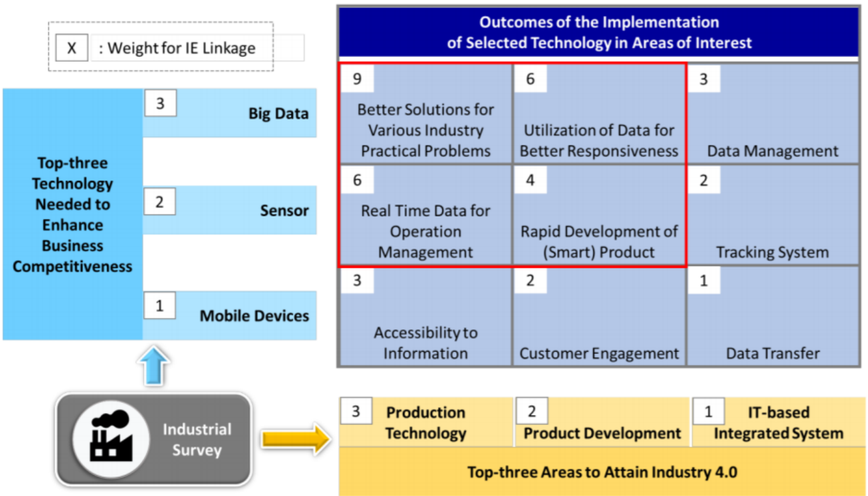


Figure 1. Relative importance of main technologies and main domains of applications for MSIE students (MSIE4.0 Project, 2020)

Moreover, the gaps between industry needs versus the corresponding competences from the current curriculum offered in the university in Thailand are also measured, as presented in Figure 2. It is interesting to note that the gap between these two perspectives is considerably large on most competences. Thus, the modification of the current M.IE curriculum in Thailand is mandatory.

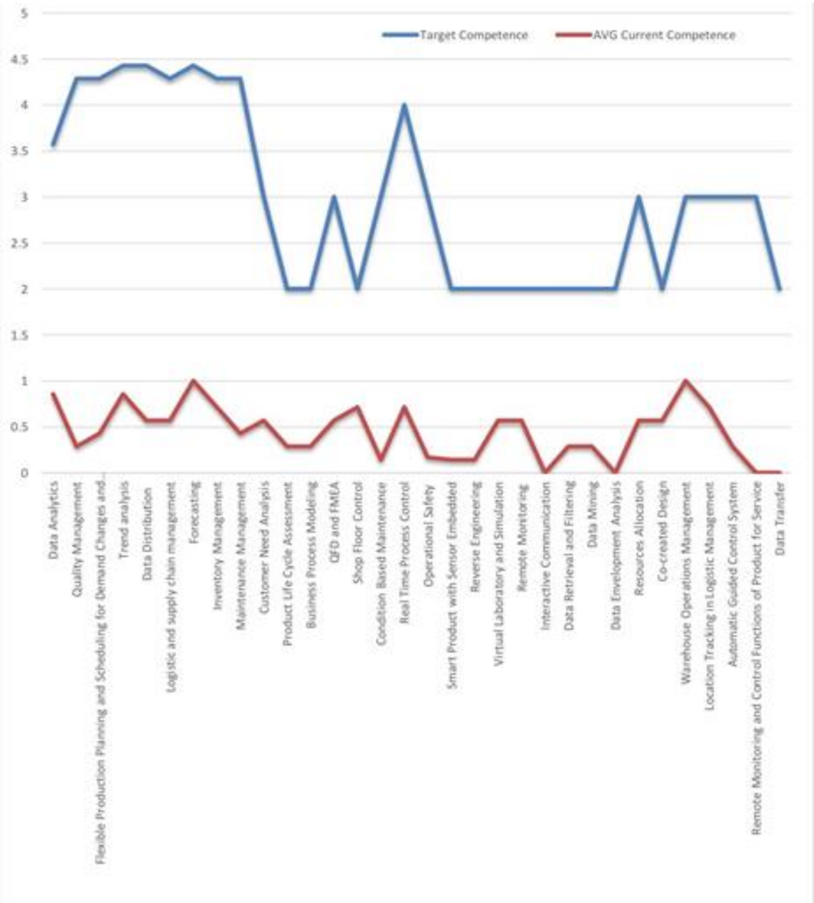


Figure 2. Gap analysis of competence level from industry needs (MSIE4.0 Project, 2020)

The findings from MSIE4.0 project was fruitful as a guideline for developing the IE curriculum in master degree level based on industry needs. However, the perspective from B.IE students on their current competence level and the expected competences level has not been studied under the I4.0 requirement on the IE competences. Besides, it would be better that B.IE graduates could have the same set of competences as equipped on M.IE graduates, although the competence levels would be different. As such, this study was done in two phases to find out the missing competences as mentioned by industry. In the first phase, we analysed the B.IE curriculum that is currently offered at TU. The aim of this phase is to identify the difference between the set of competences needed from industry on I4.0 and the set of competences provided in the current B.IE curriculum. In the second phase, the survey of B.IE students and the data analysis were conducted to obtain the awareness of students on the competence levels. The result was discussed in three views. These include the gap between current competence levels and expected levels of B.IE students, the trend of students' competence level changed after completing each academic year, and the similarity of industry expectation and B.IE students' expectation on the competence level. The summary of this study is then reported in the sections below.

2 Analysis of current B.IE curriculum

The current curriculum of B.IE offered at Thammasat University is the version of academic year 2018-2022. We also compared the list of competences with the previous version of the B.IE curriculum, the version of academic year 2013-2017. The analysis was done by investigating the course description and course outlines from all courses defined in the curriculum. The competences were then extracted to match the list of industry needs from MSIE4.0 report. In summary, the latest version of the B.IE curriculum currently offered at TU can respond to 20 competences required by Industry 4.0, as depicted in Figure 3. These competences were then used to develop the questionnaire in the next phase.

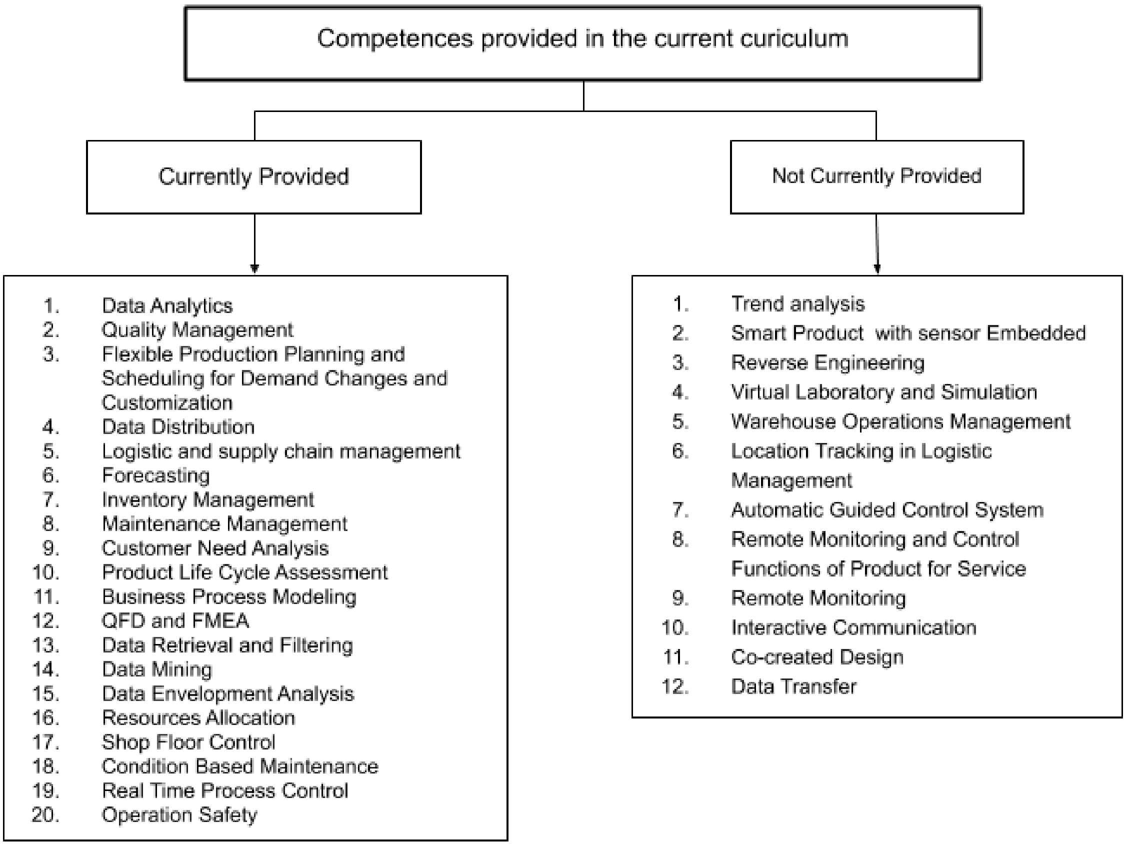


Figure 3. Summary of competences provided in the current B.IE curriculum at TU

3 Methodology

The questionnaire was developed based on the list of competences provided by the current curriculum, see Section 2. Based on Bloom's taxonomy (Bloom et al, 1984), students were asked to evaluate their current competence levels. Competence levels are detailed in Table 1. After that, they were asked whether they want to increase their competence level or not. In the case that students want to increase their competence level, they have to define the expected level on each competence. Using questionnaire as a tool to assess student's awareness is a well-known method and is widely used in several aspects, such as the study presented in Delgado (2008), Yacob et al. (2012), and Root and McKay (2014).

The participants are the entire B.IE students at TU who were asked to complete the questionnaire after the midterm exam of the second semester, i.e. Spring semester, of the academic year 2019. There was 100% of the questionnaire returned to us. After the validation of data, we found that there are 186 answers qualified for the analysis, which is approximately 85% of the total number of enrolled B.IE students.

The data was analyzed using statistical methods based on the normal distribution assumption for the mean and standard deviation of samples. The hypothesis testing on the difference of the mean competence level was conducted using the analysis of variance for one-factor. The Tukey's HSD test method is then used for the multiple comparison procedure on the mean of competence level. See details and formula of the statistical analysis in (Walpole et al, 1994). The analysis was done in Minitab(R) software.

The level of competence used in this study is based on the Bloom's Taxonomy. There are five levels of competences, which are understand, apply, analyze, evaluate, and create. Note that from the graph in Figure 2, the level of competence from MSIE4.0 project report ranges from 1 to 5. In this study, since the survey is focused on undergraduate students, it is possible that students may not have heard about the advanced name of competences, especially for the first-year students. Thus, the competence level in this study ranges from 0 to 7 as explained in Table1. After the survey, data was collected and analyzed using the statistical software, Minitab(R). The average of competence levels was categorized according to the criteria in Table1.

Table1. Explanation of competence level used in questionnaire

Bloom's Taxonomy	**Competence level used in MSIE4.0**	**Competence level used in this study**	**Range of average value from survey**
Unknown	0	0	0.00 - 0.49
Know	-	1	0.50 – 1.49
Remember	-	2	1.50 – 2.49
Understand	1	3	2.50 – 3.49
Apply	2	4	3.50 – 4.49
Analyze	3	5	4.50 – 5.49
Evaluate	4	6	5.50 – 6.49
Create	5	7	6.50- 7.00

4 Analysis of students' awareness and expectation

In this study, the competence level of students was surveyed in three aspects, the current competence level from student's self-evaluation, the expected competence level from student's view, and the expected competence level from industry. The average trend of current student skill level changing at each stage of the academic year and distance between skill levels for each Industry 4.0 requirement were likewise noted, as well as current undergraduate skill level through the questionnaire.

The study can be concluded as follows. For student competence levels as presented in Figure 5, most competence levels seem to be increased after completing each academic year. The lines in the graph represent 20 competences provided in the current curriculum from Figure 3. From Figure 6, the gaps between expected competence level and current competence level of students after completing the bachelor's degree program was quantified. The survey reveals that, on average, the expectation from industry and students on the level of competences are on the same level, that is the analyzed level. See definition in Section 3.2. However, the average competence levels of students are on the apply level. Thus, there are gaps between the current competence level and the expected competence level from either student's expectation and industrial expectation. These findings can offer suggestions for revising academic curricula to meet the needs of Industry 4.0.

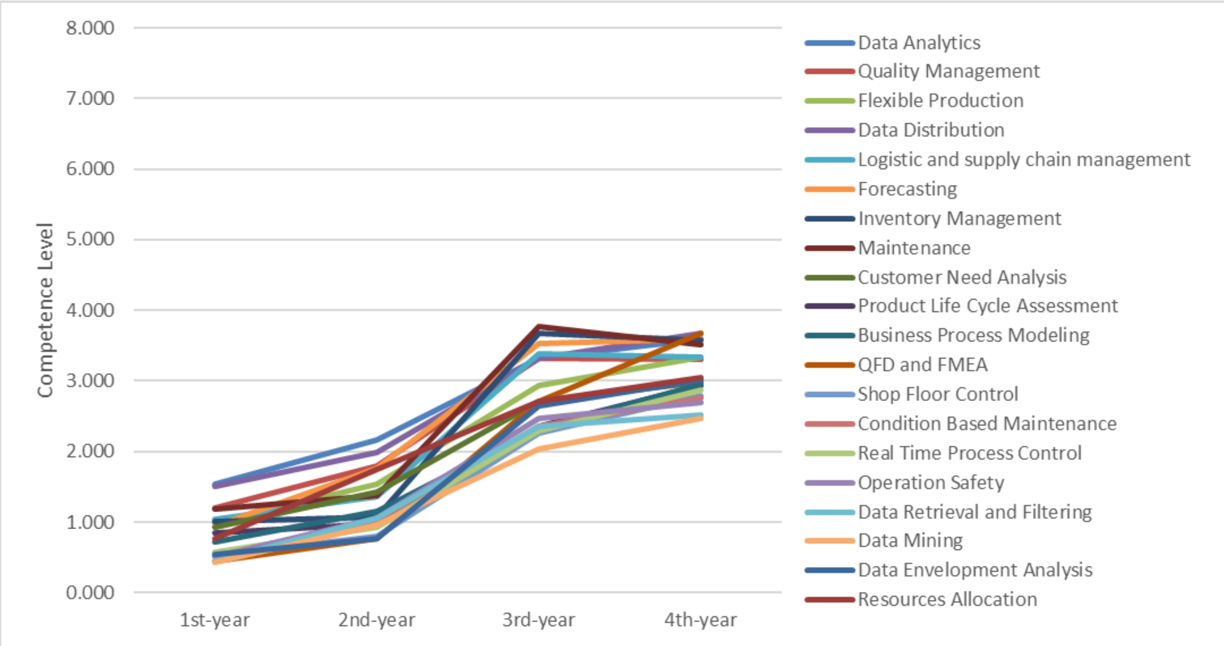


Figure 5. Summary of average competence level of students from first-year to fourth-year

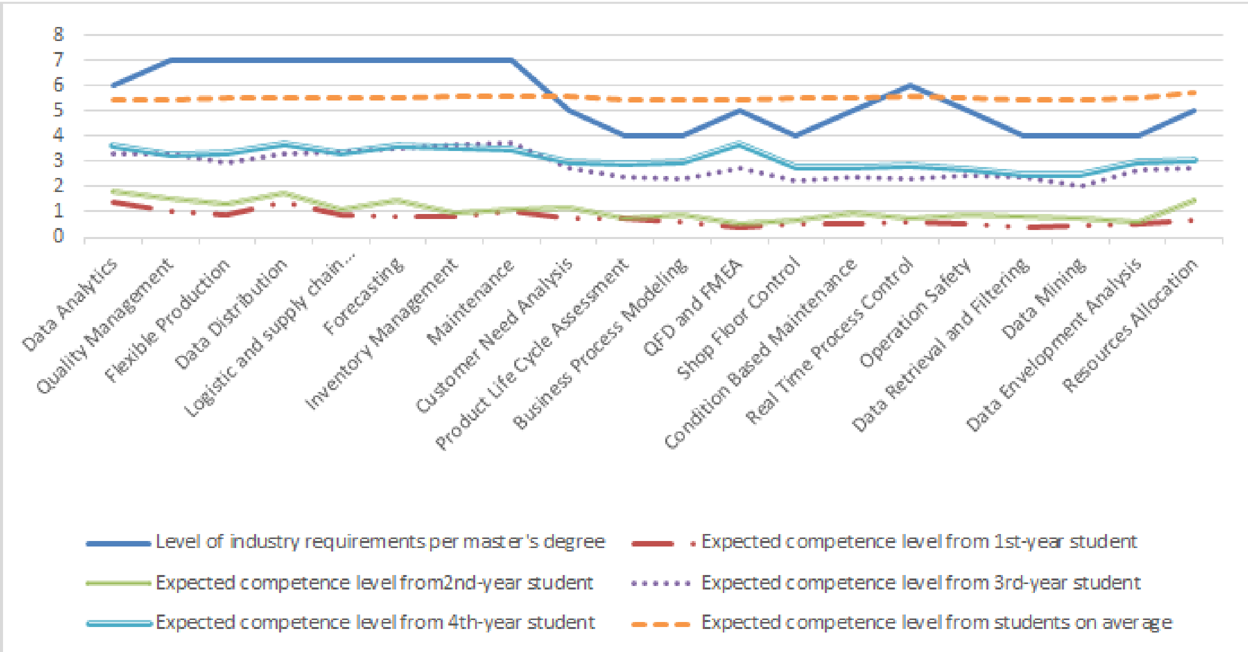


Figure 6. Summary of expected level of competences from industry (solid line), student's expectation on average (dashed line), and expected level from student in each year.

5 Conclusion

The main objectives and benefits of this research is to learn about the perceptions and expectations of the skill level that the industry requires under the context of Industry 4.0 in order to be a way to adjust the curriculum to meet the needs of today's industry. Results from the analysis of current curriculum suggest the decisive information that can be used for the curriculum revision. A set of questionnaires was developed to understand the expectation of students toward the competences required by industry. The expectations from students and industry are on the same level, yet the perception of students on their own competences are lower than their expectations. However, the study uses a survey to measure the perception of students on the competence level they have already had, the result might be different if another method were used, such as using a test to measure the competences level.

Acknowledgements

This publication is a partial outcome of project „Curriculum Development of Master's Degree Program in Industrial Engineering for Thailand Sustainable Smart Industry (MSIE4.0)" that has been funded with support from the European Commission (Project Number: 586137-EPP-1-2017-1-TH-EPPKA2-CBHE-JP).

6 References

Bloom, B. S., Krathwohl, D. R., & Masia, B. B. (1984). Bloom taxonomy of educational objectives. In Allyn and Bacon. Pearson Education.

Curriculum of *Bachelor of Engineering Program in Industrial Engineering version B.E. 2558* (2013).Retrieved 20 August 2019. http://www.ie.engr.tu.ac.th/upload/static_file/B.Degree_56.pdf

Curriculum of *Bachelor of Engineering Program in Industrial Engineering version B.E. 2561 (2018)*. Retrieved 20 August 2019. http://www.ie.engr.tu.ac.th/upload/static_file/B_Degree_61.pdf

Delgado, C. E. (2008). Undergraduate student awareness of issues related to preconception health and pregnancy. Maternal and Child Health Journal, 12(6), 774-782.

Korkueasuebsai, O. (2017).*A study of factors and effects of Industry 4.0 policy on Thai electronics industry.*(Master's thesis). Silpakorn University. Engineering and Industrial Technology. Retrieved from http://ithesis-ir.su.ac.th/dspace/handle/123456789/1783.

Minitab (2020), Minitab Inc.

MSIE4.0 Project.*Curriculum Development of Master's Degree Program in Industrial Engineering for Thailand Sustainable Smart Industry*. https://msie4.ait.ac.th/category/gallery/reports/.

Pingwong, P. (2017). *The impact of industry 4.0 on laborers: a case study of OTC DAIHEN Asia Co., Ltd*. (Master's thesis).Thammasat University, Faculty of economics. Retrieved from http://ethesisarchive.library.tu.ac.th/thesis/2017/TU_2017_5904010625_8262_7010.pdf.

Rohitratana, K., Kumpirarusk, P. (2018). *Industry 4.0: Future Industries of Thailand. (Research).*Thammasat University. Thammasat Business School.

Root, T., & McKay, S. (2014). Student awareness of the use of social media screening by prospective employers. Journal of Education for Business, 89(4), 202-206.

Walpole, R. E., Myers, R. H., Myers, S. L., & Ye, K. (1993). Probability and statistics for engineers and scientists (Vol. 5). New York: Macmillan.

Yacob, A., Kadir, A. Z. A., Zainudin, O., & Zurairah, A. (2012). Student awareness towards e-learning in education. Procedia-Social and Behavioral Sciences, 67, 93-101.

Students feedback on the forced transition to online classroom during Covid-19

Parichat Chuenwatanakul[1], Anintaya Khamkanya[2*]

[1,2] Department of Industrial Engineering, Thammasat University, Thailand

Email: cparicha@engr.tu.ac.th, kanintay@engr.tu.ac.th*

Abstract

Social distancing has become a new normal for a university in Thailand due to the Covid-19 pandemic since mid-March 2020. All traditional classes in a face-to-face style, therefore, were forced to be conducted online. This study presents the survey of students' reaction to online classrooms and the adaptability to the online classroom of both students and instructors from the department of industrial engineering, Thammasat University. Students' feedback was collected after the first week of online classroom. The result shows that, in the beginning, there were several problems reported from students, such as the confusion of different platforms used among all courses, sense of isolation, lack of equipment of students, and limited skills of using the online teaching platform of instructors. The most recommended online classroom platforms by students are Zoom for online meetings and Microsoft Teams for learning management systems. It seems that the most concern for students is lacking peer interaction and the learning atmosphere as provided in the traditional classroom. The results of this study were then used as decisive information for the improvement of students' experience of the online classrooms.

Keywords: Student perception, Online classroom, Covid-19

1 Introduction

During Covid-19 pandemic in Thailand, the government has ordered shut down on most public places, especially school and university. Some universities in Thailand, at that time, are in the middle of the second semester of 2019. The university has no choices but to move to the online classroom for all courses (Thammasat, 2020a). After the first week of the forced transition to online classrooms, there were complaints from students. At Thammasat University (TU), we consider student voices as decisive information. Thus, the department of industrial engineering was then decided to obtain feedback from students, to improve students' satisfaction for the online classroom.

It is well known that collecting feedback from students is mandatory in a university. Generally, students' feedback is obtained at the end of a semester. As Covid-19 caused the forced transition to online classrooms, it is important to obtain students' feedback as soon as possible. Questionnaire is a predominant method to obtain feedback (Huxham et al., 2008). Although questionnaire has pitfalls in validity and reliability on the questionnaire design (Penny 2003), it is still the most commonly used mechanism to obtain feedback by far (Brennan and Williams, 2004) in most colleges and universities (Kember et al., 2002).

The survey research design was selected for this study to investigate the perception of students regarding problems and opinions on the related topics of online classrooms. It is very likely that the pandemic would be longer than expected. The results will be used to develop action plans to help students on the online classroom. More importantly, the results from this study could also help improve the classroom management for the online classroom in a similarly context. In this paper, the research methodology is presented in Section 2. The results and conclusions are then summarized in Sections 3 and 4, respectively.

2 Methodology

In the second semester of the academic year 2019, there were 226 undergraduate students enrolled in the department of industrial engineering, at TU. All students were asked to participate in this study, to share their thoughts after the first week of being forced to online classrooms. At TU, the online classroom is an optional teaching method. Generally, more than 90% of classrooms are taught using the traditional face-to-face style. Thus, the online classrooms are new to both students and instructors.

The purpose of this survey was threefold: (1) to identify student readiness on equipment used for online classrooms; (2) to assess student's perception on the platform used for online classrooms; and (3) to investigate the problems from the online classroom. The questionnaires including both closed and open-ended questions were used to collect data. There are three main sections of questionnaires. The closed questions are used to observe the perception of students. The data analytics was done in Microsoft Excel. The open-ended questions were analysed using exploratory content analysis (Auerbach & Silverstein, 2003). The survey was distributed online to students after the first week of online classrooms. The response rate is 80%, 172 out of 226 surveys was returned with completed answers.

The first section of questionnaire focused on the availability of equipment and internet speed that students used for online classrooms. For the second section, students were asked to evaluate their satisfaction on the experience of using different platforms for online classrooms. See the list of platforms in Section 3. Students can select one of these four answers for each platform, which are (i) I have never used this platform; (ii) I have used it, but I do not like it; (iii) It is okay to use this platform; and, (iv) I would recommend using this platform for all courses. The third section of the questionnaire was set to observe students' concerns. There are eight questions with three levels of urgency to be answered by students. The options of answer are (i) I have never had this problem; (ii) I have some problems on this, but it is fine (I have fixed it already); and, (iii) this is a serious problem, I need immediate help. The students' concerns were also collected using the open-ended question which askes students to share their opinion or concerns in a required field. It is also used to verify the answers from the closed questions. Finally, the overall satisfaction was evaluated on a scale of 1-Not satisfied to 10-Satisfied.

3 Results

3.1 Readiness of equipment for online classrooms

The readiness of equipment for online classrooms is crucial to the learning effectiveness and equality in learning. Due to the difference in financial backgrounds of students' families, this section of survey aims to quantify problems of lacking in equipment for learning online. Four types of electronics equipment were used in the questionnaire. These include a personal computer (PC) of either desktop PC or laptop, a smartphone, a tablet, and a PC in any public space. Based on the survey, students own at least one device that can access the online learning materials. It was found that 77% of students have a PC/Laptop, 67% have a smartphone, and 42% have a tablet. From Table1, we found that 32% of students use one device for online classroom, where 8% use a tablet, 9% use a smartphone, and 15% use a PC. Moreover, 68% of students own two or more devices for learning online. The combination of devices owned are varied. The results from this section reveal that all students have at least one device to access the online learning material. The popular combination of owning two devices are a PC and a smartphone.

Table 1. Devices used by students for learning online.

Type of Devices	*Tally*	*Percent*
1 device	55	32%
- Tablet	14	8%
- Smartphone	16	9%
- PC	25	15%
2 devices	64	37%
- PC and Smartphone	47	27%
- PC and Tablet	8	5%
- Tablet and Smartphone	9	5%
More than 2 devices	53	31%
- PC+Smartphone+Tablet	52	30%
- PC+Smartphone+Tablet+Public PC	1	1%
Total	172	

For the speed of internet connection, there are about 9% of students experiencing problems from using low speed internet to learn online. Students mentioned that low speed of the internet causes inequality when instructors use the fastest response as a criterion to give bonus or let students answer the question with grade. The speed of the internet is graphed in Figure 1.

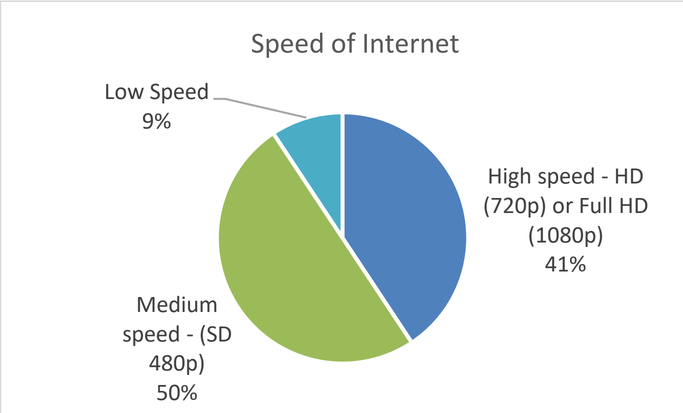


Figure 1. Speed of the internet used for online classrooms

3.2 Perception on online classrooms' platform

The main platform for online classroom at TU is Microsoft Teams (MS Teams). TU have prepared supporting materials and technicians for instructors and students on using MS Teams as a classroom platform (Thammasat, 2020b). However, it is not a requirement that all courses must use MS Teams. Thus, instructors may use another online classroom platform if preferred. For this reason, students have to use several platforms for online learning. In this survey, we focused on ten platforms that are available for TU students without additional cost. The list of platforms and the result from the survey are shown in Table 2 and Figure 2. The top three platforms that have low negative feedback from students are Zoom, MS Teams, and Facebook, respectively. The top three platforms recommended by students are Zoom, MS Teams, and YouTube. It seems that Zoom is preferred by students in this survey. Note that Zoom is an online meeting platform that does not have the learning management system (LMS) at this moment, therefore another LMS platform must be used simultaneously. For these reasons, Zoom is considered as the most preferable online meeting platform and MS Teams is the most preferable LMS platform.

Table 2. Results of students' perception on platform for online classroom

Platforms for online clasrooms	*I have never used this platform*	*I have used it, but I do not like it*	*It is okay to use this platform*	*I would recommend using this platform*
Email	*15%*	*39%*	*40%*	*6%*
Facebook Live/Group	*22%*	*19%*	*52%*	*8%*
Google Classroom	*10%*	*39%*	*46%*	*5%*
Google Team/Hangouts	*5%*	*77%*	*18%*	*0%*
Line Group/ Line call	*20%*	*43%*	*35%*	*2%*
Microsoft Team	*10%*	*19%*	*50%*	*20%*
TU GenNext	*3%*	*85%*	*11%*	*1%*
TU Moodle	*5%*	*33%*	*53%*	*9%*
Youtube	*5%*	*30%*	*46%*	*19%*
Zoom	*8%*	*14%*	*53%*	*26%*

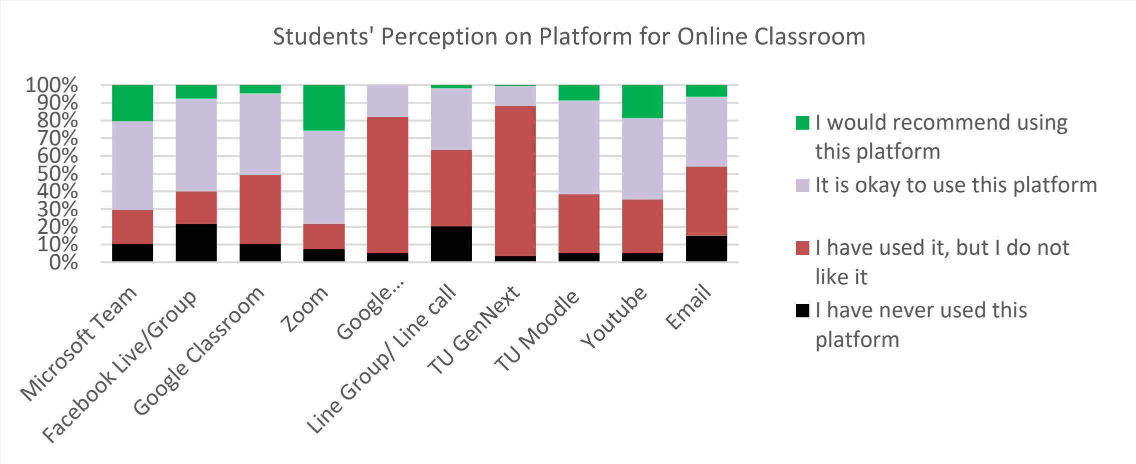


Figure 2. Summary of students' perception on the platforms for online classroom

3.3 Problems reported from students on online classrooms

This survey was launched after the first week of online classrooms. There were concerns from students reported to the department continuously during that time. The list of concerns was then used to create the list of problems. Moreover, this survey also provided an open-ended question for students to inform their thoughts. The results of a survey regarding problems from the first week of online classrooms are presented in Table 3 and Figure 3. In summary, there are two problems that 90% of students have experienced, which are P6 – Confusion of online learning platforms used among different and P8 – Feel lonely, need to interact with friends during class time. Besides, problems P6 and P8 are also the top two problems that students think should be fixed immediately.

According to section 3.1, the survey result suggests that all students can access the online contents using their own electronic devices and around 10% of students encountered the problem of low speed of the internet. The results from problems P1 - P5 also suggest similar results, that is, around 10% of students have the problem of lacking equipment or internet connection. Moreover, since some courses require software that can only be used in a PC, students were mentioned via the survey that they need to borrow a PC. The department was then helping those students in need promptly.

Table 2. Results of problems reported from students on online classrooms.

Type of Problems	*No problem*	*Problem solved*	*Need help*
P1 – Unable to join the online classroom	64%	31%	5%
P2 – Unable to get points due to using low speed of the internet	37%	52%	11%
P3 – Have only smartphone to watch lecture video	39%	49%	12%
P4 – Loss of internet connection during live lecture	40%	46%	14%
P5 – Cannot download lecture video due to large file size	58%	36%	6%
P6 – Confusion of online learning platform used among different courses	8%	52%	40%
P7 – Feel sleepy during online classroom	53%	36%	11%
P8 – Feel lonely, need to interact with friends during classes	9%	27%	63%
Additional opinions from the open-ended question			
A1- Complain about the multiple platform used in a different course	n/a	n/a	14%[1]
A2 - Worry about the changes in course outlines and examination method	n/a	n/a	14%[1]
A3 – Prefer to not answering questions during live lecture and suggest about providing recorded video of the live lecture	n/a	n/a	19%[1]

[1] Calculated from 227 pieces of comments from 172 students

From the open-ended question that let students share their opinions or concerns freely, students restated that they have the problems regarding the confusion of different platforms used among all courses. It was also found that students were also concerned about their study plan since all activities will be done online. The technical issues of online classrooms were also reported. Lacking experience in using an online classroom platform of instructors was also mentioned as a problem from students' view. These problems are due to the sudden transition of the classroom. Finally, the satisfaction of the first week online classroom evaluated by students is 6.13 from scale 1-10. It is definitely lower than the expectation from the faculty members. The information was then sent out to all instructors in the department for improvement purposes. The corrective actions were instantly launched to solve the problems.

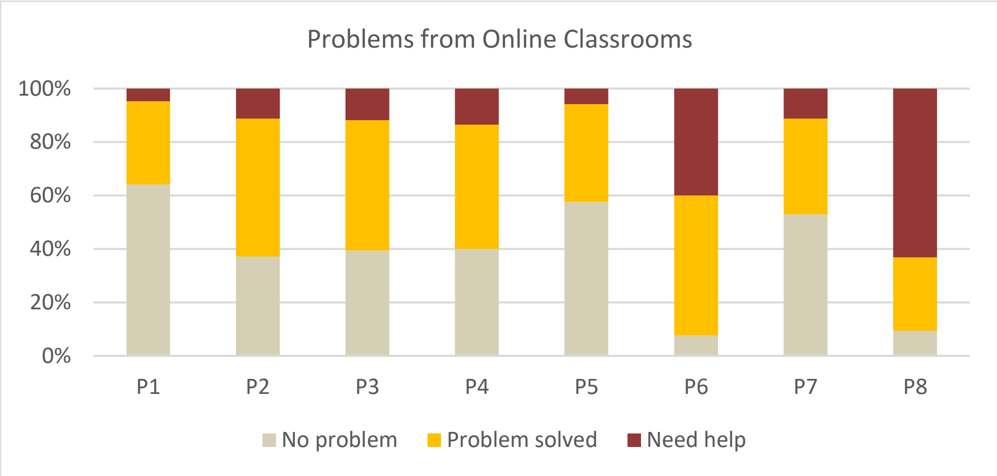


Figure 3. Summary of problems reported from students on online classrooms

4 Conclusions

Online classrooms are more likely to become the new normal for education in all levels. The results in this paper presented feedback from students that were forced to learn online during the pandemic. It was found that there were problems that arose due to the forced transition. Technical-based problems such as lacking of equipment or internet connection seems to have little effects on students' experience during the transition. Besides, lacking of peer interaction and uninspired learning atmosphere seem to be more desiderate from students' point-of-view. The feedback from students after the end of the semester has not yet been reported. However, it is expected that the action plan implemented based on the feedback surveyed in this study would help students to excel their online classes effectively for the upcoming semester.

Acknowledgements

This publication is a partial outcome of project „Curriculum Development of Master's Degree Program in Industrial Engineering for Thailand Sustainable Smart Industry (MSIE4.0)" that has been funded with support from the European Commission (Project Number: 586137-EPP-1-2017-1-TH-EPPKA2-CBHE-JP).

5 References

Auerbach, C. F. & Silverstein, L.B. (2003). Qualitative data: An introduction to coding and analysis. New York: New York University Press.

Huxham, M., Laybourn, P., Cairncross, S., Gray, M., Brown, N., Goldfinch, J., & Earl, S. (2008). Collecting student feedback: a comparison of questionnaire and other methods. Assessment & Evaluation in Higher Education, 33(6), 675-686.

Kember, D., Leung, D. Y., & Kwan, K. (2002). Does the use of student feedback questionnaires improve the overall quality of teaching?. *Assessment & Evaluation in Higher Education*, *27*(5), 411-425.

Penny, A. R. (2003). Changing the agenda for research into students' views about university teaching: Four shortcomings of SRT research. Teaching in higher education, 8(3), 399-411.

Thammasat (2020a). Thammasat University Notification on Measures and Suggestions on the Prevention and Control of Coronavirus 19 (Covid-19) (No. 6). https://tu.ac.th/uploads/news-tu/images/mar63/file/Thammasat-University-Notification-Commencement-6-EN.pdf

Thammasat (2020b). https://tu.ac.th/onlinelearning

Williams, R., & Brennan, J. (2004). Collecting and using student feedback Date: A guide to good practice. York: LTSN.

Curricular and pedagogic innovation in a Social Education programme: findings from the implementation of PBL

Sandra Fernandes[1,2], Marta Abelha[1,3], Ana Sílvia Albuquerque[1], Edgar Sousa

[1]Portucalense Institute for Human Development – INPP, Portucalense University, Portugal
[2]Research Centre on Child Studies – CIEC, University of Minho, Portugal
[3]CEIS20 – University of Coimbra, Portucalense University, Porto, Open University (UAb), Portugal

Email: sandraf@upt.pt, mabelha@upt.pt; anan@upt.pt; edgarsousap@icloud.com

Abstract

This paper describes the results from the implementation of PBL experiences in the Social Education degree programme at Portucalense University, Portugal. It aims to discuss the curricular and pedagogical changes implemented in the past three years, in this programme. In total, five PBL experiences will be reported in this study: three editions were carried out with second year students and two editions with first year students, since the academic year of 2017/2018 to 2019/2020. The objective of this study is to report findings concerning the main curricular and pedagogic innovations implemented as a result of the shift to the PBL approach, such as the teaching strategies, assessment methods, learning outcomes, student competences, partnerships with community, amongst others. Students' and teachers' opinions have been collected at the end of each PBL edition, through questionnaires and individual narratives. Until the present, ten different curricular units have participated in the PBL projects, involving about forty students and five teachers in the five PBL editions mentioned. The results, in general, suggest a positive view of the PBL experiences and the role of the project to enhance student centred teaching and learning. Teachers showed interest in developing active learning strategies and openness to change / rethink their teaching practices. Creativity, oral and written communication, problem solving, project management, interpersonal and teamwork skills were key competencies highlighted by students as a result of the PBL project. This also resulted in greater student autonomy and the development of an active role by students, characteristics which are in accordance with the main guidelines of European Standards and Guidelines for Quality in Higher Education.

Key-words: Higher Education; Pedagogic innovation; Project-based Learning (PBL), Social Education.

1 Introduction

In accordance with the Standards and Guidelines for Quality Assurance in the European Higher Education Area (2015), Higher Education institutions must ensure that the process of teaching, learning and assessment is focused on students, where students should take an active role in their learning process. Along the same lines, Cerrillo, García-Peinado & López-Bueno (2013) and Rutti et al. (2016) argue that Higher Education should prepare students for their future profession, endowing and enabling them with the appropriate practical and necessary skills. Society calls for autonomous and proactive professionals able to make decisions, work in teams and lifelong learners (Behrens, 1999). These skills can be acquired and/or developed by Higher Education students through active teaching and learning methodologies. According to Berbel (2011), these must be based on real or simulated situations which challenge students to analyse and solve problems related to their future work practices. Santos, Spagnolo, Nascimento & Santos (2017) not only present a similar definition to the one presented by Berbel (2011) but also further highlight the essential need for these methodologies in Higher Education context, given that, as stated by Miter et al. (2008), these allow the interaction between Higher Education institutions, the service and the community, through "a consistent reading and intervention on reality" (p. 2139).

The use of active methodologies in the classroom enables students to develop the capacity for critical reflection, search for new information, knowledge and solutions for a problem they ultimately must solve (Macedo et al., 2018). Additionally, according to Imaz's theoretical perspective (2015), adopting this approach proves to be beneficial as it promotes greater motivation, interest and involvement of students, increased articulation between theory and practice and the students' development of professional skills.

Project-based Learning (PBL) is one of the most successful active learning methodologies in the context of Higher Education (Kokotsaki, Menzies, & Wiggins, 2016; Lima et al., 2017; Newman, 2003; Powell & Weenk, 2003). As pointed out in the theoretical perspective of Aldabbus (2018), this methodology was based on the constructivist theories of Gergen (1995), Piaget & Inhelder (1969) and Vygotsky (1978). The definitions that Imaz (2015) and Fernandes, Abelha, Fernandes & Albuquerque (2018) give about this methodology correlate with Berbel's (2011) active teaching and learning methodology, described above. Imaz (2015, p.682) portrays project-based learning as "a didactic strategy, where students, in groups, develop projects based on real-life situations (Boss y Krauss, 2007; Bender, 2012; Patton, 2012; Garrigós y Valero-García, 2012)", whereas Fernandes, Abelha, Fernandes & Albuquerque (2018, p.447) define it as "an active teaching and learning methodology, focused on the student and development of their skills (Fernandes, 2011; Lima et al., 2017)".

According to Thomas (2000, cited in Monteiro, Reis, Silva & Souza, 2017), projects of this nature must be mainly concerned with the curriculum of the students, focused on problems or situations which prompt students to identify and apply what they have learned on the course, involve the students in researching and should reflect the reality beyond academic life. In order to develop and implement a PBL project, the following steps are required (Vára y Valero, 2010, cited in Imaz, 2015): define the context; define the theme of the project and what it aims to achieve; design a first draft of the project; outline moments of delivery and briefing of aspects related to the project; outline the evaluation process and the final classification criteria; plan the activities to be implemented; identify how the five factors that facilitate cooperative learning will incorporate the project (positive interdependence, level of demand, face-to-face interaction, ability to work as a team and to reflect back on the work accomplished); devise a schedule; identify the material resources necessary for the project and develop a help script to guide the students on the project.

The major advantage of implementing this methodology relies on the fact that it does not require far more time or resources compared to the current system of traditional education (Kokotsaki, Menzies & Wiggins, 2016). Imaz (2015) also reckons that this methodology allows students to develop cognitive skills, such as analysing information, decision-making and judgement, since the student projects are based on real or tangible problems and the role of the teacher is solely to promote the teaching and learning process. Within this methodology, learning is carried out by the students themselves, from the beginning to the end of the process, in which they play an active role in problem-solving, articulation between theory and practice, cooperative work, etc., some of the main features of the said methodology (Fernandes, Abelha, Fernandes, Albuquerque, 2018). Regarding the negative side of project-based learning, Rodríguez-Sandoval, Vargas-Solnado & Luna-Cortés (2010), based on the work of Van den Bergh et al. (2006), claim that the two main disadvantages of applying this methodology might be the work overload and the overly broad range of the resulting projects, therefore, straining the teacher that has to carefully considerate each one of them (Mesquita et al., 2009; Alves et al., 2016).

2 Context of Study

In the academic year of 2017/2018, an opportunity arose for the development of a pilot project in the Social Education Degree course (Fernandes, Abelha, Fernandes, & Albuquerque, 2018), due to the participation of teachers in pedagogical training sessions promoted by the Rectory of the Portucalense University, through its Center for Excellence in Teaching (CET@UPT). Recognizing the importance of teacher training and professional development for the quality of teaching, CET@UPT is a structure that aims to promote reflection and discussion on student-centred pedagogical practices, develop training for UPT teachers and also seeks to distinguish and disseminate examples of best practices at UPT.

Since this pilot experience, which was the first edition of the PBL in this program, four other editions of PBL have already been carried out afterwards. Table 1 presents a summary of the five editions of PBL held from the academic year 2017/2018 to the academic year 2019/2020. These experiences took place in the 1st and 2nd year of the Social Education program, involving 2 to 3 curricular units (CUs) in the each semester. The total number of students who participated in each edition varied according to the number of students enrolled each year. This difference varied between a total of 5 students, in the 1st year of 2017/2018, and a total of 13 students, in the 2nd year of 2017/2018.

Table 1. Summary of the PBL editions developed in the Social Education program at UPT

	1st Edition	2nd Edition	3th Edition	4th Edition	5th Edition	In summary…
Academic year	2017/2018	2017/2018	2018/2019	2019/2020	2019/2020	**3 academic years**
Semester	1st semester	2nd semester	1st semester	1st semester	2nd semester	**5 different semesters**
Course Year	2nd year	1st year	2nd year	2nd year	1st year	**2 different years**
No. of Teachers:	3 (SF, SMF, MA)	3 (ASA, MA, SF)	2 (SF, MA)	3 (SF, MA, IM)	3 (ASA, MA, SF)	**5 different teachers**
No. of CUs	Educational Mediation	Ethics and Education	Educational Mediation	Educational Mediation	Ethics and Education	**10 different CUs**
	Health Education	Models of Socio-Educational Intervention	Planning, Management and Evaluation of Social Projects	Planning, Management and Evaluation of Social Projects	Sociology of Education	
	Adult Training	Techniques of Sociocultural Animation	--	Social Psychology	Research Methods and Techniques II	
Project Theme	Mediation project in the area of health education - intervention in addictive behaviors	Socio-educational animation project with refugee children -MyFriend Project	Mediation project in a school context - reducing dropout and school failure	Mediation project in an educational context - conflict management	Research project on a social issue	**Diversity of themes in the field of Social Education**
No. of students	13	5	7	10	10	**45 students involved**
Number of groups	5	1	2	3	3	**14 groups involved**

The number of CUs that integrated the project, per semester, varied from 2 to 3 CUs. However, in total, up to now, ten different curricular units have been part of the Social Education course syllabus, with the CU of "Educational Mediation", of the 2nd year, having the most frequent participation in the PBL projects (involvement in a total three editions). This is followed by the UCs of "Planning, Management and Evaluation of Social Projects", from the 2nd year, and "Ethics and Education", from the 1st year, with the participation in two editions of PBL each. It should also be noted that the academic staff responsible for lecturing the 3 CUs mentioned above has remained the same over the past three years, which has facilitated the active collaboration of these teachers in the PBL projects over the past academic years.

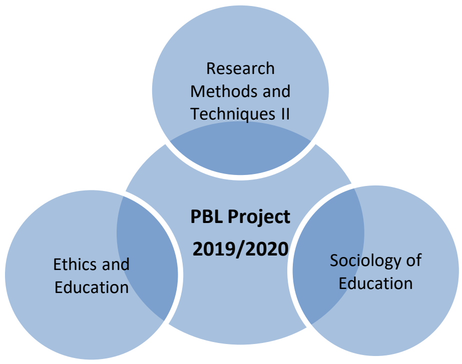


Figure 1. Articulation between the CUs and the PBL Project of the 1st year, 2nd semester, in 2019/2020

The curricular and pedagogical organization of the semesters that integrate PBL methodology requires articulation between the learning outcomes, contents and assessment strategies of each curricular unit. The moments for student assessment are also defined in a common way, since PBL entails the existence of several milestones where the student groups present their projects development state. These milestones aim to provide students with moments of feedback on project development and an opportunity to clarify doubts regarding the integration of the curricular units in the project. Table 2 presents the milestones of the project, according to the last five editions of PBL projects in the Social Education degree at UPT.

Table 2. PBL-LES Project Miletones Schedule

#	Week	*Milestone*
1	2nd Week	Presentation of the PBL-LES Project
2	3th Week	Open Lecture on the Project Theme
3	4thWeek	Presentation # 1 (Submission in Moodle)
4	10th Week	Presentation # 2 (Submission in Moodle)
5	13th Week	Presentation # 3 (Submission in Moodle)
6	13th Week	Preliminary Project Report Submission
7	14th Week	PreliminaryProject Report Feedback (for each CU)
8	15th Week	Final Presentation and Discussion of the Project (Submission of the Final Ptoject Report)
9	15th Week	Submission of Reflection on Individual Performance

Concerning the project's evaluation elements, these are distributed at different times, throughout the semester. The final grade of the group results from several factors, with a different weight in the final classification of the group. These values have undergone slight changes over the years. The following elements and weights are usually used: Presentation # 1 (5%) + Presentation # 2 (5%) + Presentation # 3 (5%), Preliminary Project Report (20%), Final Project Report (30%), Final Presentation and Project Discussion (15 %), Reflection on Individual Performance in the Group – self and peer assessment (20%)

3 Results

As stated, this paper aims to describe the results from the implementation of PBL experiences in the Social Education degree programme at UPT, with particular emphasis on the curricular and pedagogical changes implemented within this programme. For this, the authors will focus on the results of the last edition (5th) of PBL, carried out in 2019/2020.

3.1 Feedback from Students

This topic provides the results from the survey applied to first-year students, at the end of the second semester. This survey was adapted from the original version of the survey developed Lima et al. (2017), a group of researchers from the University of Minho who have deep and extensive experience in PBL. The survey explored the following sections: I) project theme; II) student learning and skills developed; III) teamwork; IV) the role of the teacher; V) student assessment and VI) PBL as a teaching-learning methodology.

3.1.1 Results from the Survey

The scale used to answer each question covers a set of choices between 1 = strongly disagree; 2 = disagree; 3 = neither agree nor disagree; 4 = agree and 5 = strongly agree. In that sense, students were asked to specify their level of agreement or disagreement according to each statement presented.

I. Project theme

Regarding the project theme, which addressed social issues selected by each one of the working groups and, subsequently, approved by the staff coordination team, it is possible to see in Figure 2, that the aspects which scored higher show that students managed to understand the articulation established between curricular units. The fact that the students selected these social problems by themselves may have served as a motivating factor itself.

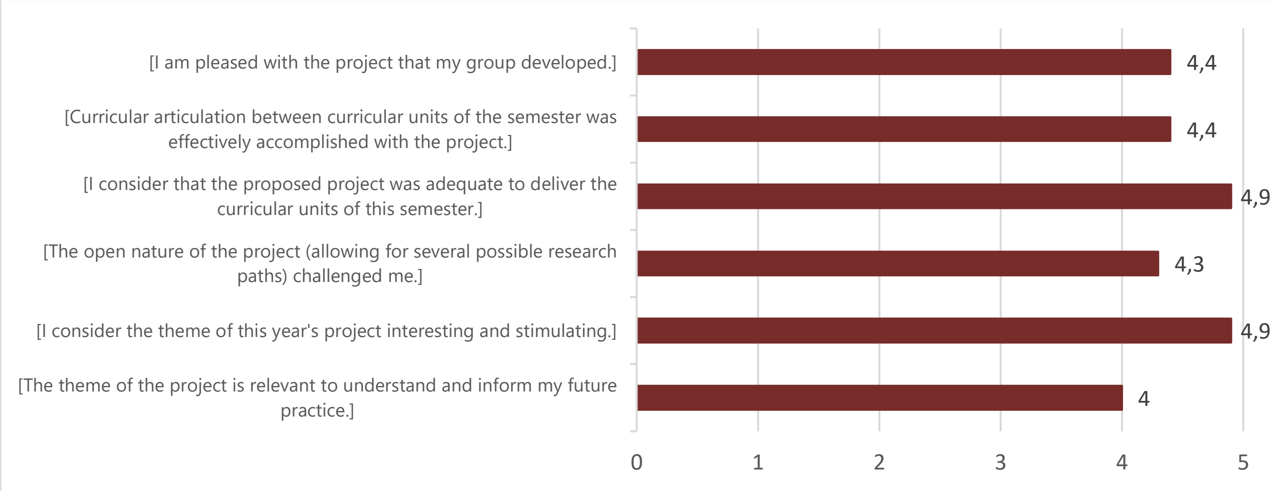


Figure 2. Results from section I - Project Theme

II. Student learning and skills developed

The items “Better understanding of the curricular content” (4.4) and “the application of the curricular contents to real situations” (4.3) were the topics better rated by students (see Figure 3). Thus, PBL seems to promote an opportunity for students to understand and integrate different contents of curricular units in real-life situations by crossing theory and practice, in line with Berbel's thinking (2011). Competences such as the “creativity” and the “ability to take initiative” scored 4.2 amongst students. On the other hand, “providing feedback to other groups was important and allowed me to develop my critical thinking” obtained the lowest score (3.6), which is understandable taking into account that these are first-year students. Nonetheless, the teaching staff considers that being able to give feedback is a capacity that must be trained with greater depth in the coming semesters in order to boost students’ critical thinking and reflection skills.

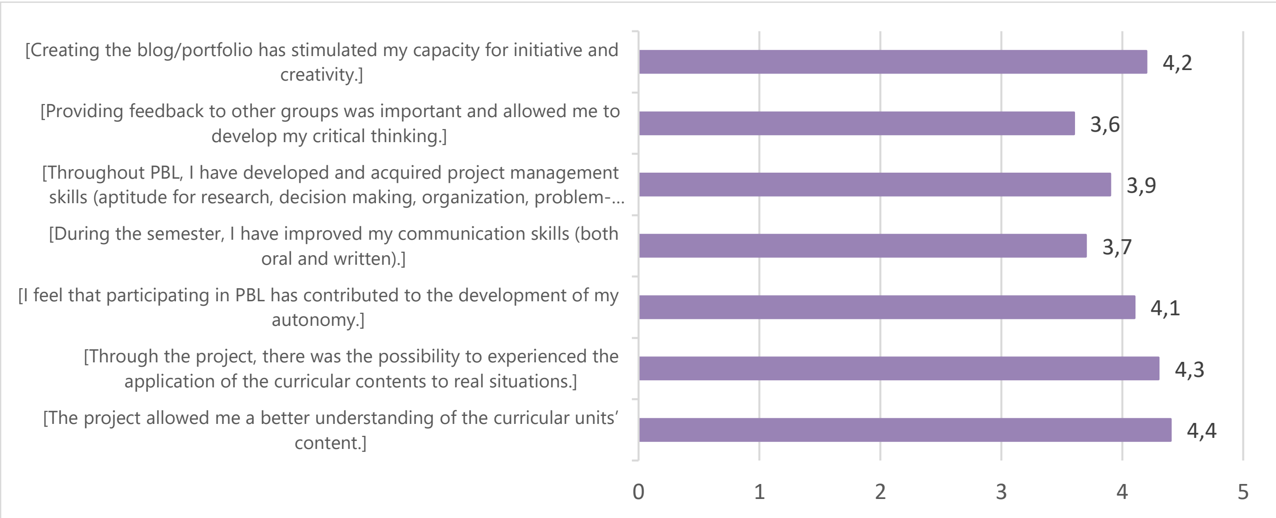


Figure 3. Results from section II – Student learning and skills developed through PBL

III. Teamwork

As shown in Figure 4, the majority of students consider that “tasks and knowledge were shared within the group" (4.9) and believe that “during the semester, (they) have played an active role in the group” (4.7). However, the “preference for group work over individual work” gathered the lowest rating (2.6). This may be related to poor management of conflict situations that may have emerged within the student groups, motivated, for example, by different opinions or weak communication between members. On this subject, Lima et al. (2011) note that overcoming these problems implies understanding them first so that later these can be effectively overcome using the appropriate strategy. “Understanding and overcoming these difficulties are two particularly important components of the learning and coordination process" when using the PBL methodology (Lima et al., 2011, p.97).

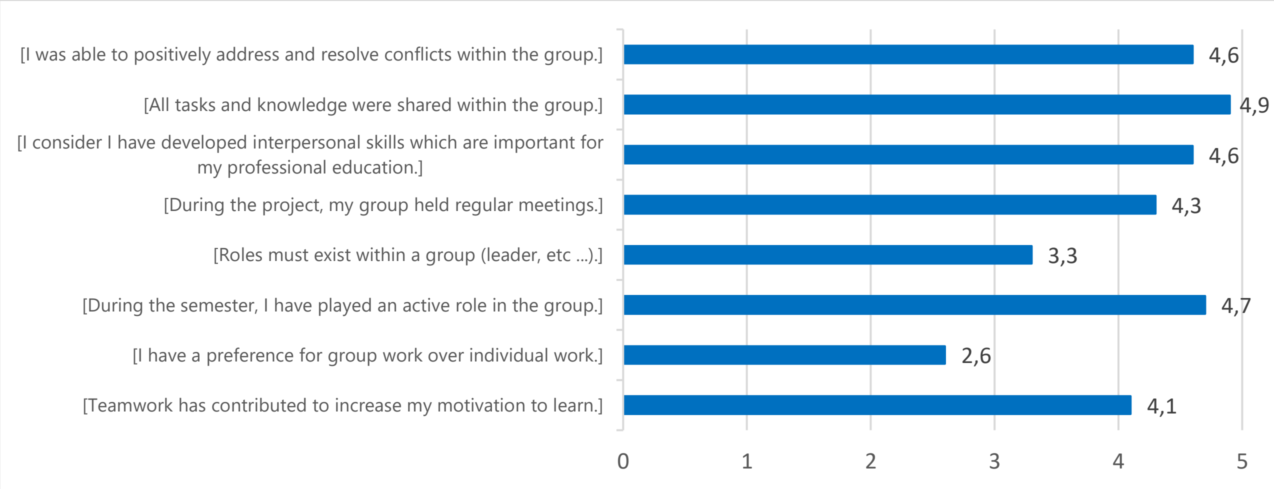


Figure 4. Results from section III - Teamwork in PBL

IV. The role of the teacher

Data presented in Figure 5 shows that students, in general, seem to be highly satisfied with the "technical support given by the teaching team to help carry out the project" (5), the "availability of the teachers to support the students" (5) and the "performance of the teaching team" (4.9). It is worth noting that past experience of teachers, acquired through previous editions, may have significantly and successfully contributed to the implementation and development of the PBL methodology.

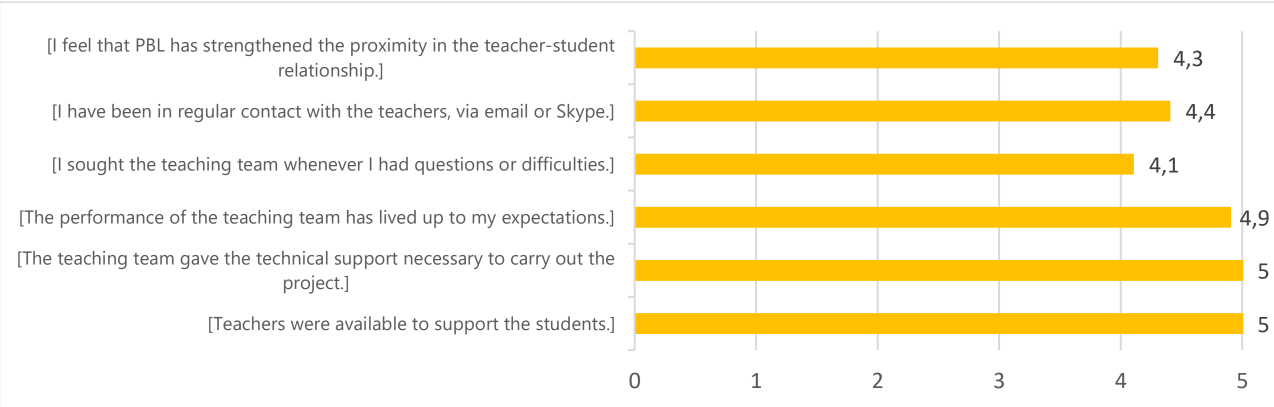


Figure 5. Results from section IV - The role of the teacher in PBL

V. Student Assessment

Student assessment of PBL emphasised how important it is that "feedback given by the teachers about presentations and reports" (4.6) is clear and, overall, expressed satisfaction "with the results obtained in the project" (4.4). A large part of the surveyed students also agrees with the number of presentations during the project, which further stresses the importance given to feedback since every presentation was followed with oral feedback and every report followed by written feedback from the teaching team, stimulating improvements on the project.

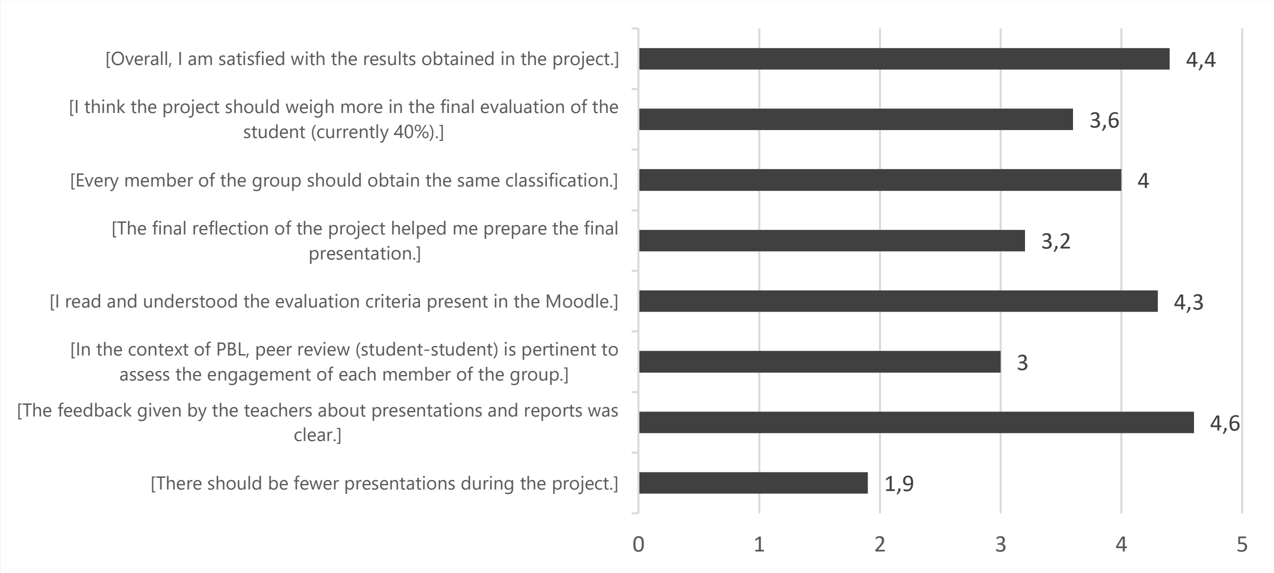


Figure 6. Results from section V - Student assessment in PBL

VI. PBL as teaching-learning methodology

Most students are satisfied with the role played by PBL as a teaching-learning approach. However, students tend to disagree that "PBL promoted (their) integration and socialisation at the University", which stands out as the least positive (2.7). This may be related to the effect that the COVID-19 pandemic phase had worldwide, forcing academic institutions to shift to online learning, thus avoiding he opportunity for a greater integration and socialisation of students across the University.

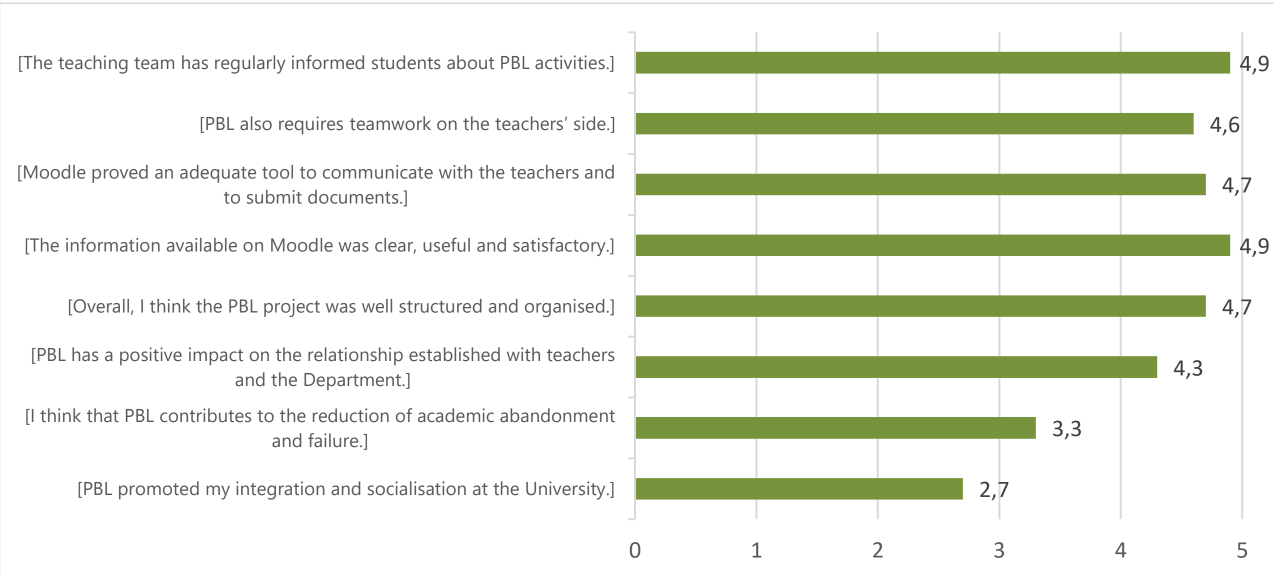


Figure 7. Results from section VI - PBL as teaching-learning methodology

3.1.2 Results from the open-ended questions of the Survey

Students were asked to point out which aspects of the PBL experience they considered to be the most positive. Teamwork, the development of autonomy and the ability to communicate were the most indicated competences, which follow and corroborate the theory of Behrens (1999). The author asserts that society demands that professionals show skills such as autonomy, initiative, decision-making, and teamwork spirit. Similarly to Ramos et al. (2013, p. 119) we believe that "learning should be focused on what the student is capable of, promoting individual and cooperative work in order to develop fundamental and transversal skills (soft skills), for instance, the ability to work as a team". Difficulties in managing time, as well as adversities in managing conflicts that sometimes arise inside groups, were the main issues students identified as the least positive aspects of the PBL experience. The authors presume that the reasons why most students struggled with time management may be due to the fact that they are still first-year students and that this teaching-learning methodology is entirely new for them. Suggestions for improvement were limited to the students' own performance, who mention that, if they were to start PBL "now", they would manage time more efficiently and, therefore, more effectively. Regarding suggestions for further improvement, some students suggested another interim report, as a new milestone, which could support students in doing a better time management.

3.2 Curricular and pedagogical innovation with PBL

The Project-Based Learning methodology is an approach that focuses, mostly, on the student, where it is sought that the student learns for himself and that the teacher assumes the role of advisor/facilitator of that same learning. PBL was considered, in the five editions, as an integrating methodology for content from different CUs, in which students "learn to learn" and prepare themselves to solve questions/problems related to their future profession, in this case, Social Educators. This integration and curricular articulation of the different contents, connected to each of the CUs involved, enabled students to have a more holistic and integrative view of theory and practice.

Throughout the different editions, each of the CUs involved in the PBL project had classes centered on instanced content inherent to the CUs themselves and classes to support the PBL project throughout the semester. It should be noted that in the 3rd and 4th editions one of the UCs - Planning, Management and Evaluation of Social Projects - was explicitly oriented towards the project, which proved to be an important issue not only for students (who had contemplated in their three teaching hours weekly hours of dedication to the project), as well as for teachers (who had the opportunity to share the CU, seeing that time counted and optimized with regard, for example, to scheduling milestones). Thus, it is considered of utmost importance a CU dedicated to project development, which can be extended to the 1st and 3rd year of the Social Education course, similar to what happens in the 2nd year´s. Another aspect, which is considered necessary, is to guarantee the continuity of the academic staff team throughout the academic years, to ensure a more significant and successful contribution of PBL implementation and development. In this case, it is considered that more significant experience in the PBL methodology results into higher levels of confidence to implement more innovative curricular and pedagogical strategies. During the semester, each team of students had to make three oral presentations. These presentations were aimed at improving proficiency in oral communication to audiences, with each student having to individually take the lead in the presentation at some point during the performance. There were moments experienced at an early stage with some nervousness that dissipated with the course of the semester given the level of confidence of students making oral presentations. The level of autonomy some students revealed in their project final discussion with the rest of the class shows that PBL methodology is impactful in terms of the development of transversal skills, so valued by the job market. On the other hand, one of the curricular and pedagogical aspects that we consider that needs greater investment in the future PBL editions is related to students' feedback capacity, as this has proved to be a weakness that students need to be overcome, especially those of the 1st year. In this sense, to increase students' feedback capacity and, consequently, their critical analysis, it is suggested that in a next edition, students have to give written feedback to another team's intermediate report.

Concerning the assessment methods of the CU, these were considered by students as innovative, standing out from the usual assessment methods (test and group work). The assessment "model" was designed to support students regulate their learning process. For this purpose, several milestones were created (previously explained) in which oral feedback was provided in the case of presentations and written feedback in the case of reports. Each milestone was part of the assessment elements of the project. Monitoring student learning and the development of individual skills was also evaluated during the semester, through the delivery of project tasks/milestones. The weight attributed to the PBL project varied according to each CU, being determined by each teacher responsible. Some programmatic contents of each CU were evaluated by the contents included in the PBL project itself, while other specific contents were not assessed in the project. With teachers experience and the feedback given by students about intra-group evaluation, as of the 3rd edition, a milestone has been included that consists of an individual reflection aimed to evaluate student involvement, autonomy and responsibility. This task gives students the opportunity to express their feelings about the experience, identifying possible problems that arose within the group work and how they were (or not) overcome.

4 Final Remarks

The implementation of PBL in higher education context has consistently shown a remarkable interest by students and teachers, due to the results obtained in terms of learning the syllabus of the curricular units that make up the project, but also in terms of the development of skills, namely soft skills. It is a challenge for teachers, in the sense of coherently combining the contents of each CU to encourage and guide students to successfully achieve the defined goals. This objective has been accomplished in the several editions of PBL, encompassing idiosyncrasies as diverse as the individuals involved. So we can consider that it is an innovative methodology that justifies its existence, contributing to enhancing student's autonomy, communication, fulfilling the mission of higher education, leading towards full integration into life in society. In years to come, we will try to achieve some goals students expressed themselves, such as the possibility of inter-year projects in social education. Also, older students mentoring/tutoring projects, physical and virtual spaces suitable for collaborative work by students and teachers.

5 Referências Bibliográficas

Alves, A., Sousa, R., Moreira, F., Carvalho, M. A., Cardoso, E., Pimenta, P., Malheiro, T., Brito, I., Fernandes, S., Mesquita, D. (2016). Managing PBL difficulties in an industrial engineering and management program. *Journal of Industrial Engineering and Management*, *9*(3). https://doi.org/10.3926/jiem.1816

Aldabbus, S. (2018). Project-based learning: implementation & challenges. *International Journal of Education, Learning and Development, 6*(3), pp. 71-79.

Behrens. (1999). A prática pedagógica e o desafio do paradigma emergente. *Revista Brasileira de Estudos Pedagógicos*, pp. 383-403.

Berbel, N. A. (2011). As metodologias ativas e a promoção da autonomia de estudantes. *Semina: Ciências Sociais e Humanas, 32*(1), pp. 25-40.

Cerrillo, R., García-Peinado, R., & López-Bueno, H. (2013). *El aprendizaje servicio como innovación docente en la universidad para la enseñanza de la organización escolar.*

ENQA, ESU, EUA & EURASHE (2015). Standards and guidelines for quality assurance in the European higher education area (ESG). Brussels, Belgium

Fernandes, S., Abelha, M., Fernandes, S. M., & Albuquerque, A. S. (2018). Implementação de PBL no curso de educação social: resultados de um estudo piloto na universidade portucalense. *International Symposium on Project Approaches in Engineering Education*, pp. 446-455.

Fernandes, S., Morais, P., Mesquita, D., Abelha, M., Fernandes, S., & Albuquerque, A. (2018). *The centre for excellence in teaching (CET) at portucalense university: Goals, strategies and expected outcomes.* pp. 1585-1592. https://doi.org/10.4995/head18.2018.8257

Imaz, J. I. (2015). Aprendizaje basado en proyectos en los grados de pedagogía y educación social: "¿Cómo ha cambiado tu ciudad?". *Revista Complutense de Educación, 26*(3), pp. 679-696.

Kokotsaki, D., Menzies, V., & Wiggins, A. (2016). Project-based learning: a review of the literature. *Improving Schools*, pp. 1-11.

Lima, R. M., Carvalho, D., Sousa, R. M., Alves, A., Moreira, F., Mesquita, D., & Fernandes, S. (2011). Estrutura de gestão para planejamento e execução de projetos interdisciplinares de aprendizagem em engenharia. In L.C. de Campos, E.A.T. Dirani e A.L. Manrique (Eds.). *Educação em Engenharia: Novas Abordagens* (pp. 87-121). EDUC - Editora da PUC-SP, São Paulo, Brasil.

Lima, R. M., Dinis-Carvalho, J., Sousa, R. M., Alves, A. C., Moreira, F., Fernandes, S., Mesquita, D. (2017). Ten years of project-based learning (PBL) in industrial engineering and management at the university of minho. In *PBL in Engineering Education: International Perspectives on Curriculum Change*. https://doi.org/10.1007/978-94-6300-905-8

Macedo, K. D. S., Acosta, B. S., Silva, E. B., Souza, N. S., Beck, C. L. C., Silva, K. K. D. (2018). Metodologias ativas de aprendizagem: caminhos possíveis para inovação no ensino em saúde. *Escola Anna Nery Revista de Enfermagem, 22*(3), pp. 1-9.

Mesquita, D., Alves, A., Fernandes, S., Moreira, F. & Lima, R. M. (2009). A first year and first semester project-led engineering education approach 2 organization model. In D. Carvalho, N. van Hattum, & R. M. Lima (Eds.), *Proceedings of the 1st Ibero- American symposium on project approaches in engineering education (PAEE'2009)* (pp. 181-189). Braga, Portugal: Centro de Investigação em Educação, Universidade do Minho.

Mitre, S. M., Siqueira-Batista, R., Girardi-de-Mendonça, J. M., Morais-Pinto, N. M., Meirelles, C. A. B., Pinto-Porto, C., Moreira, T., Hoffmann, L. M. A. (2008). Metodologias ativas de ensino-aprendizagem na formação profissional em saúde: debates atuais. *Revista Ciência & Saúde Coletiva, 13*, pp. 2133-2144.

Monteiro, S. B., Reis, A. C., Silva, J. M., & Souza, J. C. (2015). Project-based learning curricular approach in production engineering program. *Production, 27*, pp. 1-12.

Newman, M. (2003). A pilot systematic review and meta-analysis on the effectiveness of problem-based learning. *Ltsn*.

Powell, P., & Weenk, W. (2003). *Project-Led engineering education* (Vol. 53). https://doi.org/10.1017/CBO9781107415324.004

Ramos, A., Delgado, F., Afonso, P., Cruchinho, A., Pereira, P., Sapeta, P. & Ramos, G. (2013). Implementação de novas práticas pedagógicas no ensino superior. *Revista Portuguesa de Educação*, *26*(1), pp. 115-141.

Rodríguez-Sandoval, E., Vargas-Solnado, E. M., & Luna-Cortés, J. (2010). Evaluación de la estrategia "aprendizaje basado en proyectos". *Educación y Educadores, 13*(1), pp. 13-25.

Rutti, R. M., LaBonte, J., Helms, M. M., Hervani, A. A., Sarkarat, S. (2016). The service-learning projects: stakeholder benefits and potential class topics. *Education+Training, 58*(4), pp. 422-438.

Santos, P. K., Spagnolo, C., Nascimento, L. M., & Santos, B. S. (2017). Metodologias ativas para aprendizagem na educação superior: reflexões teóricas para a permanência. *Séptima Conferencia Latinoamerica Sobre el Abandono en la Educación Superior.* Argentina.

Structuring a course based on the global engineer

Vitória Bento Botelho[1], Octavio Mattasoglio Neto[2], João de Sá Brasil Lima[1]

[1] Mauá Institute of Technology, Brazil. Mechanical Engineering Program. São Caetano do Sul, SP, Brasil.
[2] Mauá Institute of Technology, Brazil. Teaching Academy. São Caetano do Sul, SP, Brasil.

Email: vivi.bbotelho@gmail.com, omattasoglio@maua.br,joão.brasil@maua.br

Abstract

This article presents a proposal for the implementation of the Grand Challenges Scholars Program (GCSP), created by the National Academy of Engineering, in an engineering teaching institution in Brazil. The GCSP focuses on teaching by soft skills and shows great intersection with the soft skills of Curricular Guidelines for engineering programs in Brazil. Besides this relation, it is clear that the use of active strategies for learning is a point of encounter between these two strategies and, in particular, the use of projects and PBL, can be the inducer for learning these strategies. The GCSP aims to build soft skills in their participating students by placing them in the face of major problems. This work involves the elaboration of a possible way of implementing the GCSP in an educational institution and, as a reference, the construction of a project in the area of Mechanical Engineering. The GCSP requires customization, hence each student receives individual guidance from a tutor who will shape the student`s path to optimize his performance in the program. The implementation of this new teaching approach becomes important, since, currently, the freshmen in university programs, in most cases, do not arrive with the experience in the job market that students of the past used to have. In that way, only the technical part of the academic training is not enough for the professional development of the student who is inserted in an increasingly competitive job market, requiring flexible and versatile engineers, capable of proposing solutions to the most diverse problems. The work is based on document analysis method and an recorded interview with a key person to implement this proposal.

Keywords: GCSP; Teaching by projects; soft skills; global engineer.

1 Introduction

The Pro-Rector of the Maua Institute of Technology (IMT-acronym in portuguese) had the first contact with this project. He participated in a workshop in Brazil, where some schools around the world presented the implementation of the Grand Challenges Scholars Program (GCSP) in their curriculum. It was when he realized an important alignment with the IMT. The Pro-Rector shared his thoughts about the GCSP with Professor Joseph Yossif, who has been in touch with the curators of the program since 2019 as the IMT found this opportunity important to add value to the institution.

This work aims to propose a way of implementing the GCSP in an engineering higher education institution. The GCSP program, an educational supplement created by the National Academy of Engineering, was created with the motivation that institutions became interested in the 14 challenges of the NAE Grand Challenges for Engineering (National Academy of Engineering), to improve the lives of people with engineering solutions in the 21st century. This program encourages the creation of innovative projects in educational institutions that, in order to participate, need to follow five soft skills, presented in item 2.1 in this work, when addressing the chosen objective. These soft skills aim to promote the training of an engineer concerned with global problems.

In this work, the soft skills of the GCSP were raised and analyzed together with the skills required in the National Engineering Curriculum Guidelines, in order to justify the presence of the GCSP in a Brazilian institution and also, to present a possible way of implementation. The importance of this research is due to the need to create a new professional identity that can only be achieved with the effective involvement of the student with global challenges, which requires an involvement and empathy with the problems of the world. This identity seems that can only be accomplish with a path that effectively allows the development of soft skills making this professional sensitive to global problems. The GCSP program can bring this new vision to students and teachers.

2 Literature Review

2.1 Grand Challenges Scholars Program

In 2008, the National Academy of Engineering (NAE) created the NAE Grand Challenges for Engineering, with the aim of presenting an aspirational vision of what engineering needs to offer to all people on the planet in the 21st century. This idea was based on 14 objectives that the NAE raised as necessary to achieve this vision in the 21st century considering its four major areas: sustainability, health, safety and joy of living. Many engineering schools and elementary and high school programs have adopted the NAE Grand Challenges to inspire practical projects for their students through an educational supplement called the Grand Challenges Scholars Program (GCSP). The GCSP points out the following five competencies as essential for students to have the necessary tools to deal with these global challenges:

I. Talent competence: guided research / creative experience on a topic similar to the Grand Challenge

II. Multidisciplinary competence: understanding the multidisciplinary of engineering systems solutions developed through personal engagement

III. Viable business / entrepreneurship competence: understanding, preferably developed through experience, of the need for a viable business model for implementing the solution

IV. Multicultural competence: understanding different cultures, preferably through multicultural experiences, to ensure cultural acceptance of the proposed engineering solutions

V. Competence in Social Consciousness: understanding that engineering solutions must mainly serve people and society, reflecting social awareness The GCSP is a supplementary program that focuses on four major areas: health, safety, sustainability and joy of living.

The intention is to add to the training of the engineer and make that engineer have a global view, thus, he can use his knowledge to help the world as a whole and not just his community.

2.2 National Curriculum Guidelines to engineering programs of Brazil

The National Curriculum Guidelines (Diretrizes Curriculares Nacionais- DCNs) originate from the Education Guidelines and Bases Act (The Law on Brazilian Education Guidelines and Bases - LDB), 1996, which states that it is the responsibility of the Union, to establish, in collaboration with the states, the Federal District and the municipalities, competences and guidelines for Early Childhood Education, Elementary Education and High School, which will guide the curricula and their minimum contents, in order to ensure common basic training.

The DCNs deal with the structuring of the engineering course, aligning all engineering institutions to guarantee a good training for the engineer. Therefore, the guidelines need to be more generic and comprehensive to achieve the requirements of all areas of engineering and, also, of any professional choice of the trained engineer.

2.3 Curriculum

The engineering curriculum must be according to the most current recommendations of ABENGE (Brazilian Association of Engineering Education), where the student must be able to develop skills and attitudes based on specific knowledge gain through personal experience. What is sought with this curriculum is to deliver to society professionals with training that enables innovation and entrepreneurship, applying what they have learned in practical matters with technique and creativity.

3 Research Method

The research method chosen to develop this work was the case study as it is exceptionally evaluating the scenario of the GCSP implementation in the IMT. However, in this stage of the study will only be considered the DCNs and the boundering conditions for the implementing phase of the GCSP. This research method is a detailed analysis of an individual case, it uses qualitative data, collected from real events, with the aim of explaining, exploring or describing current phenomena inserted in their own context.

In this research was analysed the documents of GCSP and DCNs to compare and cross the skills that are common and those that are no common in each other. To know haw the implementation of GCSP are be considered in the school, was carried out an interview with a key person, responsible to structure the proposal of the GCSP.

As a background of the research, the study of the skills desirable to the engineering students have been carried out, as a complement necessary to discuss these process.

4 Data and Results

4.1 IMT curriculum

IMT has a curriculum composed of the following curricular elements: disciplines (fixed, elective, optional), complementary activities, TCC and mandatory supervised internship. The fixed disciplines presents the minimum set of subjects necessary for the formation of the engineer according to the DCNs. While complementary activities, named PAEs in the IMT curriculum, presents a variety of more than 200 subjects as well as academic activities such as Mauaracing, that designs and builds formula SAE style cars or Enactus that does social work. The student is free to select whichever complementary activities he founds more atractive, so that he can complete the mandatory eighty hours per semester of PAEs. These subjects are offered both within the student's area of study, as well as subjects that contribute to the student's personal development. Within the complementary activities, it is also possible to participate in scientific initiation.

Also, the IMT offers minors certificates for the fifth year student who does one of the sets of optional subjects. The mandatory Internship is a supervised school educational act, developed in the work environment, which aims to prepare for productive work.

The IMT dedicates a week before classes start to receive the freshmen, when dynamics and workshops are prepared for students involving engineering challenges. In 2020, one of the proposed dynamics was the resolution of the GCSP water access challenge, which shows the institution's alignment with the GCSP's values, putting the students in contact with engineering problems aligned with GCSP, since the beginning of the graduation program.

4.2 Mechanical Engineering program

The mechanical engineering program at IMT presents the possibility of specializing students in their area of interest. The program is the only one in IMT divided into cells. The objective of the division into cells is to optimize the efforts of all the professors grouped around a common theme like: I) mechanics of solids; II) energy and fluids; III) design and manufacturing processes; IV) materials and V) automotive engineering. The first cell comprises themes like theory of structures, analytical mechanics, vibrations and finite element methods. The second one, themes like fluid mechanics, thermodynamics, heat transfer, turbo machinery and thermal machines. The third cell, themes like manufacturing processes and project/construction of machines. At last, but not least, the last two ones, comprises, respectively, areas like materials for mechanical construction and vehicular propulsion. It is important to point out that are others subareas that pertain to the cells but were not presented here. According to this structure presented, each cell is responsible for all disciplines related to its theme as also as research projects related to the cell. Within each cell there are several trails that the student can take if he/she wants to specialize in some area or wants to prepare him/herself to work, after the undergraduate, in a specific area. The trails were made by the teachers of each area and are formed by the subjects, PAEs, disciplines (elective, optional) and minors. Their creation was motivated because students used to ask professors about what PAEs and disciplines should they take according to their preferences.

4.3 Structural Elements for the implementation of the GCSP

The GCSP, being a supplementary program, presents several ways of implantation in the IMT, however it must follow some basic norms. First, as it is a personalized program, it will be offered to a few people as it is a program that requires a high commitment from the student but as well as from the teacher, who will need to monitor and evaluate his student individually throughout the program that can begin in the second year and last until the student's final year. The exact number of participating students will still be studied, depends on the availability of teachers and the interest of the student.

There is a consciousness that a few number of students could be attracted by the specific objectives of the GCSP, however it is accepted that the skills developed in the program could influence other students along the scholar life. But, at the first time, it is not the expected.

For the second point of the implementation of the GCSP will be selected the students who most identify with the program in their first or second year of the course, they must be hardworking, curious and creative thinkers, as well as having the will to use their skills to improve the world. To help in this selection the Talent Academy, which is an area of the IMT that is responsible for assisting students in building their curriculum and preparing for job interviews and the job market in general, will be making the selective process of the students willing to participate.

To accompany each student participating in the program, semi and full time resident's teachers of the IMT must be trained to become GCSP tutors. The few tutors selected to the program must be aligned with its values to pass them on to the students. Each participating will be signed with the tutor who can better help their development in whichever area of interest they eventually chose. Once the student chooses between the four grand areas, sustainability, health, security or joy of living, he should set up the trail, that he will go through in his time in the program with his tutor.

The tutoring is a program that already exists in the school, and was implemented since 2015 when a curricular change was started. The role of this tutor is too act as a mentor, being as reference to the students. The tutor, as implemented, accompanies the students only the first semester of the program, helping them to closer the course, oriented them to choose the PAEs at the first initial stages of the program, and make clear the curriculum. With the GSCP implementation, others features will be need to the teacher that will assume this position, and will be necessary training to help them to perform this new function.

For the third point of the implementation of the GCSP will be selected the students who most identify with the program in their first or second year of the course, they must be hardworking, curious and creative thinkers, as well as having the will to use their skills to improve the world. To help in this selection the Talent Academy.

Each participating will be signed with the tutor who can better help their development in whichever area of interest they eventually chose. Once the student chooses between the four grand areas, sustainability, health, security or joy of living, he should set up the trail, that he will go through in his time in the program with his tutor.

In order to trace this path one must follow a pre-defined trail made by IMT and by the NAE, but it is possible to customize according to needs and interests. This pre-defined trail will be made with the complementary activities of the curriculum of IMT, therefore, the PAES. Also the student will have to develop a project, in the style of a scientific work that involves his chosen grand area. The tutor must also evaluate his student to make sure his developing the soft skills required by the GCSP and to help the student to modify the trail as often as it needs to enhance the performance of the participant. The duration of this program depends on which college it is being implemented, however it should last at least two years.

4.4 Discussion

The DCNS soft skills are concerned with the learning process that is, providing tools for the student to develop the skills and competencies necessary for his professional life as an engineer. The GCSP's competences are focused on training engineers who are concerned with the continuity of life on the planet and the quality of the same.

To be aligned with the GCSP and the DCNs one doesn`t have to go different ways, on the contrary, the intersection between these approaches indicates that meeting the DCNs for engineering courses puts schools in a technical condition to meet the GCSP, this is an encouraging factor to participate in the GCSP . However, the GCSP is not just a technical guideline, there is a purpose which is the creation of a professional identity that can only be achieved with the effective involvement of the student with global challenges, which requires an involvement and empathy with the problems that it seems can only be achieved with a path that effectively allows the development of skills that make this professional sensitive to global problems.

The purpose of this program is to the student develops the five soft skills quoted in item 2.1 so that, in addition to their technical knowledge, it is possible to become a global engineer. The Mechanical Engineering course will have several projects to develop and will be in advantage as it has already different trails that one can choose between the four cells of specialization in the curriculum.

The path of each student in the program is flexible to be shaped, so it is unique to each one. The student will be able to take PAES, both subjects or the academic activities (item 4.1) and also do a scientific initiation about one or more of the forty-one (41) projects that were choosen for being aligned with one or more of the four grand areas of the GCSP. The student will choose between these projects for his research. At this point, there are projects involving biologic flows, wind energy, thermo-magnetic engines, waste treatment and much more.

The expectation is to make the assesment of the students based on how they developed and the outcomes of their participation in the activities mentioned above.

As for the instruments of evaluation is being created a structure that predict the implementation of rubrics, so that the tutors can make an individual assessment of the students and also the elaboration of dynamics in which the students will be evaluated in groups. These elements are based on the creation of a formative assessment that guarantees the student a feedback on the development of their performance. Even in the initial phase, these elements are being prepared by the GSCP implementation team at IMT.

The school recognizes that it already has the elements that can be conjugated for the implementation of the GCSP. However, the effective implementation will give the more conditions to evaluate how the soft skills can be developed and also, how the tutors will evaluate more precisely the students.

5 Conclusion

The objective of this work was to present the initial process of implementation of the GCSP in an engineering school, indicating the challenges related to the alignment of this program with the curricular structure, the selection of the students, the role of the tutor and the evaluation of the students. The purpose of this work is, in addition to bringing elements that are the basis of a scientific analysis of this implementation, to help schools that have this same purpose, to follow this path with less difficulties.

Therefore, the IMT has an advantage to implement the GCSP as it is aligned with the DCNs. Though, it is necessary to study and think carefully about the process to select the students and the tutors. The people who are implementing this program are considering more than numbers, such as grades and years of experience, to select someone to join the program, instead they must look to the individual and humanize it. After all, the goals of the GCSP are to make the world more sustainable, healthy and with more joy of living, in order to the deliver these it is necessary, above all qualities, empathy and humbleness to learn.

Acknowledgment

The authors thank Professor Joseph Youssif Saab Junior for his collaboration at this work with the recorded interview.

6 References

ABENGE. Brazilian Association of Engineering Education (Accessed 04 March 2019). Proposta de parecer e de resolução para as DCNs Engenharia. http://www.abenge.org.br/file/Minuta%20Parecer%20DCNs_07%2003%202018.pdf

Carvalho, L. de A.; Tonini, A. M. (2017). Uma análise comparativa entre as competências requeridas na atuação profissional do engenheiro contemporâneo e aquelas previstas nas diretrizes curriculares nacionais dos cursos de Engenharia. São Carlos, v. 24, ed. 4, p. 829-841.

Caulley, D. N. (1983). Document Analysis in Program Evaluation. La Trobe University.

Eisenhardt, K. M. (1989). Building theories form case study research. Academy of Management Review. New York, New York, v. 14 n. 4.

Lüdke, M.; E. D. A. André, M. (1986). Pesquisa em educação: abordagens qualitativas. São Paulo.
MEC. (2019). Ministério da Educação e Cultura. Conselho Nacional de Educação. Câmara de Educação Superior. Diretrizes Curriculares para os cursos de engenharia. Resolução CNE/CES nº 2.
MEC. (2013). Ministério da Educação e Cultura. Conselho Nacional de Educação. Câmara Nacional de Educação Básica. Diretrizes Curriculares Nacionais Gerais da Educação Básica. MEC, SEB, DICEI.
Mesquita, D., Lima, R. M., Flores, M. A. (2013). *Developing professional competencies through projects in interaction with companies: A study in Industrial Engineering and Management Master Degree.* 5th International Symposium on Project Approaches in Engineering Education, PAEE'2013. Eindhoven, The Netherlands.
National Academy of Engineering (Estados Unidos). (200-). Grand Challenges Schollars Program (org.). NAE Grand Challenges Scholars Program: Grand Challenges Scholars Program. Estados Unidos: National Academy of Engineering.

Class dissatisfaction and intelligibility of PBL

Octavio Mattasoglio Neto[1], Paulo Henrique Mendes Silva[2], Renam Rubam Barberini[3], Rui M. Lima[4]

[1] Mauá Institute of Technology. Basic Cycle, São Caetano do Sul, São Paulo, Brazil
[2] Mauá Institute of Technology, Civil Engineering, São Caetano do Sul, São Paulo, Brazil
[3] Mauá Institute of Technology, Mechanical Engineering, São Caetano do Sul, São Paulo, Brazil
[4] University of Minho, School of Engineering, Department of Production and Systems, ALGORITMI Centre, Campus of Azurém, Guimarães, Portugal

Email: omattasoglio@uol.com.br; ph-29@hotmail.com; renanbarberini@gmail.com; rml@dps.uminho.pt

Abstract

In the context of changing strategies, many teachers are challenged to leave their teaching models and switch to others that bring concepts and principles that often do not meet the previous model in teaching. This change is not trivial, because at the slightest sign of weakness in the new model, there is a tendency to return to the previous model experienced for a long time and even if it proves unsatisfactory, it is a safe haven for the teacher. In this work, data regarding satisfaction with previous teaching models and the intelligibility of teachers about new teaching models that provide for the use of projects will be presented. This is a complement to the work previously presented at PAEE. The teachers' previous conception of a model to structure the PBL will be raised based on data obtained in two stages from a questionnaire conducted with different groups of teachers. The results indicate that the basic principles of PBL are known and understood by teachers, though the same give it a peculiar structure, changing the order of the steps in relation to the standard models of PBL. Teachers also realize the advantage of using PBL, that is, there is the belief that the use of this strategy can contribute to learning. At the same time, there is resistance to the use of these strategies, which may be associated with the doubt that new models can be positive to promote learning.

Keywords: PBL; Teachers conceptions; Active learning; Conceptual change.

1 Introduction

Project Based Learning - PBL - has been offered as an encouraging strategy for training engineers, and many schools have incorporated this strategy into their curricula. The success of this proposal depends on the engagement of teachers, without which the best performance that this strategy offers may not be achieved. This engagement is important, because in a process of moving to PBL, the more efficient the process of implementing the higher the teacher engagement will be.

The PBL presupposes the student to be the main responsible for his learning, and the teacher the one who assists in the construction of learning, having a role of "tutor", and evaluating the student's learning. In this strategy, teachers propose projects, but the responsibility for execution lies with the student (KOLMOS, 1996; ALVES et al, 2012) with the assistance of the teacher.

A basis for this work is the conceptual change model (POSSNER et al, 1982). Interpretation is the process of changing teachers that involves a first stage of dissatisfaction with the teaching-learning process, and a later stage of PBL intelligibility, which allows for their participation and eventual adherence to this teaching strategy. Installed a dissatisfaction, the model of conceptual change envisage a second stage until a change to a new strategy is consolidated. Intelligibility, the second stage, refers to understanding the principals of PBL, which determines the construction of coherent representations of the model used, whether as propositions or representations that are internal of the individual.

The work of Ribeiro was used as the PBL model, which indicates the steps of PBL: Step 1. Identification of one or more problem(s); Step 2. Survey of the possible solutions by the students; Step 3. Attempt of an initial resolution of the problem with the basic knowledge of the students; Step 4. Analysis of which would be the learning points in the project; Step 5. Planning of the teamwork; Step 6. Independent study by the students (individually or in teams); Step 7. Meeting and sharing of information from the students in the team; Step 8. Application of the knowledge acquired in the project; Step 9. Final presentation of the project of the students; Step 10. Final assessments and feedback (Ribeiro, 2008).

The aim of this work is to assess dissatisfaction with the teaching models used and the intelligibility about the PBL. It is worth clarifying that in order to obtain good results in this process of conceptual change, teachers must be motivated and engaged for a good performance.

This work presents the combination of two stages of a larger research on the changing conditions for the incorporation of PBL in the teaching of Engineering. These two steps were reported in previous works and are aligned in this work, to clarify the path of change.

2 Methodology

2.1 Study context

The change has been studied with teachers at an engineering school that implemented projects to complement engineering courses. Teachers were responsible for the design and implementation of these projects, which have no direct link with the course subjects but intend to develop technical or transversal skills that can contribute to the education of the student.

2.2 Data collection and analysis

The focus of the work is the professors of the engineering course, and because it is the synthesis of two stages of a larger research work, it presents the data collection in two different moments and with two different groups of professors. It is an exploratory case study with quantitative and qualitative data (Lüdke & André, 1986). In both stages, data were collected from questionnaires sent to teachers in order to obtain information that characterized the sample, data about satisfaction with the teaching methods used and the intelligibility about the use of PBL. The questionnaire was essentially composed of multiple choice questions and questions with five points in the Likert scale.

For the distribution of the questionnaires, google forms was used and the link was sent to teachers by email. Out of approximately 200 teachers at the Institution, 80 answered the questionnaires in the 1st stage. In the 2nd stage, the questionnaire was sent to 80 teachers and 27 questionnaires were answered. The lower number in the 2nd stage is because only three programs were considered among the nine offered by the institution.

An Excel spreadsheet were used to analyze the data. For data related to beliefs, it was used the mean and standard deviation of the responses obtained. For data related to intelligibility, graphs were constructed with the absolute frequency of responses.

To analyze the sequence of steps perceived by teachers in their projects, a table of the sequence suggested by Ribeiro (2008) was given and placed in a random order, then respondents were asked to indicate the order of these steps in the projects they proposed to students. For the analysis of how far each step performed differed from the order proposed by Ribeiro (2008), the average of difference between the order practiced by the teacher and that indicated by the author was weighted, which guaranteed the possibility of comparison in the deviation of each step.

3 Results and Discussion

3.1 Analysis of (dis)satisfaction with teaching strategies

Using a Likert scale in which "1" is strongly disagree and "5" strongly agree, the following results were obtained.

3.1.1 Belief in usual active learning strategies

The results in **Table** indicate that teachers believe on active learning strategies (Average 3.96). It is interesting to note that the possibility of using active strategies soon is low (Average 2.06), which may indicate a reluctance to change.

Table 1 – Belief in the use of active learning strategies

Item	Average	Standard deviation
I believe that the use of active strategies is more effective for learning, than the traditional / expository model.	3,96	0,89
I have doubts about the effectiveness of using active learning strategies.	2,38	0,97
I do not use active learning strategies but I want to use them soon	2,06	1,07

3.1.2 Difficulty in using active learning strategies

Regarding the difficulty in using active strategies, that is, putting the use of these strategies into practice in the classroom, the results presented in Table 2 indicate that teachers feel safe in the use of active learning strategies (Average 3.80), however, also indicate that the use of these strategies is laborious and requires time for their preparation.

Table 2 – Results on the difficulty in using active learning strategies

Item	Average	Standard deviation
I believe that the use of active strategies is very laborious as it requires time to prepare them	3,36	1,01
I feel safe to use active strategies	3,80	0,89

3.2 Conceptions on the PBL

Approximately half of the interviewed (47%) admit to having knowledge on the PBL. Other 41% do not agree or disagree with this affirmation. Regarding to the affirmation that the seeking of knowledge in the PBL by the students is more important than the transmission of the knowledge by teacher (Fig. 1), the majority recognizing the importance of the students acting as protagonists in researching and seeking their own knowledge. In PBL, the students is the responsible for their learning, while the teacher assumes the posture of a tutor, motivating the students, facilitating the learning and stimulating the students (Silveira, 2008). This function of motivator meets the affirmation of some authors (Lima et, al, 2012, Terrón-López, 2016) that indicates that the PBL stimulates the teaching through questioning, connecting specific contents with the transversal skills that, on their turn, will be developed by the students.

Regarding the possibility for the students to have their own approaches to solving problems, 64% agree with it, as the same way, with the possibility for the students to bring their own solutions teachers also recognize the virtues of the PBL (Fig. 2). Data indicate a positive perception regarding the promotion of the student's autonomy in proposing approaches and solutions for the problems by the principles of the PBL.

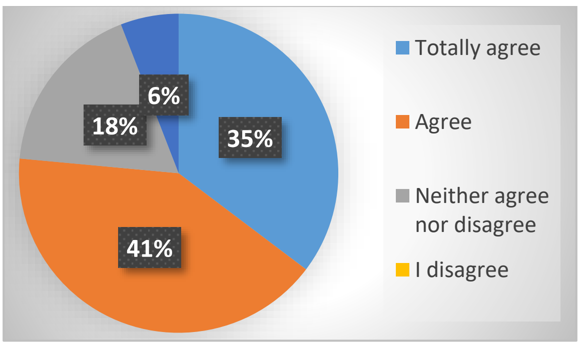


Fig. 1. In the PBL the search for knowledge is more important them transmitted by the teacher

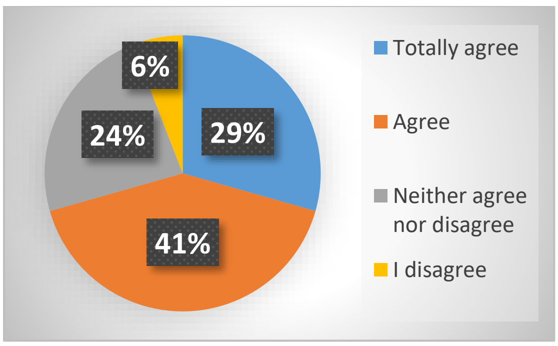


Fig. 2. The students bring solutions that are different from those proposed by teacher

3.3 The assessment of the learning in the PBL

About the steps "final presentation of the project" and "final assessments and feedbacks" in the model of Ribeiro (2008) these elements correspond respectively to the steps nine and ten. It was observed that to the respondents it happens in different steps, Fig. 3 and Fig. 4. There are no agreement that the final presentation should happen in the ninth step, but in the sixth or seventh step and a small percentage chose the eighth step. Regarding "final assessments and feedbacks", only 9% agree that this is the final step of the PBL. These indicate that the respondents perform these steps before those of the theoretical model, maintaining it, but shortening the process

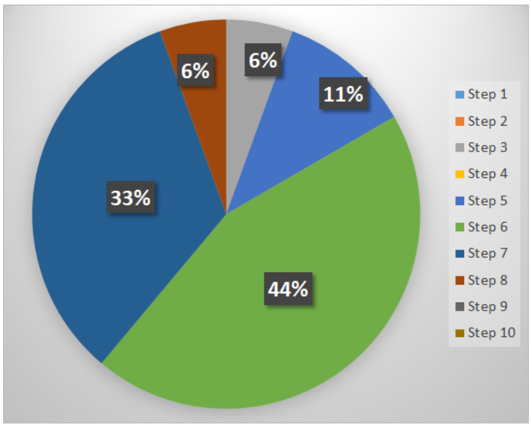


Fig. 3. Final presentation of the project by the students

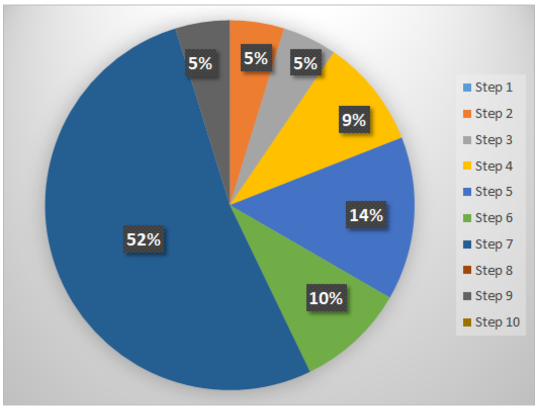


Fig. 4. Final assessments and feedback to the students

The data from Fig. 5 and Fig. 6 indicate that the respondents follow up the work and provide feedback to the students, contributing for the progress of the work and the student's learning, avoiding repetition of mistakes and highlighting positive points. The answers show that the 94% agree concerning the fact that they provide feedback to their students. The concordance rate is 70% in case of holding periodical meetings in order to discuss the project.

The respondents reveals the use of elements of the PBL to structure their projects, but changing some steps of the classic model, leading to different models of PBL of their own. However, elements as final assessment and follow-up are present in these models, even if in different steps of the model of Ribeiro (2008).

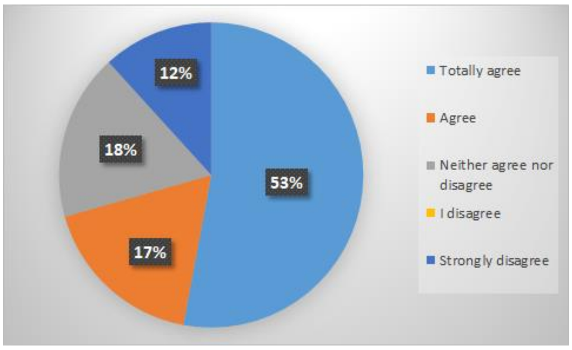


Fig. 5. Performs periodical meetings with the students in order to discuss the project

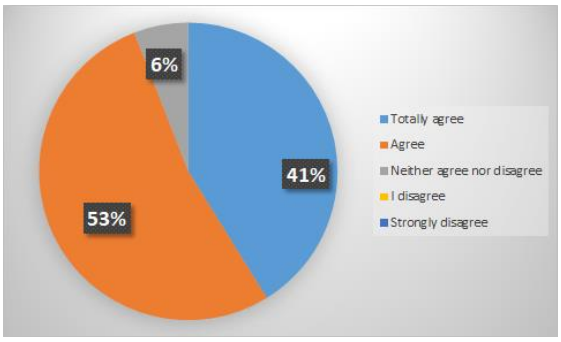


Fig. 6. Provides full feedback for the teams

Instruments of assessment in the projects

A question regarding the instruments for the assessment was used. From the options offered, all of them were pointed out as answers, except the "Written test". The data indicates that several assessments instruments are used, which go to meet of the PBL nature to develop other soft skills and assess them, besides the ones that can be observed in written tests and examinations. The teachers perceive the need of a multiplicity of assessment instruments in order to observe what the students are reaching. The respondents revel that use mainly seminar (21%), oral presentation (35%) and project report (28%).

A list with 13 soft skills was presented to teachers to freely point, those, which were developed by the students in the projects carried out. These data are presented in Fig. 7, and it indicates that teachers perceive that the students in the projects develop soft skills.

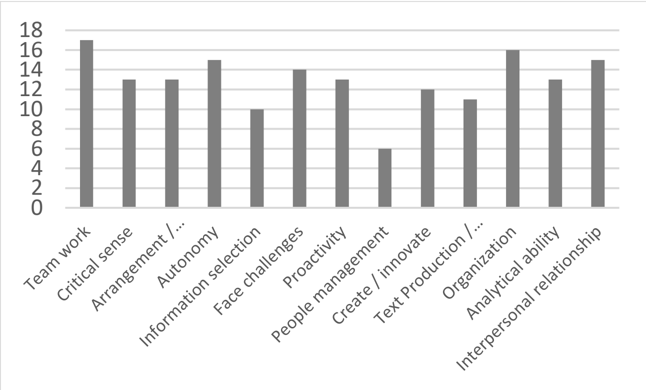


Fig. 7. Competencies developed in the PAEs using PBL

3.4 The structuring of the PBL

Based on the comparison table between the model that Ribeiro structured and the order practiced by the respondents, it is possible to obtain a weighted average considering the order of the steps. In this weighing, it was considered if the respondent would indicate as step 1 the step 1 from the theoretical model, the weight would be 10 and then regressively until reaching the weight 1, if the respondent indicated that the step 1 of the theoretical model would correspond to the tenth step in their application model of the PBL. This analysis was carried out for each of the 10 steps of the theoretical model. Fig. 13 presents the averages, in a scale from 1 through 5. These same pieces of data are indicated in Table II, in order to facilitate the reading of this article.

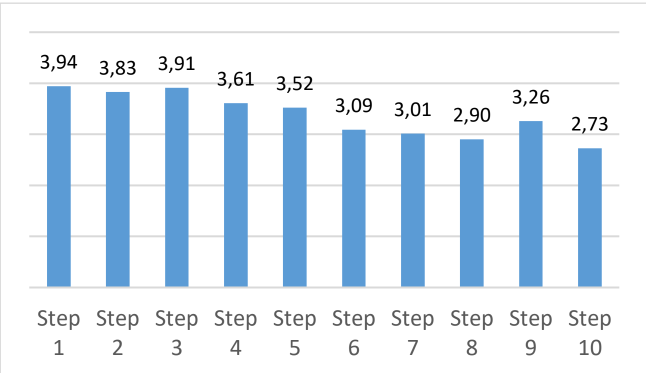


Fig. 8. Affinity between the theoretical model and the one applied in the PBL used by teachers

The steps 9 and 10 appear as the final steps for the teachers, going against the structure adapted from Ribeiro (2008). However, these steps are not carried out following the order of the theoretical model.

Fig. 9 provides more details regarding steps 1, 2, 5, 9 and 10 of the model (Axis of the abscissas) and the frequency with which the respondents indicated these steps in the questionnaire (Legends in the graphic).

In order to illustrate that, it is worthy of mentioning that step 1 "Identification of one or more problem(s)" is even associated with the 6th step of the work in the project. That is, for some respondents, the identification of the problem can happen at any of the 6 initial steps of the project. Steps 9 and 10, as already discussed in the data contained in Fig. 9, are displaced and appear more strongly until the eighth and ninth steps of the project, but more strongly until the sixth step of the project. In the specific case of the feedback, step 10 of the theoretical model, which is an important step for the students to know how their performances were, it has not worked on the moment indicated in the theoretical model. "Planning of teamwork", which corresponds to the fifth step in the theoretical model is, according to the respondents, more frequently used until the 4th step of the project.

These results indicate that teachers create their own steps when conducting the PBL, which can be associated with the need for an adaptation either for a model of conducting a project or for the needs they face when carrying out work with students.

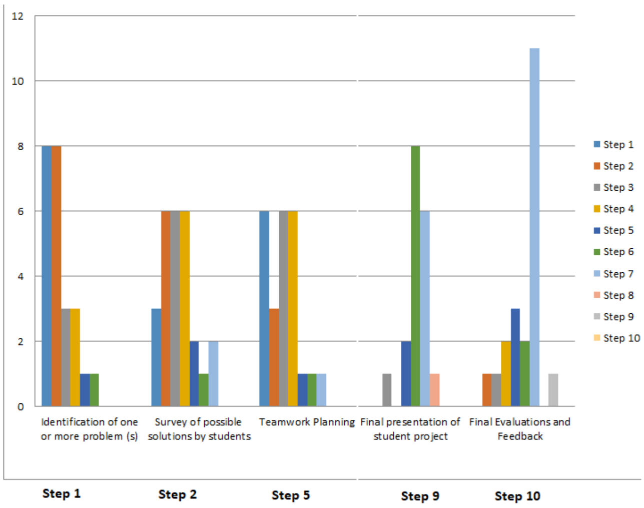


Fig. 9. Steps according to the theoretical model and respondent options

Not following the structure of the PBL as indicated by Ribeiro (2008) might be an indication of the unawareness regarding this structure of the PBL, an adaptation of other models [13] (With 7 or 8 steps), or even of a model created by the teachers themselves.

4 Conclusion

The central issue of the work is about the dissatisfaction with traditional classroom and intelligibility of the PBL by teachers working in projects and workshops offered in parallel of the subjects of an engineering course. Half of the respondents know and have alignment with the principles of the PBL as students as protagonist of the process, making research, seeking knowledge without dependence of the teacher.

The teachers also recognized the advantages from the PBL, perceiving that the students create their strategies for approaching and to seek solutions for the problems, which are competencies associated with autonomy and desired in the engineering professionals.

In line with the belief that the use of active strategies can contribute to learning, there is still resistance to the use of these strategies, which is indicate by the high rate of use of traditional classes. In turn, teachers recognize the elements of PBL but build their own models, indicating a spontaneous conception in the construction of this teaching strategy. Related to the assessment of learning and competences development teachers make use of instruments that allow assessing such as oral presentations, seminars and reports. Thus, the evaluation, the feedback, the follow-up meeting with the students happen differently from the model indicated by Ribeiro (2008) used as a standard in this research.

Acknowledgments

To the teachers that kindly responded to the research. This work was partially supported by CNPq - National Council for Scientific and Technological Development - as scientific initiation sponsorship, and partially supported by FCT – Fundação para a Ciência e Tecnologia - within the R&D Units Project Scope: UIDB/00319/2020.

5 References

Alves, A. C., Moreira, F., Lima, R., Sousa, R., Carvalho, J. D., Mesquita, D., Fernandes, S., & Hattun-Janssen, N. van. (2012) Project Based Learning in First Year, First Semester of Industrial Engineering and Management: Some Results. In: Proceedings of the ASME 2012 International Mechanical Engineering Congress & Exposition. November 9-15, , Houston, Texas, USA.

Kolmos, A. (1996) Reflections on Project Work and Problem-based Learning. In: European Journal of Engineering Education, vol. 21, no. 2, 1996. P. 141-148.

Lima, R. M., Carvalho, D., Sousa, R. M. A. da S. e, Alves, A., Moreira, F., Mesquita, D., & Fernandes, S. (2012) A Project management framework for planning and executing interdisciplinary learning projects in engineering education. In: Project approaches to learning in engineering education. (2012) Campos, L. C. de, Dirani, E. A. T., Manrique, A. L. and Hattun-Janssen, N. van. Rotterdan: Sense Publisers.

Lüdke, M., & E. D. A. André, M. (1986). Pesquisa em educação: abordagens qualitativas. São Paulo.

Possner, G. J.; Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982) Accommodation of a Scientific Conception: Towards a Theory of Conceptual Change. Science Education. v. 66, p. 211-227.

Ribeiro, L. C. Aprendizagem baseada em problemas (PBL) na educação em Engenharia. Revista de Ensino de Engenharia, v. 27, n. 2, pp. 23-32, 2008 – ISSN 0101-5001.

Terón-López, M-J. Students' and teachers' perceptions: initial achievements of a Project-Based Engineering School. European Journal of Engineering Education, 2016.

Silveira, M. A. da, Parise, J. A. R., Campos, R. C., & Almeida, N. N. (2008) Projeto LAPIN: um caminho para a implementação do aprendizado baseado em projetos. Anais: XXXVI – Congresso Brasileiro de Ensino de Engenharia. São Paulo: ABENGE.

PBL Student Projects and Sustainable Development Goals: A Case Study

Jens Myrup Pedersen[1], Rasmi-Vlad Mahmoud[1], Christian Hundborg Liboriussen[1], Jo Besford[2], Mark Swartz[2]

[1] Aalborg University, Department of Electronic Systems, Denmark
[2] Green Shoots Education, South Africa

Email: jens@es.aau.dk, rvm@es.aau.dk, christian@liboriussen.eu, jo@gsed.co.za , mark@gsed.zo.za

Abstract

Working with the Sustainable Development Goals can be a highly motivating factor in Problem Based Learning, especially if the solutions produced can be used afterwards and have an actual impact on people and communities. This paper describes how three engineering students from Aalborg University, Denmark, collaborated with the South African Organisation Green Shoots on bringing IT-supported Math education out to some of the most disadvantaged learners from townships and rural areas of the Western Cape. The project provided the Danish students with a unique learning experience and have a lasting impact on the communities involved. While the content of the project focused on bringing IT-supported Math education to learners in previously disadvantaged areas around the Western Cape, the project also provided valuable insight into how such students' projects, where the outcomes benefit people and communities suffering from socio-economic challenges e.g. poverty, can be carried out. In addition to demonstrate that such projects are actually possible, we studied three critical aspects: How to ensure a good fit between learning objectives and project outcome, how to ensure that the project creates value for the partner organisation and communities, and how to ensure that the projects can be conducted without overloading the university supervisors. We believe that student projects focusing on SDGs have a big potential in terms of providing highly motivating student projects yet at the same time contribute to a better world through solutions that are being used even afterwards. However, our study was just a single case with one group of three students. We hope it will serve as inspiration for larger studies, where more quantitative data could be gathered in terms of how to establish a good framework around such projects, and in order to demonstrate the value for students and societies.

Keywords: Problem Based Learning; Sustainability; Student engagement in learning.

1 Introduction

The Sustainable Development Goals (SDGs) are defined by the United Nations as a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity. They came into effect in January 2016 and will continue to guide UNDP policy and funding until 2030 (United Nations Development Program, 2016). The goals were agreed upon among all the countries in the world.

There is a big potential for students in working with the SDGs: There are many motivating and interesting problems to work on, it is possible to make a positive difference for the world, and the students can learn a lot from working in a context that is often very different from what they have otherwise experienced. Moreover, at least at a high level it fits very well in a Problem Based Learning (PBL) setting, such as the model practiced at Aalborg University (AAU) (Kolmos et al., 2004), where there is a big emphasis on analyzing and understanding the problem at hand before designing a relevant solution. The PBL setting, where the problem guides the choice of methods and tools, also provides a good starting point for developing solutions that can actually be used and applied and thus create value for collaboration partners, communities and societies.

Student projects focusing on the SDGs can take many shapes and forms: They can focus on students solving local problems in their own communities or through international collaboration; They can be mono- or interdisciplinary; And they can happen either within academia, or in collaboration with different kinds of partners including NGOs, industry, public bodies and communities. In this project we search to explore how projects can be carried out in an international setting in a collaboration between students and an NGO who can use the developed solution in achieving their goals of improving education among learners in the Western Cape province of South Africa.

The paper searches to answer the research question: How can PBL student projects support the development of the SDGs through collaboration with local partners? In particular, we search to understand how this can be done in a way that (1) ensures that the students learn what they are required to learn according to their learning objectives, (2) ensures that the solutions developed have sufficient value for the local organizations to justify their investment of time and resources, and (3) does not lead to an overload of the supervisors involved in the project. This research question is further motivated in the Background Section.

The main contribution of the paper is a small case demonstrating how all the three points listed above were achieved, as well as an identification of points that are crucial in order for the points to be fulfilled. This is done by analyzing all steps of the project, from development of the project proposal to the actual handover of the final product.

The rest of the paper is organized as follows: The background section provides the context, and the research gap is identified. We also present the theoretical framework for the project and the research methodology used. In the Analysis section, we describe and analyze the different steps of carrying out the project, which leads to the Discussion section where we discuss the most important findings. We summarize our findings in the Conclusion section, which also contains suggestions for further work in the field.

2 Background

2.1 Context

Aalborg University has been applying the Problem Based Learning model since 1974, and during the last years intensified the work with sustainability in engineering education through a number of student projects (Krogh-Hansen et al., 2014) as well as a number of research studies, e.g. (Smink et al., 2018) which concludes that both among students in sustainability programmes and among other students, very few (19,7% and 13,1%) find themselves well prepared in relation to social responsibility. The study concludes that one of the ways to go is to establish problem-based learning environments, where students work in cross-programme project groups to deal with a sustainability problem that calls for both disciplines, but also that structures need to be in place in order to find each other and release this potential. However, we would add that another important aspect of this is to match companies/organisations with students, in order to find students with the right competences and learning objectives in order to help solving the problems at hand. The match between the problems that motivate the project and the learning objectives of the students is important also to achieve a good alignment between what the students learn, and on which basis they are actually examined. This is well known and described as constructive alignment (Biggs and Tang, 2011).

Another study – also a case where students work on a sustainability project – was carried out in (Dahms, 1998). The paper focuses especially on the challenges in virtual collaboration throughout the project period. Challenges in international and virtual collaboration are also described in the recent papers such as (Pedersen et. al., 2018). Here, projects are carried out in collaboration between students from different countries, in collaboration with companies, and based on real problems. While these projects do not necessarily have their focus on sustainability, they do have the components of both virtual collaboration and collaboration between students and companies. Their preliminary findings also include that it is important that learning objectives are aligned, that the virtual collaboration is facilitated, and that the companies actually benefit from participation, so they are interested in continuing the collaboration.

In this paper, we investigate an example of a collaborative project, where students work on solving real-life problems with respect to improving the life conditions of some of the most disadvantaged children in the world. This is a challenging setting for the students, partly because the context is so different from what they are used to, and partly because the collaboration has a large virtual component. In particular, our research aims at determining major barriers for such projects to be established and executed as well as good practices for making such projects successful for both students and collaboration partners.

The project itself was centred around practical issues faced by Green Shoots, a Not-for-profit organisation, which has developed and is now operating an IT system for math education that is being used in South Africa, predominantly in the Western Cape. The system is implemented as a website, requiring a reliable internet connection in order to function properly. For many schools this is not problem, as they have a working internet connection, but this is not the situation for all schools in South Africa, particularly in rural areas.

In order to help disadvantaged children in rural areas, Green Shoots came up with a solution to this problem. Green Shoots divides schools into two categories, online schools with a functioning internet connection and offline schools with an unreliable internet connection. Since offline schools are not able to access the website on the internet, a computer is placed at the school that provides a local version of the website. This means that access to educational material is not dependent on the state of the internet connection.

The benefit of this solution for offline schools, is that children will always be able to practice their math. As Green Shoots found, there were however downsides to this type of solution.

Regularly updates to the IT system has to be made by Green Shoots, this includes adding new children to the system at the beginning of the school year and updating educational content and tests. For online schools this is simple, an update can be made to the central system, the website, which will be available immediately to all online schools. It's not as easy for offline schools. Since the offline schools are not connected to the internet, they can't be updated centrally, meaning that each offline school has to be updated manually. This was typically done by using a remote desktop application or physically driving out to the school.

These problems made maintenance of an offline school very expensive and hard to scale, causing Green Shoots to limit the amount of offline schools, meaning that disadvantaged children in rural areas could not be helped as effectively.

The solution developed for this problem was a software application that would monitor the state of an offline schools' unreliable internet connection and determine the most opportune time to communicate with a central system. Once communication was available, updates to offline schools could be sent, and updates to the local IT system could be made automatically. This solution gave Green Shoots the same flexibility for offline schools as online schools, reducing maintenance costs and allowing Green Shoots to support schools in rural areas with disadvantaged children.

2.2 Research contribution

Based on the background and research described above, we identify two important research questions when it comes to PBL student projects, where students work on the SDGs in collaboration with partner organisations that are not physically located close to the university:

- How do we ensure that the students learning objectives are fulfilled, i.e. that there is a good match between the problem to be solved and the learning objectives?
- How to ensure that the project – either the process or the end product - creates value for the partner organisation?

Based on our own experience with both sustainability and international student projects, we add one additional research question, which is also critical to answer in order to develop projects that are sustainable in the longer run:

- How to ensure that these projects can be carried out without overloading the supervisors in either phase of the project work?

2.3 Methodology

The paper is based on the study of a single case of collaboration between the South African not-for-profit organization Green Shoots and a group of master degree students on the 8th semester (4th year) of the engineering program of Networks and Distributed Systems. This paper is co-authored by the key stakeholders in the collaboration (students, university supervisor and contacts in Green Shoots), and the experiences described are based on systematic evaluations collected throughout the duration of the project and collaboration process. The structure of the analysis follows this systematic approach by presenting the different phases of the project, and for each phase containing:

- A description of how that phase was carried out
- An evaluation of what worked well and not so well
- A summary of the most important learning points from this phase

3 Analysis

In this section we describe the different phases and the experience throughout the different phases. We focus on all learning points, but with special emphasis on covering the research questions presented in the Background section.

The phases cover the project, but also the whole PBL learning experience: Initially, the students observe and analyse the problem, leading to a problem analysis and formulation that is discussed with the stakeholders. Based on the problem formulation, a solution is designed and implemented in close collaboration with the stakeholders. After this, the project is evaluated and graded, but in this case the students put in additional efforts after the exam to ensure the project was ready for deployment and went on a second study trip to ensure a good handover process.

It is important to note that both students, supervisor and Green Shoots took active part in all the phases, however the first phase of setting up the collaboration was done before the students got involved, and the two last phases of finalizing the project and handover was done directly between the students and Green Shoots without much involvement of the supervisor.

3.1 Setting up the collaboration (January-October 2017)

Description: The initial contact was established when the academic supervisor of the project met the Director of Green Shoots at a learning conference in Philadelphia during December 2016, more than a year before the actual student project started up. Green Shoots was running an IT-based system for Math Education, deployed already at that time to more than 200 schools in the Western Cape, where the learners were given access to interactive math education, while the teachers and school districts could collect valuable data to monitor progress and identify challenges. However, the current technical solution did not support schools with poor Internet connectivity in a scalable way. This seemed like a good match for students in the Department of Electronic Systems, working with computer networks and distributed systems. Based on this initial contact, the dialogue continued through Skype meetings and exchange of emails, which helped to narrow down the selection of students from a semester with relevant backgrounds and learning objectives, until a final project proposal was ready in the spring 2017. Already at this stage, it was identified that the project had a better fit with students of the spring semester, and it was decided to aim for having the project during spring 2018. In AAU this semester runs from February to May, with exams in June. However, in this case the students onboarded the project already in November 2017, and the final handover took place after the exams, i.e. in July 2018.

Reflections and experiences: At this point no students were involved, and at the end of the phase a good project proposal was in place. As such, one of the critical challenges had at least initially been overcome by matching company needs with students with relevant backgrounds and learning objectives. However, in our case this happened only because the right people met at the right time: Otherwise it could have been hard to identify such a match. It requires a good insight into each other's domains to match problem and potential solution before an actual problem analysis has been carried out. Another critical factor is the time it took from initial contact to starting up the project, which was partly due to this phase taking so long: This implied that Green Shoots were already looking at alternative solutions once the students started working on the project. While it took time, we think it was crucial that we managed to establish clear expectations as to the goals of the project, commitments of the time required from all sides, and a mutual understanding of the perceived value for all partners. On a final note, we found that this is a phase where the supervisor has to invest more resources than in other student projects: On the other hand, we believe that if the same collaboration can be continued in the longer term, the workload will be less once the collaboration has been established.

3.2 Recruiting the students (November 2017)

Description: At Aalborg University, students select project topics during the first week of the semester (in February), and on the particular study in Networks and Distributed systems there are often many more project proposals than student groups. However, in this case it was agreed that the students would visit Green Shoots in South Africa already in January (before the semester and courses start), and together with the need for fundraising for the travel this created a need for choosing the project much earlier: In fact, the students were selected already in the beginning of November.

Reflections and experiences: This is a more or less hand-held solution, which worked well in practice, but it is challenging how the semester start and project selection process is usually carried out: Usually the groups are formed by students, where the policy is that "no group is formed before all groups are formed", and here some students can shortcut that process by settling in the group so early. Also, at this time the students do not know what alternative projects they could select from. A final hand-held aspect is that there is no policy in place as to which students can apply: One could imagine a situation, where only students with a certain level could choose these projects, to ensure that the university remains an attractive collaboration partner: This reflects the balance between doing projects for the benefit of the students, and for the benefits of the collaborating organizations. One of the drawbacks of such hand-held solutions is that they put an additional workload on the supervisors. With a more streamlined "standard" procedure in place, we believe this additional workload could be significantly reduced if not eliminated.

3.3 Field visit to get a problem understanding and scoping (January 2018)

Description: The purpose of the first field visit was to identify the problem(s) to solve, and to scope the project accordingly together with the relevant stakeholders. This happened through visiting not only Green Shoots, but also their collaboration partners (e.g. software developers) and schools, where it was important both to see and understand the conditions the schools were working under, and to speak to the teachers and learn about their experiences. The visit lasted a week, and took place in the last week of January: This is just before the start of the semester, and thus collisions with other learning activities were avoided. Only two students were able to participate due to VISA issues. The supervisor also participated. Based on previous experience, the physical meeting was also used to establish a project plan for the collaboration, to be sure there was a mutual understanding of milestones, deliverables and communication throughout the project. The study trip was financed through a mix of self-contributions from the students, internal grants from the university, and grants from external foundations.

Reflections and experiences: First, the possibility to experience the context of the system and get a first-hand experience of the challenges and constraints was non-negotiable, as was understanding the value of Green Shoots interventions and consequently the real-world impact of the project beyond being a paper exercise. Establishing this was an important extension of the already mentioned points about clear goals, and understandings of the value and commitment for all parties. Secondly, having face-to-face meetings and establishing a good relationship between the teams was very important in order to be able to work together remotely later on. These findings are well in line with the experiences from (Dahms, 1998) and (Pedersen et. al., 2018).

3.4 Virtual collaboration phase (February-June 2018)

Description: The virtual collaboration phase was throughout the duration of the project, officially from February to May (where the project report was to be handed in), but in reality continuing throughout July to ensure that the product was ready for handover. A joint virtual communication platform (Asana), which was already used by Green Shoots was established from the beginning and used for ongoing updates as well as regular conference calls. However, the need for communication went beyond updates and ongoing feedback/discussions. In particular, there was a need for establishing a technical sandbox environment for testing purposes, and also the project scope was adjusted over time due to other development projects around Green Shoots. While being able to follow the communication through Asana, the supervisor was not in general a part of the communication that happened directly between the students and Green Shoots. Instead, the supervisor helped the students with both technical aspects of the course, and with advice on how to handle the collaboration with Green Shoots. At some point, where the students were busy with other study activities of the semester, the supervisor played a more active role.

Reflections and experiences: The virtual collaboration phase went well overall, but not without challenges. First, in many traditional projects the problem and context remain static throughout the solution development, which was not the case here because Green Shoots in parallel was working on developing and improving the systems. This required an agile approach, but also close communication in order to shape the interfaces of the project with the parallel development activities. Having learning objectives which includes the process of developing solutions (rather than just the technical aspects of the solution) is crucial in order to credit the students for this effort. We believe this is an important aspect of engineering education. We also found that the way of working with the supervisor remaining “on the side” worked well, and it kept the communication quite simple. With respect to the ongoing communication with Green Shoots, and the assistance in setting up the right technical tools, we found this to be a crucial investment of time/resources from Green Shoots in order to achieve results, which are useful afterwards. However, communication is also an aspect where the students could have been better trained, especially the necessity to continue the communication even in periods where other study activities caused progress to slow down.

3.5 Official project closing, reporting and evaluation (June 1018)

Description: The project was handed in as any other student project at AAU, and as usual documented through both code and report. Based on the report, an oral examination was held where the students presented the project and discussed it. The project was evaluated and graded according to the normal learning objectives of the semester, where the theme is “Distributed Systems Design”. The learning objectives covers system design in a broad sense, which also makes it possible to give credits for the context analysis that the students spend so much effort on. Also, the study regulation refers to “system design methodologies” without being specific, which allows a focus on agile design and development methodologies as was applied in this project. The students note that much of the added value from participating in the project was not so much related to the technical aspects, but rather the skills related to communication, organisation, collaboration, and an appreciation of understanding the context a problem resides in. However, these aspects are not really covered by the learning objectives of the semester.

Reflections and experiences: As demonstrated in previous research (e.g. constructive alignment, see Section 2.1), it is important that the objectives of the project are aligned with the learning objectives of the semester. The project here turned out to be well aligned with the learning objectives, but there is a real risk that the initial phase of the project leads to different conclusions: For example, the analysis conducted after the field trip might conclude that there is a need for different methods than initially expected. If the learning objectives are defined too narrow or too specific, this can lead to a situation with lack of alignment between project objectives and learning objectives, potentially forcing the students to choose between satisfying the project requirements (and make a project that is useful for the partner) or to satisfy the learning objectives (and make a project for which they can receive a high grade). We are speculating if this would be less of a challenge with long-term collaborations, where the university supervisor(s) might have established knowledge of the problems to work on through previous projects. We would also suggest to think into study regulations learning objectives related to the more collaborative aspects or sustainability, which would make it easier to accommodate this kind of projects.

3.6 Finalizing the project after official hand-in (June-July 2018)

Description: From a student’s perspective the development process from the beginning was different compared to a typical student project. In a typical student project, the focus of implementing a system is to show new ideas, meaning that features are prioritised ahead of other important properties in a software application, such as stability. The focus during this type of project had to be different since the final product would actually be used after the project. This was a large motivating factor for the students, since projects would often be forgotten about the day after the last exam. The fact that the priority had to be stability rather than features was clear from the beginning, based on an understanding of the ethos of Green Shoots. Based on discussions it was clear that both parties preferred a small but well-working solution. Once the students officially finished the project with the hand-in of their report, the system was prepared for implementation at Green Shoots. The students did this by working through their holiday, in order to prepare the developed solution for a production environment at Green Shoots. After hand-in the students focused on improving the stability of the application. This came at the cost of some features, that were removed, since they weren't considered mature enough. The removal of features was a hard decision, but it was made to reduce the complexity of the solution. The supervisor was generally not involved at this stage, and all communication happened directly between the students and Green Shoots.

Reflections and experiences: The time after the hand-in and before the field visit and handover was critical. It gave the students time to reflect on the system, without the stress of other exams, and allowed complete focus on the developed solution. On the other hand, this perception from the students also demonstrates that there is some difference between the requirements for the exam, and the requirements in terms of a well-functioning product at the end. It was agreed, however, that the solution of working through the summer was good, and that such a commitment from the students is fair in order to participate in a project like this. There was no additional workload for the supervisor during this phase.

3.7 Field visit and handover (July 2018)

Description With a stable and final version of the solution in hand, another field visit to South Africa took place – this time without participation of the supervisor. A test implementation of the newly developed solution was made at an offline school, in order to demonstrate the features of the solution. The students also brought documentation explaining how to use the solution, and showed how to use the system, so that it could be brought to use by Green Shoots. The solution was demonstrated to all members of the Green Shoots team, in order to show how the investment of time in a student project could pay off. The field visit again had a duration of one week. Again, the trip was financed through a mix of internal and external sources and self-contribution from students.

Reflections and experiences: The purpose of this field visit was to hand-over the solution, which happened successfully. An important aspect of this was that Green Shoots was able to take independent ownership of the solution, and as such would not rely on the student group for further integration and development. Having two intercontinental study trips as part of a semester project might not seem as a solution that can be replicated in all places, but we found that also the second trip was important to ensure a good hand-over of the project to ensure that Green Shoots could take ownership of the project from here. One way of reducing the need for travel could be that not all students participate in both trips, and/or to organize the trips so they combine hand-over of one project (or sub-project) and starting up the next (sub-) project. On the other hand, the students found it very valuable and learningful to be able to follow a project all the way through from initial investigation to implementation and hand-over.

4 Discussion

Overall, we consider the project to be a success, which demonstrates that it is indeed possible to carry out student projects related to the SDGs, which make a difference for communities, add value for the collaboration partners, and fit the learning objectives of the students. On the other hand, we also experienced some challenges, of which many relate to the structural setup of projects, and might require more systemic changes to be really resolved. In the following we will focus the discussion on the points related to the research questions.

With respect to the learning objectives, this case demonstrates an example where there is a very good fit between the learning objectives of the students, and the project defined based on the needs of Green Shoots. To a large extend this was made possible through a thorough process of collaboration setup and project scoping, and through identifying a relevant semester project for the work. As mentioned above, it is important that the learning objectives are sufficiently broad and flexible to manage that the project might be adjust over time, both as a consequence of the initial analysis conducted, or because it is impacted by other projects/processes within the partner organisations. We believe that an effort where learning goals can explicitly include sustainability and/or international collaboration can also support that the students get due credits for their work, but again we believe that flexibility is a key word, since we also need to respond to the project possibilities that are coming up.

With respect to the value creation for the communities and partner organisations, we found several factors to be of high importance. First of all, it is important that students and partner organisations develop a mutual understanding of the outcome of the project, how the outcomes will be used, and how the collaboration will work. It is also important that all partners are willing to commit time and resources. Second, the field visit – while being one of the least scalable aspects of the setup – was important develop the relationship between all partners, and to provide the students with first-hand understanding of the context. When looking at how the value is created in related to the time invested, we found that in our case both the university supervisor and Green Shoots invested quite a lot of time in setting up the collaboration. We believe that a key to reduce this overhead can be to have long-term collaborations, where more groups of students - in parallel and/or in continuation – can contribute with different parts of solutions. This could also facilitate the collaboration between disciplines as mentioned in (Smink et al., 2018). We leave it as an open question whether this kind of projects should be open for all students, or just selected students who demonstrate the capabilities and commitments to ensure a significant output for the partner organisation.

With respect to the workload of supervisors, we find that the setup with direct communication between partner organisation and students worked well, and for the supervisor the workload during the execution of the project were not more than that of any other student project. However, more time was spent during setting up the collaboration, project proposal, and during the initial problem understanding (including the study trip). In addition to seeing this as a long-term investment in a partnership as discussed above, maybe a broker function at the university could help to match problems with relevant studies and semesters: However, doing so requires some technical insights which will likely involve potential supervisors. Also, the value of early involvement of supervisors in order to establish personal relationships should not be underestimated. One suggestion to decrease the workload of the supervisor even more during the project execution could be to make use of online materials to prepare the students for this kind of collaboration, and provide them tools to work in a context that can be so different from what they have experienced in their previous studies.

5 Conclusion

This paper presented a case study, where students from Aalborg University worked with the Sustainable Development Goals in a semester project in collaboration with the not-for-profit organisation Green Shoots. While the content of the project focused on bringing IT-supported Math education to learners in previously disadvantaged areas around the Western Cape, the project also provided valuable insight into how such students' projects, where the outcome benefit people and communities suffering from socio-economic challenges e.g. poverty can be carried out. In addition to demonstrate that such projects are actually possible, we studied three critical aspects: How to ensure a good fit between learning objectives and project outcome, how to ensure that the project creates value for the partner organisation and communities, and how to ensure that the projects can be conducted without overloading the university supervisors.

We believe that student projects focusing on SDGs have a big potential in terms of providing highly motivating student projects yet at the same time contribute to a better world through solutions that are being used even afterwards. However, our study was just a single case with one group of three students. We hope it will serve as inspiration for larger studies, where more quantitative data could be gathered in terms of how to establish a good framework around such projects, and in order to demonstrate the value for students and societies.

Acknowledgements

The Authors would like to thank IT-Vest for supporting the student's trips to South Africa.

6 References

Kolmos, A., Fink, F., & Krogh, L. (2004). The Aalborg PBL Model: Progress, Diversity and Challenges. Aalborg University Press.

Biggs, J.B, & Tang, C.S-k. (2011). Teaching for quality learning at university: what the student does. Maidenhead: McGraw-Hill. ISBN 9780335242757.

Dahms, M (1998). International Student Co-Operation via e-mail and Internet – an EU-project on Virtual Mobility. The International Conference on Engineering for Sustainable Development (ICESD). Faculty of Engineering, University of Dar es Salaam, Tanzania, July 1998.

Krogh Hansen, K., Otrel-Cass, K., Guerra, A., & Dahms, M-L. (2014). Good Examples Catalogue: "Problem Based Learning and Sustainability in Engineering and Science Education – Practice and Potential". Faculty of Engineering and Science, Aalborg University.

Pedersen, JM, Elsner, R, Kuran, MS, Prikulis, L & Zabludowski, L (2018), International student projects in a blended setting: How to facilitate problem based project work. *10th International Symposium Project Approaches in Engineering Education, PAEE, and 15th Workshop on Active Learning in Engineering Education, ALE*, Brasilia, Brasilien, 28/02/2018.

Smink, C. K., Holgaard, J. E., Clausen, N. R., & Kolmos, A. (2018). Educating Engineers for Sustainability: understanding student differences. I R. Clark, P. M. Hussmann, H-M. Järvinen , M. Murphy, & M. E. Vigild (red.), *Proceedings of the 46th SEFI Annual Conference 2018: Creativity, Innovation and Entrepreneurship for Engineering Education Excellence (s. 437-445)*. SEFI: European Association for Engineering Education.

United Nations Development Program (2016). *Sustainable Development Goals*. Accessed at https://www.undp.org/content/undp/en/home/sustainable-development-goals.html on 15 mar 2019.

Evaluation process in the application of Case Teaching Method in Management education: a study in the perception of professors from Brazilian universities

Maria Isabel M. Brito[1], Maria Valéria P. Araújo[1], Max Leandro A. Brito[1], Dmitryev C. Silva[1], Ana Beatriz C. Santana[1], Rebeka Coelho A. Alves[1], John G. Burgoyne[2], Afrânio G. Araújo[1]

[1] Federal University of Rio Grande do Norte, Brazi
[2] Lancaster University, United Kingdom

Email: belmedeiros@gmail.com, valeriaaraujoufrn@gmail.com, maxlabrito@gmail.com, dmitryev14@gmail.com, beatrizpintocabral@hotmail.com , rebeka.coelho@gmail.com, j.burgoyne@lancaster.ac.uk, afranioga@gmail.com

Abstract

Active methodologies allow the use of evaluation formats that cover weaknesses of current evaluation methods (Mansur & Alves, 2018). As for teaching cases, Dalfovo (2013) and Ribeiro (2016) discuss the lack of systematic assessment. The work aims to understand the evaluation process in the application of the case method in management courses at Brazilian universities, with specific objectives: to describe the planning process in the application of learning evaluation; investigate the adoption of instruments and strategies used in case evaluation for teaching; identify the monitoring adopted in the evaluation and identify a suggestion for improvement from the data of the evaluation carried out with the students. This is a multiple and exploratory case study. A semi-structured interview script was applied with management professors from two Brazilian universities. The data were discussed from the qualitative approach adopting content analysis. The results of the research are similar to the studies on evaluation in teaching methods, although none of them is the method of the case. All teachers surveyed carry out planning, corroborating the studies by Silva, Santos & Paixão (2014). Some teachers value the moment of the evaluation, elaborating the teaching plan (Tormena & Figueiredo, 2010). Otherwise, the group plans to value the forms of evaluation adopted (Fernandes & Fialho, 2012). Regarding assessment instruments (Depresbiteris & Tavares, 2009), most teachers use student observation. In the monitoring of the evaluation, a large part of it does so through group discussions (Depresbiteris & Tavares, 2017). With the results of the evaluation, most teachers perceive the need for the student to know the theory to associate the content with the resolution of the case (Miranda, 2008). The findings of the work are the different ways of planning, the observation of groups as an assessment tool, as well as the follow-up of discussions, based on these observations and the importance of theory for solving the case.

Keywords: Method Case; Evaluation; Learning; Management Education.

1 Introduction

The manager's work pace makes his practice less reflective (Mintzberg, 2010). This reality is also a reflection of teaching historically based only on reproducing and had to transform itself so that the professional develops the skills of understanding, critical analysis and reflection in a competitive market (Sauaia, 2013, Kakouris, 2015). In this context, Silva, Oliveira and Mota (2013) points out the case of the method of teaching as one of the learning system in action strategies for management education. From the practice of methodologies such as the case for teaching, it is also necessary to apply other forms of assessment that can cover the weaknesses of the assessment methods applied until then (Mansur & Alves, 2018).

In this sense, this article aims to understand the process of learning assessment with the application of the case method for teaching in Brazilian administration courses and specific objectives: (i) Describe the planning process for the application of learning assessment; (ii) Investigate the adoption of instruments and strategies used in the evaluation process; (iii) Identify the monitoring and control mechanisms adopted in the evaluation and; (iv) identify a suggestion for improvement from the data of the evaluation carried out with the students, when they applied the cases for teaching.

Despite the research being carried out in the a Administration context, the study has a relevant contribution to Engineering, since Administrative Science has, in its curriculum, contents and curricular units, transversal disciplines, when compared to the Engineering area. Thus, a study of Administration in an Engineering meeting becomes relevant mainly to generate a discussion about the need to contemplate transdisciplinary contents aimed also at developing Engineering students, as well as in Administration area, the technical skills, attitudes and abilities necessary to lead people and work teams, so important for both careers..

2 Case Method for teaching and the learning assessment process

Gil (2004) conceptualizes the case method for teaching as reports used and studied by individuals or groups to solve problems and make decisions. For Araujo, Rejowsky and Leal (2012), it is a methodology that describes a real problem faced by a person in the organization, usually presented from the point of view of the decision maker, in order to take this situation to a learning context, inviting people and students to reflect and position themselves in the context presented. The case teaching method can be named as many variables: case study method, case-based learning, case method for teaching, but still carrying the same meaning and being related to the same active methodology.

To Burgoyne & Mumford (2001) the Case Teaching Method in management education and development is the most used approach outside the traditional lecture/instruction format. For the student to be able to position himself and put himself in the role of the decision maker to find the solution to the problem presented, it is necessary that he has sufficient theoretical foundation to apply theory to practice and solve the problem presented, avoiding the risk of be based on 'beliefs' (Christense, 1987)

Miranda (2008), when studying the evaluation of learning through teaching cases in graduate courses in business, describes the learning process in three stages: a) individual preparation of the student: familiarization reading, complementary readings , diagnosis of the problem, development of alternatives, definition of criteria, proposal of solution ; b) group discussion (Mendes, Trevisan & Souza, 2016), where there is an opportunity to debate individual positions and advance the level of understanding; c) plenary discussion, where the understanding of the case develops.

Therefore, it is necessary to take into account the importance of planning and carrying out the work proposed by the teacher. One of the ways to carry out this planning is from the preparation of the teaching plan built at the beginning of the discipline (Silva, Santos & Paixão, 2014). The plan helps the teacher to organize the necessary resources for the classes and favors the monitoring of the activities that will be developed (Tormena & Figueiredo, 2010). This avoids improvisation, facilitates the integration of students with learning experiences, so that the student's vision is broadened, cooperative, participatory and he develops autonomy in learning (Sassaki, 1997, Nogaro, 2018)

To put into practice the forms of assessment, the professor should make use of assessment tools to assist in their practice, diversifying forms of collect accurate information and carry out analysis and interpretation in order to improve the process of learning (Depresbiteris & Tavares, 2017, Haydt, 2002). Once the assessment instruments are applied, the professor is able to monitor the development of the student's learning process. Dalfavo (2013) & Ribeiro (2016) draw attention to the difficulties encountered by teachers in evaluating students when applying cases for teaching. One of the ways to carry out this monitoring, for example, is through the observation of group discussions, when the case is applied. For Depresbiteris and Tavares (2017) and Mendes, Trevisan and Souza (2016), group observation must be systematic and planned so that the teacher has the amount of information necessary to assess the student's level of learning.

3 Methodology

This is a multiple and exploratory case study, with a qualitative analysis approach. In this perspective, the present study investigates the perception of professors from UFRN and UFPB who use the case method for teaching in their disciplines. Four professors from UFRN were interviewed personally and five professors from UFPB through skype meetings, during September to December 2019.

Data processing was carried out through content analysis, where the categories of analysis emerged from theoretical support: evaluation planning (Silva, Santos & Paixão, 2014), evaluation instruments and strategies (Depresbiteris & Tavares, 2009), monitoring of the evaluation (Depresbiteris & Tavares, 2017) and actions taken after the evaluation (Miranda, 2008).

Finally, for data analysis, the transcribed comments of the interview were read, with the objective of coding and grouping the text units, comparing them with those categories already identified in the theory.

4 Analysis of Results

In order to maintain the anonymity of the respondents, a codification was established for the subjects and their speeches, distinguishing them between participants from Rio Grande do Norte and Paraíba. In this way, the code "P" represents that the respondent is the professor, as in UFRN four professors were interviewed, the codes varied from being from P1 to P4, on the other hand, among the UFPB professors, which were five, the codes ranged from P5 to P9.

The acronyms RN were added to the end of the professors' codes, to facilitate the identification of professors in Rio Grande do Norte and professors in Paraíba - PB. At the end of the initials of each professor's status, codes ranging from f1 to f4 were also established to represent the participants' statements.

The first question of the interview script sought to identify how the teacher planned the assessment of learning in the application of cases for teaching in the discipline taught. The results of the interviews carried out demonstrate that all professors interviewed at UFRN and UFPB carry out the planning, in some way, of the case evaluation process for applied teaching in the classroom.

The teachers' response corroborates the studies by Silva, Santos and Paixão (2014), who carried out their research with the assessment of learning in general. This study is used to compare with the results found here, because in the research found on teaching cases, there are no registers of teachers who planned evaluation when using this methodology.

The authors point out that a survey carried out among professors of the Administration course, all the teachers interviewed carry out the planning of the academic semester, including in it the evaluations performed. Planning is presented to the students and discussed in class, even if students do not engage in an active way, the intention is to clarify the what will be covered in class.

Thus, and according to the supported studies, planning serves as a guide to lead teachers during the development period of the discipline, helping to achieve the learning objectives. In this way, the teacher does not run over the content and follows the calendar to guide the course of the classes.

Therefore, it is understood that the teacher who plans his evaluations is able to organize his work in advance for the duration of the classes and to apply the evaluative activities at the appropriate moments in the classroom, avoiding improvisations and being able to accompany his students during the process of learning.

The planning of the evaluation is carried out in two ways by the teachers surveyed: a first group that carries out from the moment of the evaluation, using the teaching plan (Sassaki, 1997, Nogaro, 2018) and a second group that focuses on the forms of evaluation, valuing student participation in small groups and in plenary (Tormena & Figueiredo, 2010). The results of the research are similar to the studies by Sassaki (1997) and Tormena and Figueiredo (2010) although these refer to evaluation methods in general. They are also close to the research of Nogaro (2018) that refer to the assessment of learning when using problem-based learning. The statements of the following subjects refer to the teachers of the first group.

> "I usually deliver a lesson plan, where they already know the days they have activity because I score all of them, you know, I don't just do tests, I like to do continuous assessment and I use the case not only to bring the student closer to the practice , but I also do an evaluation with him. [...] The planning is always prior." (Ppb7F1)

> "They know, oh, you'll be evaluated like this, they know everything, the whole process, before, well before, they don't know before, they know well before, they know the whole evaluation process and how much the case will weigh in their evaluation in the discipline's learning process. They know everything so as not to have improvisations." (Ppb5F1)

The reports showed that they value the importance of planning carried out *a priori* in relation to methodological choices and evaluations carried out during the course of the disciplines. Teachers' statements confirm the results of research carried out by Sassaki (1997), Nogaro (2018) when they state that planning is necessary, thus avoiding improvisation and facilitating the integration of students with learning experiences.

From this, the moment the teacher makes the prior planning of his classes, the research teacher chooses the most appropriate evaluation method that he will use for each moment of the discipline, according to the programmed content and, he passes this information on to the students. The subjects' speeches strengthen their concern with regard to anticipating the planning of activities because they understand the importance of caring for the educational process and the training of professionals. The act of training requires the teacher to anticipate questions such as: what do you intend to develop in students' learning? What skills and how to achieve them? How to attain the learning objectives?

According to the studies pointed out in this work, when teachers present to students the planning of classes that contain the evaluative activities that will be performed, this attitude may be related to the need to avoid improvisation, since it is known what will happen in classroom, thus assisting in the quality of student learning. In addition, when teachers reinforce in the testimonies, for example, "they already know the days when they have activity" and "They know everything", these statements demonstrate that for them, prior communication with the student is also a relevant parameter.

Unlike the perception of this first group of teachers, the second group values the forms of assessment they will adopt in the classroom, that is, they did not detail the time period in which they planned the assessments, but described the type of assessment they adopt when applying the teaching cases. In this way, when discussing the forms of assessment, teachers also address the strategies used when performing assessment in the classroom. Most teachers, therefore, report that they perform based on student participation in small groups and then expand the debate to a large group discussion, as can be seen in the excerpts of the statements below.

> "[...] then students can discuss in groups and then we take a larger approach with the whole room and then I make theoretical connections and clarify some concepts" (Prn2F1).

> "[...] we do the discussion in small groups and then do the discussion in the plenary." (Ppb10F1)

> "[...] they divide it into groups, they debate the answers in groups and then, they get the whole group together so that we can arrive more or less at a common denominator, more or less." (Ppb6F1)

> "[...] to what extent the case solutions developed by groups of students, I never worked individually, I worked in groups, to what extent the answers offered by the groups to the dilemmas of the cases involved the effective use of literature that was being presented." (Ppb8F1)

> "At first, the participation of students and their involvement in small groups, right? When we separate the class, go to the groups and pass the questions, pass the case and pass the questions. So I evaluate the interaction between them, you see the participation of everyone, round between the groups observing the interaction, participation and contribution, right. This is a first step. In the second moment it makes a large group and then again I evaluate the general participation group by group and individually in the solution of the issues." (Ppb9F1)

In the reports presented by the teachers, it is clear that they prefer to adopt an assessment considering the student's participation in the case discussions, both in small groups and in the plenary discussion, so that the student himself can interact, argue and discuss the solutions of the case and learn during the debates.

The excerpts from the speeches corroborate the studies by Miranda (2008) who point out that in discussions in small groups and in plenary there is an opportunity to debate individual positions and advance the level of complete and detailed understanding of the case. In this way, when the teacher describes the student's participation in the discussions using this to evaluate him, according to what the studies present, he helps the student to position himself in the discussions, to place himself as the decision maker, reflecting on the problem and understanding the situation presented.

Still in relation to execution, there was another question in the interview script that aimed to discover the instruments and strategies used by the teacher when assessing learning when applying cases for teaching in the discipline taught. The reports show that the majority of professors at UFRN and UFPB carry out the assessment based on observation, which has subjective characteristics.

The studies by Depresbiteris and Tavares (2009), when researching evaluation in general, assure that the instruments are used as tools to collect information about student learning and can be diverse, such as: tests, case analysis, map conceptual, portfolios, situational evidence, operational evidence and several others. For the authors, the diversification of instruments is important because it gives the possibility to analyze students' learning from different angles. The subjects' statements point out that,

> “[...] I usually observe in fact, because as I understand that the case is the moment to generate only reflections, discussions, which is not right or wrong, right from the answers, each one has their own way of manage and solve problems.” (Ppb9F2)
>
> “[...] as the case he has this peculiarity of not having a single answer, it is important to observe how the students behave because they like cases a lot, it is very interesting to see” (Ppb10F3)
>
> “No, I never used assessment tools. (Pp b8F2) [...] I did not use criteria that were objective, no scales or tables that aimed, it was much more in the sense of how creative or how inventive [...] how plausible the solutions were”(Ppb8F1)
>
> “Usually I make a qualitative judgment, I take the characterization of what was produced and I make the judgment in relation to density, depth. [...] it is more in the qualitative perspective of me as a judge to observe if that provision makes sense, does not make sense and under what conditions it is being treated ”(Prn4F2).
>
> “I rate according to what the class is going on. I don't use an instrument and now at that moment in each case I don't. I have some skills that I want, for example, that they develop, for example, part of teamwork in interpersonal relationships, it is an interesting skill that they work in the classroom. So I observe this, I see how it will flow”(Prn2F2)

So this group of teachers prefer to evaluate students based on the observation strategy, so that they follow the evolution of the learning of these students in the classroom. These results also showed that teachers evaluate students during the entire development process and not just performing assessments in a timely manner.

According to Depresbiteris and Tavares (2017), observation must be systematic and planned so that we have rich information. For this to happen, observation needs to occur throughout the entire learning process. In this same direction, Haydt's (2002) studies conclude that the more data the teacher collects and records about the student in his observation, the more condition he will have to make an accurate analysis of his performance.

Therefore, it is believed that, from the studies described, teachers who use observation as an evaluation strategy are able to follow the evolution of students' learning throughout the entire process in the classroom, without resorting only to traditional assessments. Accredited ta also that when the teacher performs this monitoring, gives the student more safety without need to be evaluating the tension in just a moment, as the realization of an event, for example.

Teachers were also asked about the monitoring and control mechanisms adopted in the learning assessment process. The reports show that the majority of professors at UFRN and UFPB somehow carry out the monitoring of students' learning assessment through group discussions, based on observations.

> "I follow the groups as they discuss and talk about the answers." (Ppb9F3)

> "[...] we don't intervene in his resolution, we follow the discussions and see how they are working in a group" (Prn1F3)
>
> "[...] I go around the groups, observe the most interesting comments and follow the discussions." (Prn2F3)
>
> "[...] participation in groups and engagement in activities, I observe participation, engagement and the performance of these activities for me has become much more important than the mere bureaucratic issue, reading and discussing, reading and discussing, read and discuss "(Ppb8F3)
>
> "And then, in small groups, I'm already taking my notes, right, when I go past them, I'm already watching the discussions." (Ppb5F3)
>
> "[...] I really visit the teams and follow the discussions" (Ppb7F3)

Teachers follow the students' evaluation process by visiting the small groups formed in the classroom and observing their discussions regarding the problem proposed in the case.

The studies by Mendes, Trevisan and Souza (2016) show that the teacher, when observing his students' group work, can generate information that will serve to support decisions related to the teaching and learning processes. These observations, even if they are mere impressions captured by the teacher during a lesson, can provide a very complete picture of the learning process.

The authors also point out that observing the student's activity involves paying attention: the level of solution sought for the task, the types of mistakes made, their collaboration with classmates, their need for support, their suggestions, the emotional aspects, motivation and concentration

It is understood, according to the studies mentioned, that the teachers observe the participation and engagement of students in the groups and make the necessary notes to accompany the learning process. This monitoring becomes important so that, in addition to observing the participation of each student in the discussions, the teacher can verify the student's development in the proposed activity, realizing the difficulties encountered by the students, helping, guiding them so that they can achieve the goal of study.

Another question was asked to the teachers now related to a suggestion that they would make from the data of the evaluation carried out with the students, when they applied the cases for teaching. Most professors at UFRN and UFPB replied that they reinforce with students the importance of using theory as an important tool for solving the case.

> "I realized that the students in the resolution had learned very little about HR practices, for example, then I said, look, now we are going to redo a reprogramming here, because we failed in this aspect, we needed theoretical support in this, right, so as they were unable to rescue what they studied there, I was able to reinforce it. " (Ppb5F4)
>
> "[...] we are always reinforcing the use of the theoretical foundation, we ask the student to read and have the theoretical foundation and then he will test [...] why this foundation and theorist when it is put to solve practical situations he manages to develop technical competence. "(Prn1F4)
>
> "[...] it's important to know the theory because without an instrument, you can't walk. Stay in that empty managerial speech that you think is an untrained administrator. " (Prn4F4)
>
> "[...] if they managed to make associations with the content seen in the classroom, the theory, right? If we managed to work this well." (Ppb6F4)

Teachers recognize as an important action to strengthen for students the discourse that they need to know the theory that is supporting the case so that they can have enough elements to discuss the proposed problems and provide solutions. Christensen (1987) suggests, therefore, in his studies that the discussions are based on the point of view of management theories so that there is no risk that students will argue based only on common sense or 'guesswork', but be based on the suitable theories for such a subject.

Wherefore, It is understood that the theories that support the performance of activities must be clear for the learning process to happen. In this way, the student will be able to demonstrate how they have developed the necessary skills to achieve the learning objectives. When there is an approximation with the theory, the student has the opportunity to apply it in real world situations, positioning himself as the decision maker, corroborating with the studies of Marion and Marion (2006). The authors also point out that when Professor Prn1F4 reinforces in his testimony that the student will "have the theoretical foundation and then he will test" and "he is placed to solve practical situations", these statements demonstrate that he considers the theory important for the student develops the necessary skills in his training as an administrator.

5 Conclusion

The result of the research showed that professors who consider the moment of planning important, value the preparation of the teaching plan and thinking about the evaluation in advance because they value the importance of their teaching and the responsibility committed to training administrator. At the same time, there are those who consider the forms of assessment used to explain the planning of activities. This may be related to the fact that the teacher has the planning activity already normalized, which already does so involuntarily. It was also identified that most teachers evaluate their students based on the observation of groups in the classroom, which take into account the student's autonomy in their learning process. As well as the monitoring of the evaluation, which takes place from the discussions promoted in groups, occurs.

Pursuant to, this process invites the student to reflect and position himself in the discussions, developing the skills and competencies to achieve the learning objectives developed by the teacher. However, in order for the student to have the security of conducting group discussions, the teachers interviewed report that it is necessary that they approach the theories required to solve the dilemma reported in the case.

The study does not intend to make generalizations, nor does it intend to serve as a unique path to be followed by teachers and institutions. Thus, it seeks to serve as a source of comparison and inspiration, generating possibilities for new research, reflections and discussions related to the difficulties and challenges that teachers already have in relation to evaluation and that they face when applying a new pedagogical model .

Finally, it can be pointed out as a weak point of the study the difficulty of carrying out the research with the professors due to the unavailability of time, which led to the need to extend the term of completion of this study. As suggestions for further studies, research based on the results found is recommended, expand on the sample size of participants in the analysis, as well as, using quantitative research methods, and yet relating them to the students' perception of the application of learning assessment when using the case method, comparing them with the results found here.

Aknowledgments

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil(Capes)- Finance Code 001.

6 References

Araujo, MVP, Rejowski, M. & Leal, SR (2012). Use of Cases for Teaching in Tourism: Teaching-Learning Strategy for Higher Education in Brazil. *Brazilian Journal of Tourism Research* , 6 (1), 109-126.

Boaventura, PSM, Souza, LLF, Gerhard, F. & Brito, EPZ (2018). Challenges in the training of professionals in Administration in Brazil. *Administration* : Teaching and Research, 19 (1), 1-31, doi :. http://dx.doi.org/10.13058/raep.2018.v19n1.775.

Burgoyne, J.; Mumford, A. (2001). Learning from the case method, Report to the European Case Clearing House. ECCH.

Christensen, CR (1987). Teaching and the case method. *HBS Publisching Division Harvard Business School* .

Cunha, JA, Freitas, NK & Raymundo, MGB (2000). *V Psychodiagnosis* . Porto Alegre, RS: Medical Arts.

Dalfovo, MS (2013). *Multiformat Cases in Administration* : Analysis of the influence of learning styles and environments (Doctoral Thesis). University of Vale do Itajaí, Biguaçu, SC.

Depresbiteris, L. & Tavares, MR (2017). *Diversifying is necessary* ... Tools and Techniques for assessing Learning. São Paulo, SP: Senac.

Ferreira, AG & Marques, AAM (2016). Administration teaching at Federal Universities: A perspective from the analysis of the curricula of undergraduate courses at Universities in RS. In Anais 4th Brazilian Congress of Organizational Studies. (p. 18). Porto Alegre, RS: Ufrgs.

Gil, AC (2004). Elaboration of Cases for the Teaching of Administration. *Contemporary Journal of Economics and Management,* 2 (2), 07-16

Haydt, RCC (2002). *Evaluation of the teaching-learning process* . General Didactics Course. São Paulo, SP: Editora Ática.

Kakouris, A. (2015). Entrepreneurship pedagogies in lifelong learning: emergence of criticality? *Learning, Culture and Social Interaction* , 6, 87-97.

Lucena, FO & Ramalho, AMC, Souza, J .. G. & Melo Filho, LCF (2016). Evaluation of the teaching-learning process in the course of administration of an HEI: Perspectives of teachers and students. *Brazilian Journal of Scientific Administration* , 7 (1), 14-30.

Mansur, AFU & Alves, AC (2018). The Importance of Peer Review and Self-Assessment in PBL Applied to an Administration Course. *Ibero-American Journal of Education Studies* , 13, p.456-473.

Marion, JC & MARION, ALC (2006). *Teaching methodologies in the business area* **:** for courses in administration, management, accounting and MBA. São Paulo: Atlas.

Mendes, MT, Trevisan, AL & Souza, TS (2016). Observation of group work as an instrument for assessing learning in mathematics classes. *Journal of the Graduate Program in Mathematics Education at the Federal University of Mato Grosso do Sul* , 9 (19), 581-593.

Miranda, MG (2008). The researcher teacher and his intention to resolve the relationship between theory and practice in teacher education. In André, M. (Org.). *The role of research in teacher training and practice* (pp. 129-143). Campinas: Papirus.

Nogaro, A. (2018). Active teaching and learning methodologies and assessment by competence matrix in higher education. In Tauchen, G. & Fávero, AA (Org.). *Higher Education Evaluation* **:** Teaching and learning perspective. Curitiba, PR: Crv, 79-100.

Ribeiro, RP (2016). *Problem-based learning in the teaching of simulation applied to administration* (Doctoral Thesis). University of São Paulo, São Paulo, SP.

Sassaki, RK. (1999). *Inclusion* : Building a Society for All (3rd ed.). Rio de Janeiro: WVA.

Sauaia, ACA (2013). *Management Laboratory* : organizational simulator, business games and applied research (3rd ed.). Barueri: Manole.

Schmitz, EXS (2016). *Inverted Classroom* : an approach to combine active methodologies and engage students in the teaching-learning process. (Masters dissertation). Federal University of Santa Maria, Santa Maria, RS.

Silva, AK, Santos, MDL & Paixão, CJ (2014). Teaching and learning in Brazil: a study of curricular practices at universities in the North Region. In *Evaluation, teaching and learning in higher education in Portugal and Brazil: realities and perspectives* Lisbon, Portugal: EDUCA.

Silva, SS, Oliveira, MA & Motta, GS (2013). Business Games and Case Method: Contributions to the Teaching and Learning Process in Administration. *Administration:* Teaching and Research, 14 (4), 677-705. doi: http://dx.doi.org/10.13058/raep.2013.v14n4.52.

Tormena, AA & Figueiredo, JA (2010). *The PDE teacher and the challenges of the public school in Paraná* . Retrieved from http://www.diaadiaeducacao.pr.gov.br/portals/cadernospde/pdebusca/producoes_pde/2010/2010_fafipa_ped_artigo_ana_aparecida_tormena.pdf.

International Student Projects and Sustainable Development Goals: A Perfect Match

Jens Myrup Pedersen[1], Jan Frick[2], Marite Kirikova[3]

[1] Aalborg University, Denmark
[2] University of Stavanger, Norway
[3] Riga Technical University, Latvia

Email: jens@es.aau.dk, rml@dps.uminho.pt, jan.frick@uis.no, marite.kirikova@rtu.lv

Abstract

Engineering Education is currently going through a transformation, driven by the need for educating better engineers and more engineers, and largely build on elements such as problem orientation, interdisciplinarity, internationalization, digitalization and sustainability. In 2020, the Erasmus+ Strategic Partnership EPIC (Improving Employability Through Internationalization and Collaboration) has combined all these elements, and demonstrated how international and interdisciplinary student projects, focusing on solving real-world problems related to sustainability, can be carried out in a setting where students mainly work together online. A total of 56 students from 7 EU and 2 international universities, with backgrounds ranging from Electrical Engineering and Mechanical Engineering to Textile Technologies and Business Informatics were working on 9 different projects throughout the spring of 2020. The paper presents the experiences from the setup and discusses some general recommendations for setting up this type of projects. The paper goes through the stages of defining and carrying out the projects: Defining the overall framework, identifying problems/project proposals in collaboration with relevant stakeholders, identifying the students and assigning students to projects, preparing students and supervisors, organising the physical kick-off seminar, and supporting the online collaboration. We also discuss evaluation and hand-over of the solutions, to ensure the projects have a lasting impact. We conclude that the sustainable development goals provide a highly motivating framework for interdisciplinary, international student projects based on problem-based learning. We also note that a careful design and execution of the all the preparatory stages are crucial in order for the projects to succeed, and discuss specific recommendations for these.

Keywords: Active Learning; Engineering Education; Conference Information; Project Approaches.

1 Introduction

The engineering professionals we educate today need to master not only their own specific discipline: They have to be able to work in teams, solve problems in collaboration with other people from all over the world and with different backgrounds, and of course also to master digital technologies (Hadgraft & Kolmos, 2020). Recently there has been also a movement towards including sustainability in the curricula: Partly because many of the challenges engineers are working with are related to sustainability, and partly because the focus on sustainability can help in attracting more students to the engineering disciplines. See e.g. (Guerra, 2017) and (Dahms, Krogh Hansen & Otrel-Cass, 2012). It is also well known that Problem-Based Learning (Graaff & Kolmos, 2003) and learning based on projects is a good way for the students to work in interdisciplinary teams and on real-world problems, achieving competences within e.g. project management and communication (Lima, Dinis-Carvalho, Flores & Hattum-Janssen, 2007).

The Erasmus+ EPIC project runs through 2017-2020, each spring semester testing out new ways of setting up international and interdisciplinary student projects with focus on solving real-life problems posed by companies or communities. The students come from one of the eight partner universities (Riga Technical University (Latvia), Technical University of Hamburg (Germany), UPC Barcelona (Spain), University of Stavanger (Norway), UTP University of Life Sciences (Poland), Saxion University of Applied Sciences (The Netherlands), Abdullah Gul University (Turkey) and Aalborg University (Denmark)), and in addition to the universities the project consortium also includes two companies. However, most of the student projects are done in collaboration with companies outside of the formal project partnership. The project work is based on blended mobilities, where the students collaborate mainly online, along with one physical seminar to kick-off the projects. In the first two years (2018 and 2019) the students also had the chance for a second physical meeting, but in 2020 this was cancelled due to the Covid-19 situation. The project and the previous experiences are described in (Pedersen, Kirikova, Kuladinithi & Janssen, 2019) and (Pedersen & Jensen, 2018). It is a guiding principle throughout the EPIC project that all students work in collaborative projects, yet under the rules and frameworks of their local universities: This also means that students hand in their projects to their home universities and are examined according to their rules and guidelines. This choice is made in order to ensure that the approach is scalable, and that it can be replicated beyond the EPIC consortium without the need for hand-held solutions. Moreover, it makes it possible to overcome some of the more bureaucratic issues in terms of enrolment, recognition, credits etc. On the other hand, this also requires a careful project design to ensure that the students can collaborate and yet fulfil the requirements and learning objectives from their home universities. EPIC is co-funded by the Erasmus+ programme of the European Union, which made it possible for the students to participate free of charge.

One of the challenges in the previous years was to create a common denominator for the different student projects. In 2020, we sought to achieve this by creating a common theme for all the projects: The UN Sustainable Development Goals (SDGs) (UN Development Goals website, 2020). In addition to creating a joint reference framework and demonstrating how the students were all contributing to solving a bigger societal challenge, this also made it possible to experiment with how sustainability can be integrated in many different engineering disciplines.

Our experience and approach are described in this paper. Our main contribution is the walk-through of the whole process from idea to carrying out the projects, with particular focus on sustainability and the SDGs. The paper is organised as follows. First in Section 2, a background for the project is given. After this, we describe the process of integrating sustainability with the student projects, followed by a discussion on our experience and at last the conclusion.

2 Background

As mentioned in the introduction, the EPIC project aims at bringing together students from different disciplines and countries to work together on solving real-world problems defined by companies or other organisations. The model is inspired by the Problem Based Learning model from Aalborg University (Kolmos, Fink & Krogh, 2004), but also largely based on previous Erasmus+ Projects such as COLIBRI (Collaboration and Innovation for Better, Personalized and IT-supported Learning) (COLIBRI website, 2020), where experiences and evaluations demonstrated a high learning outcome for the participating students working on interdisciplinary problems in international groups based on blended learning. However, a main difference is that EPIC is not a particular course, but rather an integration of activities at the partner institutions.

From a student point of view, the semester is organised as illustrated in Figure 1. As it can be seen, there is quite some flexibility in the schedule to accommodate for the different timings at the different universities. Some of the deadlines (e.g. the deadline for handing in the joint report) can also be made flexible if all students have later local project hand-in deadlines.

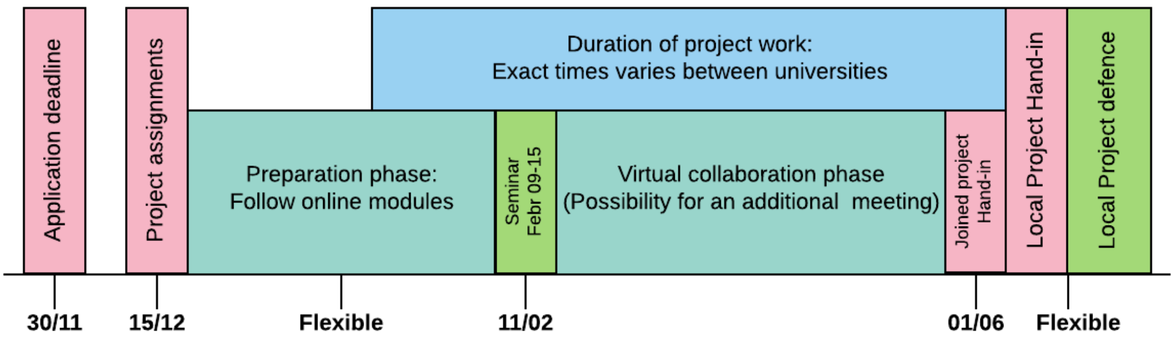


Figure 1: Semester structure of EPIC

3 Integration of projects and SDGs

In this section, we go through the stages of the EPIC semester: Setting up the projects including defining the projects and the groups, the kick-off seminar, the virtual collaboration phase, and the project hand-over at the end. The main focus throughout the description is on the sustainability aspects and integration of SDGs.

3.1 Setting up the projects

From the beginning, it was decided to use the SDGs as the common frame for the projects. Where in previous years, the focus was on a number of "topics" or "themes" this year it would be an array of problems related to the SDGs. In particular, the following SDGs were chosen (UN Development Goals website, 2020):

- Affordable and Clean Energy (SDG 7)
- Sustainable Cities and Communities (SDG 11)
- Digitalization/Industry, Innovation and Infrastructure (SDG 9)
- Good Health and Well-being (SDG 3)

These areas were decided by the partners during a meeting in September 2019, and would form the framework for the project proposals, which were defined in the next step. The topics were found to be a good fit with the study areas involved and with the companies interested so far. Also, focusing on four of the 17 SDGs would help to make it easier to see the connections between the different projects. Each university was responsible for reaching out to potential company partners in order to define the precise project proposals based on these SDGs. Thus, the project proposals were then defined in collaboration between partner universities and companies, and each of these project proposals would aim on answering one or more of the chosen SDGs, in a way that would also be relevant for the company or companies. The project proposals were defined during October 2019, and ended up with the following nine projects (the number in parenthesis indicate which SDG(s) are covered):

- Digitalisation in manufacturing (RAMBASE) (9)
- Global Recruitment Tool (9,11)
- Secure infrastructure and cyber security challenges (9)
- Measuring carbon footprint for companies (11)
- Energy optimization in 5G (7,9,11)
- Circular textile platform (11)
- Mobile education for waste pickers (3)
- IoT in selective garbage collection (3,11)
- River waste plastics recovery (11)

As the next step, the projects were announced and the students had to apply for participation which is a bit tricky: First of all, the students will not be working on the projects until the spring semester (usually starting around February 1 – for some a bit earlier, for some a bit later), and for some students electives are chosen according to specific schedules at their home universities and participation in EPIC cannot be confirmed until also other priorities are known. Second, there are also constraints from EPIC, i.e. that all projects should have students from at least two countries – and preferably at least four students per project. To solve this challenge, the students had to select their projects before November 30, and in case some projects had not enough students they would have the chance to make another choice. Generally, there was no upper limit on the number of students on each project, but in practice, having more than 8-9 students would imply that the project would be split into multiple sub-projects. Initially, there were allocated four seats per university (due to the limited funding for travelling), but eventually more students were allowed to join so we ended up with 41 students from the eight partner universities. Due to the different timings at the different universities, it was not quite possible to receive all applications by November 30, and despite all good intentions the last students were not added to the list until late January, just two weeks before the joint seminar. Also, eventually not all projects had been filled up, and the partners made an additional (and successful) effort in finding additional students for those projects so that in the end all of the projects had a sufficient number of students. The students were a mix of B.Sc. and M.Sc. students from a variety of disciplines: From engineering, to business, to textile design.

With the focus on SDGs, the project attracted also attention from outside of Europe. Since 2018, Aalborg University and University of Brasilia have been working together on joint student projects on helping create a better life for the thousands of people who worked as waste pickers in the dumpsite of Brasilia – a dumpsite that was closed in 2018, and where several programmes were established to help the waste pickers in the transition to more organised jobs. This case inspired the last three projects on the list, and all of these projects included also students from University of Brasilia who funded their own trip to also participate in the seminar. In this way, the projects could also build on existing collaborations and benefit from being part of more established projects with partners including UNDP (United Nations Development Programme) and the Central Bank of Brazil. With 15 Brazilian students, mainly from Production Engineering, the project ended up with a total of 56 students.

After the groups were formed, the students were connected and onboarded on the communication platform Slack, which was used for communication both for the overall project and within the groups. Also, before the kick-off seminar the students were invited to a Moodle-based platform (Eduspace) to be introduced to the basics of teamwork, project planning and management, and entrepreneurship. This is similar to what was done in the previous years and is not described in further details.

An important part of the preparation phase is also to organise the project supervision. In EPIC, all students have a project supervisor (responsible for the whole project) a local supervisor from their own university, and a company supervisor. All project and local supervisors followed an e-learning course prior to the seminar, and the company supervisors are provided with informative materials about EPIC and work in close dialogue with the project and local supervisors.

3.2 Seminar

The joint seminar is a physical meeting, which was this year held in Hamburg, Germany. It plays a crucial role in all the projects, because the students meet face-to-face: They get to know each other, scope the projects, make an initial problem analysis, and plan the rest of the project time. The experience from previous years, but also from previous projects (Dahms, 1998), stress how important this physical component is in order to the virtual collaboration phase to be successful. In the EPIC project, the seminar was held during a week in February, with five full working days for all participants (students and teachers/supervisors).

In this paper, we will mainly focus on the activities that deal with sustainable development goals. However, to give the full picture it is important to also mention that the week included workshops that would take the students through the initial steps of the project: They would e.g. define the project scope, define the expected contributions of individual students, create a project plan with milestones, and also define success criteria for both the project and the process (e.g. collaboration). Based on previous experience this process was well structured, and throughout the workshops the students would fill out templates to help them ensure that the results would be useful afterwards. This is a balance between giving the students freedom to define their own structures (thus providing ownership) and ensuring that the projects are student-led, and on the other hand to scaffold and steer the process. Based on the experience of previous years, we acknowledge that it is very important for the students to reach good project plans during the seminar – to avoid having to completely redo the plan afterwards in an all-virtual setting where this is much more difficult.

In the previous years, the joint content of the seminar was mainly dealing with the most generic part of the projects, e.g. project management, teamwork, peer assessment methods etc., and it was hard to present and discuss the content parts since all projects were dealing with different problems and themes. The SDGs made it possible to also bind the content closer together, in particular through the following activities:

- Day 1: The introduction to the seminar included an introduction to the UN Sustainable Development Goals. This was in the form of an oral presentation and formed the basis for the initial discussions in the groups about the scoping of the projects.
- Day 2: Keynote presentation by students from KU Leuven, who won a 3.000 km race for solar-powered cars through the Australian outback. The keynote was delivered as an interactive session, where the students discussed and had to make decisions throughout the presentation. The focus was partly on sustainability, but equally on setting out joint project objectives and achieving them as a team.

- Day 3: Keynote presentation by one of the professors from University of Brasilia, who was previously president of the waste management organisation (SLU) of Brasilia, and who led the closure of what was the world's second largest dumpsite (and the largest in Latin America). The talk was focusing on both technical, social and cultural aspects of the transformation, also to demonstrate to the students the importance of understanding the context of the engineering work.

Throughout the week, professors from the different universities were available for discussions with all the groups. In this way, the groups received inputs and feedback from their supervisors as well as from other professors, e.g. on the sustainability topics.

3.3 Virtual collaboration phase

During the virtual collaboration phase, the students were working mainly within the nine projects. The format of the collaboration was varying from group to group, but included elements such as online meetings, shared documents, and feedback on each other's work. Moreover, we created a system for systematically providing peer feedback among the students. The students also received supervision from both EPIC supervisors, local supervisors, and the involved companies.

3.4 Handing over the projects

The main purpose of the student projects is of course the students learning. However, it is also highly motivating for the students to see their results in use – and the process of taking it from "student project" to real-life implementation is an experience with many learning points. While few of the nine projects were finished as final production-ready products by the end of the semester, we see three different ways in which the projects are being used or brought to use:

- Some of the projects end up in prototypes, which are ready to be tested. This is for example the case for the IoT in selective garbage collection project. This project aims at improving the collection of garbage in the city of Brasilia by installing sensors in containers, so it is possible to plan the collection according to the full containers – in particular, this makes it possible to ensure that recyclables end up in the official recycling facilities (where the previous waste pickers are working) rather than being stolen by unofficial pickers. The prototype is limited in the sense that it should be tested at a smaller scale first, and when scaling up more specialised devices should be used.
- Some projects end up in the form of a report with analysis and suggestions, which can be useful for the company/companies involved. This was for example the case for the Energy Optimization in 5G project, where the students came up with findings and recommendations which was supported by analysis and simulations. While the impact here is less tangible, it does have an impact as it provides the companies with insights and ideas that they might not have been able to achieve on their own.
- Some projects develop master thesis which may be useful for companies involved, but this might also be seen as a research work with SDG recommendations beyond the directly involved companies. This is the case with "River waste plastics recovery" where the involved management students write "The Economics Of Plastic Recovery In Rivers: Case of Brasilia". This work investigates the business case and provides a socioeconomic analysis of plastic recovery from freshwater based on the collaboration with the engineering students in the EPIC group and collaboration with students and professors from Brazil.

For several of the projects, it was initially planned that the handover would include physical visits; For example, a joint seminar between the European and Brazilian students was planned to happen in Brasilia making both implementation and additional field studies possible. Due to the Covid-19 situation this was not possible, and even the possibility for the local students to interact with companies and communities was limited due to the situation. However, it is planned that some of these activities will be resumed if the situation normalises in the near future.

4 Discussion

4.1 Project framing

Compared to the previous years, one of the main differences was that the SDGs was used to link the different projects better together. We noted that in the past it was hard for the students to connect projects across topics (and in some cases even sub-projects within the same topics): For example, two projects on Internet of Things could be very different if one group of students worked on communication aspects, and another group worked on an application. Even if the students were having regular meetings and updating each other on progress, the projects would develop in different directions and it would become harder and harder to benefit from the meetings. Here, we experienced that the SDGs provided a very useful frame: Students could see how they all contributed to solve some of the same problems, even if the solutions were different, which also made it easier to comment and suggest on the works – and because the SDGs made it possible to communicate a joint vision for the projects. This was also supported by the activities during the seminar. However, it seems that the potential in using the framing to link the projects together is even higher, and could be strengthened through preparation materials, more activities during the seminar, and maybe also during more activities throughout the virtual collaboration phase.

We were also positively surprised about the company interests in the SDGs. During this study we did not extend that collaboration to e.g. Non-Governmental Organisations or community organisations (except for some of the collaboration partners in Brazil), but this could be an interesting direction to explore in the future.

4.2 Student evaluations

Each student group documented their work by handing in a joint EPIC report. The report consists of two parts: One part regards the content of the project, and the other part regards the evaluation of the process and reflections on the students learning. When studying the evaluation reports, we found the following comments to be quite consistent:

- The students found it highly motivating to work with the Sustainable Development Goals.
- The students liked to work on projects that can make a social/environmental difference.
- The students appreciated working in international and interdisciplinary environments and found that the groups were working towards a common goal.

On the other hand, the students also indicated some areas of further improvement:

- Supervision from the different supervisors was not always consistent, i.e. different supervisors would have different point of views.
- For some of the projects, the students would like a higher commitment from the involved companies.
- The Covid-19 situation created challenges for some of the students, mainly due to major changes in how other learning activities were carried out/delivered – but also limiting the field work to be carried out in EPIC and making it impossible to carry out the second physical mobility component.

By the end of the project, the students were asked to provide also a quantitative evaluation of the whole EPIC experience. Figure 2 presents the overall evaluation of the personal experience, and demonstrates that the students overall were happy with the experience. They found that the work will be helpful for them in their future education/career, and that it has made them better prepared for both the national and international labor markets.

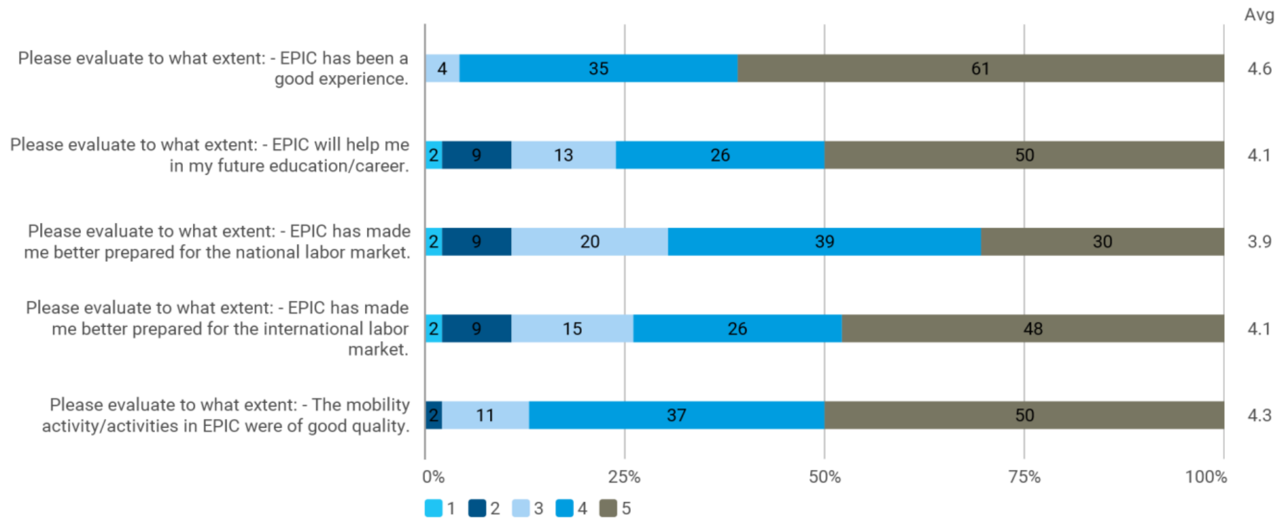


Figure 2: Students overall evaluation of EPIC on a scale 1-5, where 1="Not at all" and 5="Very much".

Figure 3 presents the students evaluation of how the methods used in EPIC contributes to improving the learning offer. While the evaluations are generally positive, it is noted that especially the promotion of active learning and problem-based learning receives high scores along with the skills within problem solving, collaboration, entrepreneurship, creativity and innovation. As such, we believe that the approach is useful in order to help the students achieve important skills for their studies and careers.

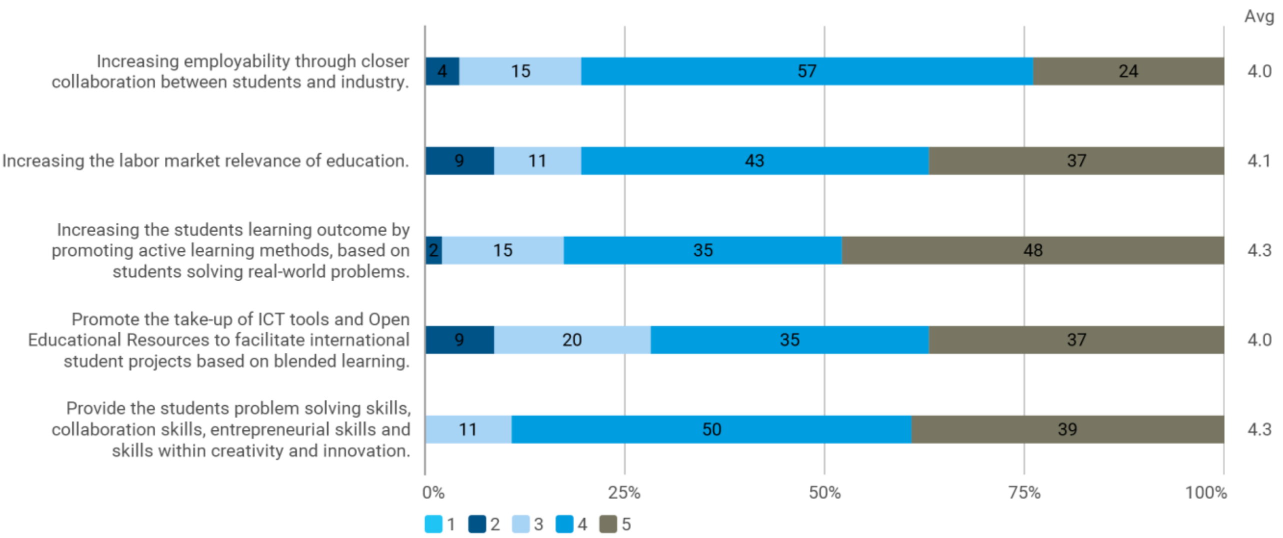


Figure 3: Students evaluation of to what extent the teaching methods of EPIC supports the listed objectives on a scale 1-5, where 1="Not at all" and 5="Very much".

Note that two of the questions to the students were further elaborated in the electronic questionnaire they filled out. Question 1: "Increasing employability through closer collaboration between students and industry, by promoting active and problem-based learning and international collaboration", Question 2: "Increasing the labor market relevance of education through closer collaboration between industry and academia, and making the students better prepared for both national and international labour markets".

4.3 Project handover

The vision of "making a difference" is a main motivational factor for the students and ending up with a solution that is actually being used is something many of the students would like to achieve.

However, making a real impact requires that:

- The projects can be either fully handed over to e.g. companies or communities who can keep using and maintaining the products without further help from the students – or they can be handed over to new groups of students who will continue the development. In both cases, the projects need to be quite mature and well documented – something that is not often the focus when doing proof-of-concept developments.

- The projects are quite complete – to fit with the timeframe/workload of the students as well as the learning objectives in curricula the projects are often scoped to cover only limited parts of the full problem. This makes it hard for other organisations to use the projects, unless they have the resources to complete the missing parts.

Overcoming these challenges requires among other things a project scope that fits well with the learning objectives of the students, together with a problem that fits the time/workload available for the students, or as it was the case in some of our projects that the students are willing to spend some of their spare time to bring the projects to a more final stage.

On this, we also note that curricula and learning objectives do not always reward students for making the products "production ready", including thorough documentation and hand-over processes. This implies that the students can be caught in a lack of alignment between learning objectives, assessments and this part of the learning objectives (Biggs & Tang, 2011) – thus creating a dilemma for the students of prioritizing maximizing the project outcome/impact and the grade achieved. We would encourage universities and educators to consider this when integrating sustainability into the learning objectives of engineering studies.

5 Conclusion

Our experience demonstrates that the Sustainable Development Goals (SDGs) fit well with international and student projects, which aim at bringing students from different backgrounds and disciplines together to work on solving real-world problems. In particular, the SDGs provide a strong framework for binding the projects together and show the students that they work towards a common goal – even if they work on different projects or sub-projects, and even if they work on projects that are different in terms of technical content. With the high motivational factor, we also believe this indicates that working on sustainability can help in attracting more students to engineering in the future. On the other hand, we also found that it is important to:

- Align learning objectives and assessment with both interdisciplinary project work and sustainability, so that the sustainability is integrated in the curricula and not just a toning of existing learning activities.
- Work closely with stakeholders, scoping the projects carefully, and maybe adjusting the learning objectives to include e.g. handover processes, so that at least some of the projects can end up being actually used and creating an impact.
- Prepare both students and supervisors on working with sustainability, and to not only consider sustainability from a technical point of view but also including social, cultural and economic aspects.

Our case involved 56 students from 9 different universities in 9 different countries. We hope that in the future more universities will integrate sustainability into their curricula at a larger scale, keeping in mind the importance of aligning learning objectives, assessments and learning activities, and that this will make it possible to conduct more systematic and larger studies.

6 References

Biggs, John B.; Tang, Catherine Kim Chow (2011). *Teaching for quality learning at university: what the student does*. Maidenhead: McGraw-Hill. ISBN 9780335242757.

COLIBRI website (2020), https://www.tuhh.de/colibri/about.html

Dahms, M (1998). International Student Co-Operation via e-mail and Internet – an EU-project on Virtual Mobility. The International Conference on Engineering for Sustainable Development (ICESD). Faculty of Engineering, University of Dar es Salaam, Tanzania, July 1998.

Dahms, M-L., Krogh Hansen, K., & Otrel-Cass, K. (2013). Sustainability in Engineering Education: – is PBL the answer? I *Proceedings, the 41th Conference of the International-Group for the European Society for Engineering Education SE*FI: European Association for Engineering Education. http://www.sefi.be/conference-2013/images/195.pdf

Graaff, E. d., & Kolmos, A. (2003). Characteristics of Problem–Based Learning. *International Journal of Engineering Education, 19*(5), 657-662

Guerra, A. (2017). Integration of Sustainability in Engineering Education: Why is PBL an answer? *International Journal of Sustainability in Higher Education (Print Edition)*, *18*(3), 436-454. https://doi.org/10.1108/IJSHE-02-2016-0022

Hadgraft, R., & Kolmos, A. (2020). Shifting engineering curricula for industry 4.0. I *Tomorrow's thinking. Today's People* (s. 39-39). GHD Digital. https://www.ghd.com/en/about-us/free-ebook-tomorrow-s-thinking-today-s-people.aspx

Kolmos, A., Fink, F. K., Krogh, L. (2004). *The Aalborg PBL Model: Progress, Diversity and Challenges*. Aalborg University Press

Lima, R. M., Dinis-Carvalho, J., Flores, M. A., & Hattum-Janssen, N. v. (2007). A case study on project led education in engineering: students' and teachers' perceptions. *European Journal of Engineering Education, 32*(3), 337 - 347.

Pedersen, J. M., & Jensen, J. V. (2018). International Student Projects - How to make it happen. I *ETALEE 2018: "Exploring Teaching for Active Learning in Engineering Education"* (s. 17-26). IngeniørUddannelsernes Pædagogiske Netværk, IUPN.

Pedersen, J. M., Kirkova, M., Kuladinithi, K., & Janssen, N. V. H. (2019). EPIC: Making Multinational Student Projects Happen. *International Symposium on Project Approaches in Engineering Education (PAEE)*, *9*, 219-228. https://paeeale.esprit.tn/wp-content/uploads/2019/06/PAEE_ALE_2019_PROCEEDINGS.pdf

UN Development Goals website (2020), https://www.un.org/sustainabledevelopment/sustainable-development-goals/.

Communication tools used by distributed teams in a BIM learning project

Anton Rzhvskyi[1], Elżbieta A. Bil[1], Gabriela Witeck[1], André L. Aquere[2], Rui M. Lima[1,3], José Granja[4], Miguel Azenha[4]

[1] Department of Production and Systems, School of Engineering, University of Minho, Portugal
[2] Department of Civil and Environment Engineering, Faculty of Technology, University of Brasília, Brazil
[3] ALGORITMI Center, School of Engineering, University of Minho, Portugal
[4] ISISE, Department of Civl Engineering, School of Engineering, University of Minho, Portugal

Email: antonrzhevskyi@gmail.com, elzbietabil.eb@gmail.com, gabiwiteck@gmail.com, andre@unb.br, rml@dps.uminho.pt, granja@civil.uminho.pt, miguel.azenha@civil.uminho.pt

Abstract

The constant changes in the world market demand flexible and fluid organizational structures, such as rotating and engaging human effort, to provide high performance. Therefore, organizations make use of distributed multicultural teams, meetings, and online lead projects. However, these social categorization processes can become a disadvantage if trigger potential conflicts during task performance. Distributed teams can also be difficult to manage, and their members can face extra adversities in communication. Architecture, Engineering and Construction Industry (AEC), is a context where the use of distributed teams is growing significantly, particularly through the enabling features of Building Information Modelling (BIM) methodologies. This paper was aimed at the diagnosis of communication behaviour in distributed teams in the context of a PBL methodology that requested students to work in distributed teams on two distinct locations. For that, the authors managed a workshop on Lean Project Management and Collaborative Tools in the European Master in Building Information Modelling (BIM A+) using a Lego for Scrum activity, adapted to a team of students distributed in Portugal and Slovenia. After that, nine distributed teams of students had to design exposition pavilions in BIM platform and using collaborative tools. At the end, each team had to present the project for the entire body of students and faculty, located in Guimaraes (Portugal) and Ljubljana (Slovenia).

Keywords: Distributed teams; Communications tools; Agile Project Management; Lean project management

1 Introduction and Motivation

Projects, as a temporary endeavour developed by a team to deliver a new result or product, may be managed with different approaches, from more predictive models to more agile models (PMI, 2017). The agile models are related to the need to cope with fast changing requirements and the desire to satisfy the client during those changes. Lean Production is an organizational approach that resulted from the Toyota Production System (Escudeiro, Escudeiro, Barata & Lobo, 2011), which main goal is "doing more with less", where less means less human effort, less stocks, less resources, less space, less product development time. This paradigm evolved to a set of concepts and tools that were one of the inspirations of Agile Project Management approaches (Sutherland & Sutherland, 2014). Thus, agile and lean can be seen as similar approaches to project management, developed with similar goals. In some way, it can be said that, if a project is planned to deliver the product while minimizing waste, it's directed to be a 'lean' project. Wastes are all activities that do not add value from the client's point of view (Escudeiro, Escudeiro, Barata & Lobo, 2011). This is the first principle of Lean Thinking: Value that derives from Lean Production (Georgios, 2014).

In the BIM (Building Information Modelling) environment, the concept of lean management is one of the factors that allows to increase efficiency and improve the quality of projects (Koskela, 2000). According to (Gupta & Moon, 2019) and (Alizadehsalehi, Hadavi & Huang, 2019), lean construction approach allows project management at their early stages, which facilitates their control and quality.

Today's world with constantly changing organizational structure requires flexibility and fluid teams with rotating and evolving team memberships (Moe et al., 2015). While organizations aim to utilize multicultural distributed teams to achieve better performance, that social categorization processes may render diversity a disadvantage as it increases the potential for relational conflicts that are detrimental to task performance

(Harush, Lisak & Glikson, 2018). Distributed teams can be difficult to manage, and their members can face extra difficulties in communication (Da Silva, Costa, França & Prikladnicki, 2010).

To mitigate these impacts, there are several aspects to consider for lean project management applied in distributed team. Therefore, it is very important to implement tools for systemizing communication in distributed teams.

In order to study this theme, this article intends to evaluate how project management tools can be used to foster collaboration in distributed teams, through the implementation of BIM learning projects with teams distributed in two different countries while developing the same project.

The object of study is the project "BIM A+", an international Master's Course in Building Information Modelling (http://www.bimaplus.org). The Master offer an advanced education programme on BIM integrated design, construction, and operation processes, with a strong focus on the collaborative practices that are the cornerstone of such integration. The Master combines the diversity of expertise at leading European universities in the relevant fields, offering education oriented to a multidisciplinary understanding of virtual construction through the involvement of experts from complementary fields (engineers, architects, programmers and others). BIM A+ has three main consortium partners that hold responsibility for teaching: (i) the University of Minho in Portugal (UMinho, which is the coordinating institution); (ii) the University of Ljubjana in Slovenia (UL); and (iii) Politecnico di Milano (PoliMi) in Italy. The Master has two semesters of duration, comprising a 1st semester of coursework (October to March), and a 2nd semester for dissertation preparation (March to July). The coursework comprises six modules (5 ECTS credits each), delivered in sequential manner, and labelled from BIM A+1 to BIM A+6:

- BIM A+1 Management of Information and Collaboration in BIM
- BIM A+2 Modelling in Architecture and Engineering
- BIM A+3 Parametric Modelling in BIM
- BIM A+4 Advanced BIM Data Systems and Interoperability
- BIM A+5 4D, 5D, 6D Modelling and Applications
- BIM A+6 BIM based Rehabilitation and Sustainability analysis

In the school year 2019/2020 (the inaugural year of the Master), the coursework of the first semester was delivered in synchronous manner at two coursework locations: UMinho and UL. A total of 42 students were attending the course, with 27 of them located at UMinho and 15 located at UL. Synchronous teaching was assured with the support of videoconferencing and mobility of staff, as to ensure that all students had personal contact with the teaching staff. The background of students was diverse, but most of them were either Architects or Civil Engineers. Nationalities were very diverse as well, with students coming from most continents: Europe, America, Africa and Asia.

The object of analysis of this article is a common assignment requested from students in the scope of BIM A+2, which comprised distributed teams with students from both UMinho and UL.

2 Literature review

The literature review will present the concepts, management, communications, methodologies and tools mainly used for distributed teams. Finally, provides an overview of transversal competencies in a teamwork environment.

2.1 Distributed teams

Distributed Team is a team which has members dispersed across globally and collaborate together to achieve a common goal, also have the characteristics of both a virtual and a multicultural team (Seshadri & Elangovan, 2019). With a high level of interdependence and cooperation among the team (Moe et al., 2015), the members have different working style, time orientation and cultural differences which can interfere in their teamwork quality (Seshadri & Elangovan, 2019).

While organizations aim to utilize multicultural distributed teams to achieve better performance, that social categorization processes may render diversity a disadvantage as it increases the potential for relational conflicts that are detrimental to task performance (Harush, Lisak & Glikson, 2018).

2.2 Management of distributed teams

In distributed teams, the typical project manager is responsible for defining and managing work (Srivastava & Jain, 2017). Work effectiveness and a constructive team climate have to be maintained using performance management strategies; leadership is therefore a central challenge (Moe et al., 2015).

Today's world with constantly changing organizational structure requires flexibility and fluid teams with rotating and evolving team memberships (Moe et al., 2015). Karhatsu (Karhatsu, et al.,2010) demonstrated that team orientation is supported by allowing the team to participate in iteration planning and goal setting and prioritize clearly. This gives team members a possibility to choose tasks on their own.

In this context, language and culture of team members represent a major challenge to the managers, especially if English is not the first language of all members (Seshadri & Elangovan, 2019). It is important for distributed teams to communicate effectively to resolve such risks in a systematic way (Alontani & Qureshi, 2014). Conflicts between distributed teams bring high risk of failing a development project due to poor communication. Therefore, it is important for distributed teams to communicate effectively to complete a successful project (Alontani & Qureshi, 2014).

Son and Park (Son & Park, 2011) studied how the communication frequency impacts team's performance. Their study concluded that the communication frequency was a major factor to manage and reduce conflicts. It is found that frequency of communication is fluctuated by each conflict type and it has an impact on performance of team. Team performance will be reduced by decreasing the frequency of communication.

The team manager activity employing member's talent to achieve synergy and synchronization of communication in an effective way, therefore managing such team require a different set of competencies than for a collocated team (Seshadri & Elangovan, 2019).

2.3 Communication management framework for distributed teams

Distributed teams can be difficult to manage, and their members can face extra difficulties in communication (Da Silva, Costa, França & Prikladnicki, 2010). Therefore, it is very important to implement tools for systemizing communication in such teams. One of proposed solutions (Alontani & Qureshi, 2014) is divided in 2 parts:

- Management of distributed teams
- Communication tools

2.3.1 Management of distributed teams

The idea is to have several special roles in the team: team leader, communicational coordinator and technical support.

Team leader can represent the whole team during online meetings with other teams or management. Communication coordinator is the person, responsible for scheduling meetings, so that all the team members, who need to attend the meetings could do it with minimal inconveniences. Technical support is responsible for providing communication tools and dealing with problems, related to them, faced by the team members.

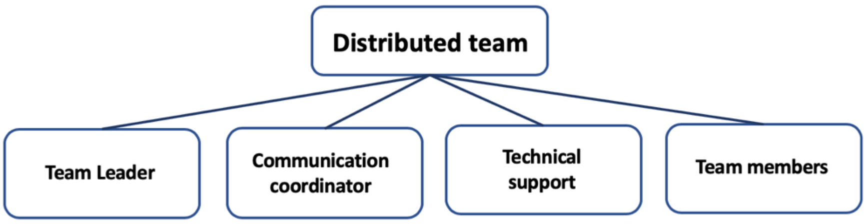


Figure 1. Roles in distributed teams.

In small teams, it is not necessary to choose a special person for a particular role.

2.3.2 Communication tools

There are many types of communication tools for different purposes those can be used for improving management of distributed teams. In study (Alontani & Qureshi, 2014) a combination of 3 types was proposed and tested: project portal, technical support and instant messaging. Project portal is used for keeping, sharing and managing all the information and documents, related to the project and for online meeting among teams. Technical support is a used for direct help with technical issues, that team members can face. Instant messaging used for one-to-one communication and preferable than email.

2.4 Distributed team transversal competences

Nowadays, in dynamically changing times, work in distributed teams is becoming more and more important (Schleutker, Caggiano, Coluzzi & Luján, 2019). Transversal competencies have an impact on team efficiency and quality. This applies not only to communication between departments in a certain company but also to distributed teams around the world (Nilugal, Thaker, Molugulu, Andrew, Ugandar & Chittur, 2015) and (Escudeiro, Escudeiro, Barata & Lobo, 2011). There is a noticeable gap in engineering environment between soft and hard skills. Currently, the lack of soft skills is one of the challenges for coherent work in distributed teams (Razdan, Polanco, Ackerman, Vidot & Razdan, 2019). According to (Sievi-Korte, Richardson & Beecham, 2019) in the architectural environment, where distributed teams are usual, the emphasis is on accurate selection of practices that support their communication and understanding of the objectives and activities. This approach aims to develop not only technical competences but also transversal competences.

There are many methods for developing transversal skills. For example, in distributed teams, agile and scrum methods allow for effective communication and collaboration of teams. According to (Berczuk, 2007), which defines the benefits of the previously mentioned concepts also draws attention to problems resulting from misunderstanding them.

The need to communicate by distributed teams means that transversal competences need to be developed. This is the result of the constant need to provide information and feedbacks (Weilkiens, Lamm, Roth & Walker, 2015).

3 Context

The work reported herein is performed within the scope of the group assignment of module BIM A+2 “Modelling in Architecture and Engineering”. This module took place in the last week of October and during November 2019, with 13 contact days (generally comprising lectures in the morning and free time for assignments in the afternoon). The following main learning objectives/outcomes are envisaged: (i) be able to differentiate the requisites and uses that are of interest for each construction specialty (Architecture and Engineering); (ii) identify and describe adequate modelling practices in view of intended uses for the models; (iii) list, apply and criticize the several modelling recommendations that exist at international level; (iv) capability to understand and perform BIM models for the specialties of Architecture, Structural Engineering and MEP Engineering; (v) understand further particular cases of modelling, targeted for monitoring and management. The lectures of BIM A+2 were led by the team of UMinho, with teaching staff having mobility towards UL (1 week of the module). All morning classes were synchronous, with students witnessing the same teacher deliver the same content (some receiving the content ‘in-person’ and others through videoconference). An example of this setting can be seen in Figure 2.

BIM A+2 comprised two assignments for students to perform. The first assignment was individual and pertained to the preparation of a class of objects, apt for use in BIM modelling (not of interest for this paper). The second assignment was a group assignment in which students were supposed to gather in groups of 4-5 to develop the BIM model of exhibition halls in a real terrain in Guimarães (neighbouring the campus). The terrain was divided in 9 plots, and students were requested to form 9 groups.

Figure 2. Classroom setting at UMinho during a lecture broadcasted from UMinho to UL (projection allows to witness the classroom setting on the classroom at UL). Image taken from the Facebook page of BIM A+.

As there were more students at UMinho (27) than at UL (15), it was not possible to ensure distributed teams in all groups. Therefore, the following strategy was followed: 9 students were randomly selected to act as 'seeds' of groups #1 to #9. Groups #1 to #7 had to be mandatorily composed of 4-5 students, with a minimum of 2 students from each coursework location, whereas groups #8 and #9 where composed of 4 members located at UMinho (not distributed teams). The 'seed' students were supposed to communicate with other students and assemble a team that would need to comprise several independent roles to carry out the assignment. The roles included BIM Manager, Architect, Structural Engineer, MEP (Mechanical Electrical and Plumbing) Engineer, other relevant roles for design (or duplication of some of the previous roles with due differentiation of work). It is noted that the 'seed' student did not have any particular role assigned to begin with, so the choice of roles had some degree of freedom. It is also worth to highlight the role of BIM Manager in the assignment, who operates as team manager, and was supposed to lead the collaborative work and communication (this was part of the assignment and was an item under evaluation). It is further noted, that regardless of the communication strategies used by the teaching staff (e.g. using ZOOM for videoconferencing platform), students were given full freedom to elect their collaborative means, platforms, and workflows of choice.

The teams were formed without the need for intervention of the teaching staff. For the scope of this paper, only the distributed teams #1 to #7 were considered. Teams #1 to #5 had 5 members each (3 members in UMinho and 2 members in UL). Team #6 had 3 members in UL and 2 members in UMinho. Team #7 had 2 members in UL and 2 members in UMinho.

4 Methodology

The purpose of this study consists in providing relevant understanding about communication between distributed teams in learning BIM projects. Within this goal, an overview of how the communication goes throughout the BIM phases will be described, including problems faced and solutions founded. Thus, this study went through the following steps:

1. Observe the working process in distributed teams.
2. Interviewing the participants about their difficulties and problems in communication and project management faced throughout it.
3. Consult and share ideas on improving the communication flow between the teams.

Each of these teams was interviewed separately to collect the data about their ways of communication, tools and problems related to it. Only the members of each team in UMinho were interviewed. All the data collected is presented in the paper. The interviews were semi-structured: we had a list of questions that we asked all the teams, but depending on their answers, we sometimes asked some extra questions

5 Description and analysis of the communication tools

Audio/video calls were necessary for virtual meeting and discussing plans in SCRUM-like methodologies every day, what helped them significantly (Kumar & McArthur, 2015; Sakikhales & Stravoravdis, 2017). Several teams have reported difficulties in agreeing and setting up efficient communication strategies that would fit their personal hardware and work style (teams #1, #2, #3, #4, #6). Software tools originally used by the teams for audio calls are Skype, Google Hangouts and WhatsApp. Teams using Google Hangouts did not report any occurrence of very bad connection, whereas one of the teams even reported very good connection. The most problematic tool was Skype. Indeed, none of the teams reported adequate degree of satisfaction when using this tool.

Some of the teams explored alternative tools and ways of communication. Teams #3 and #4 used TeamViewer for team audio calls when applicable and found it to have higher quality and allowed facilitating collaboration. Another alternative was Discord. Teams #4 and #6 included the use personal direct calls between team members. This can be perceived as creating extra separation between the teams, as some issues ended up being mostly discussed inside within the sub-sets of team members at UMinho and UL, with communications between these two sub-sets being handled by individual representatives. However, this one-to-one interaction allowed better quality and more focused interactions, and the teams found this helpful for their communication and work.

The teams also used team chats and personal messages for communication between teams. There were no issues in this interaction.

Another important part of communication were file sharing and management. The 3 most popular tools for this were Google Drive, Dropbox and BIM360 (a dedicated platform by AutoDesk in the scope of BIM Collaboration). The latter was more preferred because of better collaboration possibilities for BIM (particularly integration with proprietary formats for BIM models). Google Drive was also found to have synchronization issues that ended up causing difficulties in collaboration. Table 1 shows, which tools were used by each team.

One of the teams (kept anonymous here by choice) deserves special attention. The members at one of the locations had difficulties on using videoconferencing (lack of webcam). Teamviewer was used for most of the communication, together with exchange of photos and videos (mobile phone based). The team admitted that their communication difficulties were significant and represented a conditioning factor for the whole work. On the example of this team we can see, how lack of well-organized/efficient communication (with a bottleneck factor such as hardware being the trigger) can be crucial for teamwork, as it is shown in 2.3. Also, these problems annoyed team members and made the communication between the teams even more difficult, what emphasizes the importance of transversal competences in distributed teams, as it is shown in 2.4.

Table 1. Communication tools used by six distributed teams.

			Team number					
			1	2	3	4	5	6
Tools	Communication tools	Skype	x		x	x		
		Whatsapp	x	x	x	x	x	x
		Google Hangouts		x			x	
		Facebook				x		
		Teamviewer			x	x		
		emails					x	
		Zoom						
	File management	BIM 360	x	x		x	x	
		Google Drive	x	x	x	x		x
		DropBox					x	

As mentioned in section 3, the ‘seed’ members of each team were chosen randomly, and despite there were no restrictions for changing roles, all team ‘seed members’ ended up playing the role of ‘BIM Manager’, except for the case of a single group, in which the ‘BIM Manager’ was taken by another team member who had some previous professional experience in BIM management. There is a possibility that the team leading role has been taken in some cases by a person that might not have been best fitting one for the role of the team leader. That may have represented a conditioning factor in some cases.

Some teams reported problems with the language. Since all the members had different levels of fluency in English, the teams needed to spend extra time on some issues to make sure everyone understood everything clearly. Also, sometimes this caused extra diversity inside the teams, when some of the members had the same mother-tongue and tended to communicate more inside this team and not with all the members equally, as it is explained in 2.1 and 2.2.

6 Remarks

Working in distributed teams requires higher level of some skills from team members, for example being open to changes and ability to express yourself, your goals and approach to work, what translates into the lead time of the project. Another challenge of working in multicultural teams is the varied language levels.

An increase in transversal skills is noticeable in distributed teams. Teams are looking for new, better solutions that would allow better cooperation and proper understanding of the project's goals. It allows to know their own competences, strengths and weaknesses, and assign the roles in teams in ways those allow to get better efficiency and results.

The major challenges faced by distributed teams were found to be in the choice of adequate technical solutions that allowed seamless communication both in videoconferencing and synchronized data sharing. When not operating properly, these technical solutions can be the sources of delays and misunderstandings. Management tools, such as scrum, improve communication in distributed teams.

Choosing the correct tools for communication and file management are highly important aspects of work in distributed teams. Properly selected tools translate into decrease in the project lead time and risk of facing potential problems.

Note: this study was entirely done before the CoViD-19 pandemic and many changes in this area happened after this, because many teams around the world started working separately.

7 References

Alizadehsalehi, S., Hadavi, A. & Huang, J.C. (2019). BIM/MR-Lean construction project delivery management system. *Institute of Electrical and Electronics Engineers Inc.* doi:10.1109/TEMSCON.2019.8813574

Alontani, M. S., Qureshi, M. R. J. (2014). A Proposal to Improve Communication Between Distributed Development Teams. *I. J. Intelligent and Applications.* doi: 10.5815/IJISA.2014.12.05

Ballard, G., & Tommelein, I. (2016). Current process benchmark for the Last Planner System Lean Construction. Available at http://p2sl.berkeley.edu/wp-content/uploads/2016/10/Ballard_Tommelein-2016-Current-Process-Benchmark-for-the-Last-Planner-System.pdf, Accessed 30th Oct 2019.

Berczuk, S. (2007). Back to Basics: The Role of Agile Principles in Success with a Distributed Scrum Team. *Agile Conference (AGILE), IEEE, 382–388,* Washington DC, USA. doi: 10.1109/AGILE.2007.17

Da Silva, F., Costa, C., França, C. & Prikladnicki. R. (2010) Challenges and Solutions in Distributed Software Development Project Management: A Systematic Literature Review. *Proceedings of The Fifth IEEE International Conference on Global Software Engineering (ICGSE)*. 87-96.

Escudeiro, N., Escudeiro, P., Barata, A., & Lobo, C. (2011). Enhancing students teamwork and communication skills in international settings. *International Conference on Information Technology Based Higher Education and Training, ITHET* doi: 10.1109/ITHET.2011.6018683

Georgios P. (2014). Moving from traditional to agile software development methodologies also on large, distributed projects. *International Conference on Strategic Innovative Marketing*, IC-SIM 2014. Madrid, Spain

Gupta, S., & Moon, S. (2019). Developing lean management framework for building information modelling (BIM)-based construction project. Proceedings of 22nd International Conference on Advancement of Construction Management and Real Estate, CRIOCM 2017 pp. 851-861. SBN: 978-064807424-3

Hamzeh, F., Ballard, G., & Tommelein, I. (2008). Improving construction workflow-the connective role of lookahead planning. *Proceedings for the 16th Annual Conference of the International Group for Lean Construction*, 635-646

Harush, R., Lisak, A., & Glikson, E. (2018). The bright side of social categorization. *Cross Cultural & Strategic Management*.

Jones, D. T., & Womack, J. P. (2012). Lean thinking.

Karhatsu, Henri, et al. (2010). Building blocks for self-organizing software development teams a framework model and empirical pilot study. In: *2010 2nd International Conference on Software Technology and Engineering*. IEEE. p. V1-297-V1-304.

Koskela. L. (2000). An exploration towards a production theory and its application to construction. *VTT Technical Research Centre of Finland*. Available at: https://aaltodoc.aalto.fi/handle/123456789/2150, Accessed 30th Oct 2019.

Kumar, S. S., & McArthur, J. J. (2015). Streamlining Building Information Model Creation Using Agile Project Management. *WIT Transactions on the Built Environment,* 229–240

Moe, Nils Brede, et al. (2015). Coaching a global agile virtual team. In: *2015 IEEE 10th International Conference on Global Software Engineering*. IEEE, 33-37.

Nilugal, K.C., Thaker, N., Molugulu, N., Andrew, S.X.J., Ugandar, R.E., & Chittur, A.I. (2015). The effectiveness of communication skills, team work and professionalism: A study on the performance of pharmaceutical industry employees *Der Pharmacia Lettre.* 7(7), 396-404

Razdan R., Polanco R., Ackerman Z., Vidot X., & Razdan D. (2019). GANDALF: A real-world solution to the "soft Skills" problem for engineering careers. *IEEE Technology and Engineering Management Conference, TEMSCON*. doi: 10.1109/TEMSCON.2019.8813665

Sakikhales, M. H., & Stravoravdis, S. (2017). Building Information Modelling, Building Performance, Design and Smart Construction. *Springer, Cham.*

Schleutker K., Caggiano V., Coluzzi F., & Luján J.L.P. (2019). Soft skills and European labour market: Interviews with Finnish and Italian managers. *Edizioni Universitarie di Lettere Economia Diritto.* doi: 10.7358/ecps-2019-019-schl

Seshadri, V., & Elangovan N. (2019) Role of Manager in Geographically Distributed Team; A Review. *Journal of Management (JOM)*.

Sievi-Korte O., Richardson I., & Beecham S. (2019). Software architecture design in global software development: An empirical study. *Journal of Systems and Software.* doi: 10.1016/j.jss.2019.110400

Son, S., & Park, Heejun. (2011). Conflict management in a virtual team. In: *The 5th International Conference on New Trends in Information Science and Service Science*. IEEE, 273-276.

Srivastava, P., & Jain, S. (2017). A leadership framework for distributed self-organized scrum teams. *Team Performance Management: An International Journal*, 23.5/6, 293-314.

Tomek, R. & Kalinichuk, S. (2015). Agile PM and BIM: A Hybrid Scheduling Approach for a Technological Construction Project. *Procedia Engineering. Elsevier B.V*. 557–564.

Ohno, T. (1988). *Toyota production system: beyond large-scale production. crc Press.*

Oskouie, P., Gerber, D.J., Alves, T. & Becerik-Gerber, B. (2012). Extending the interaction of Building Information Modelling and Lean Construction. *IGLC 2012-20th Conference of the International Group for Lean Construction, The International Group for Lean Construction.*

Available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.705.3874&rep=rep1&type=pdf, Accessed 30th Oct 2019.

Uusitalo P., Seppänen O., Peltokorpi A. & Olivieri H. (2019). Solving design management problems using lean design management: the role of trust. *Emerald Group Publishing Ltd. pp. 1387-1405.* doi: 10.1108/ECAM-03-2018-0135

Versionone.com (2019). 13th Annual State of Agile Survey. Available at: https://www.stateofaile.com/#ufh-i-521251909-13th-annual-state-of-agile-report/473508

Weilkiens, T., Lamm, J.G., Roth, S. & Walker, M. (2015). Soft Skills. *Hoboken, NJ, USA: John Wiley & Sons, Inc.* doi: 10.1002/9781119051930.ch20, Accessed 30th Oct 2019.

Wiśniewska, M., Wojciechowska, A., & Żerek, D. 2016. Zastosowanie wybranych narzędzi Lean Manucfacturing do optymalizacji procesów w przedsiębiorstwach produkcyjnych. *Monografie Politechniki Łódzkiej, Łódź.*

PMI (2017). PMBOK: *A guide to the project management body of knowledge (PMBOK guide)* (6th ed.). Pennsylvania, USA: Project Management Institute (PMI).

Sutherland, J., & Sutherland, J. J. (2014). *Scrum: The Art of Doing Twice the Work in Half the Time*: Crown.

The Use of Games as A Support Tool for Active Learning in The Context Of 4.0 Industry

Ana Carla Bittencourt Reis[1], Brenda Baumann Gewehr[1], Camila Marinho Avelino da Silva[1], Vivianne Bernardino Neves da Silva[1]

[1] University of Brasília, Brasília, Brazil

Email: anacarlabr@unb.br, baumanngewehr@gmail.com, kmila2012@hotmail.com, vivianne.b.s@hotmail.com

Abstract

Active methodologies have been gaining space among learning approaches since the results positively evaluated in terms of skills development, whether technical or transversal, and the assimilation of knowledge from different areas. There are several approaches used in face-to-face and distance higher education, such as Problem-Based Learning (PBL), Game-based Learning (GBL), Gamification, Serious Games, among others that place the student at the centre of their learning process. The advent of Industry 4.0 brought challenges to the teaching-learning of future engineers who will work in this new era. Therefore, the use of games or just elements of them is an ally in this challenge of transferring knowledge and maintaining the engagement and motivation of this generation of students in which games are inserted in their daily lives, being in common use for most of them. This work aims to present a study on the adequacy of games as a driving tool highlighting the applications, advantages, and difficulties of its use. An extensive literature review was the basis for the research and as result game application models in Industry 4.0 context and technological changes are presented.

Keywords: Active Learning, Game-Based Learning, Gamification, Engineering, Education challenges, Professional skills.

1 Introduction

The labor market is undergoing several changes in the evolution of industry 4.0 (Blackwell et al., 2013). The use of mobile and digital technologies is expanding in various sectors of society. However, in the context of learning, that does not occur in the same way.

Despite the universities' abilities to offer high-quality education, many employers still consider recent graduates unprepared for the job market, especially in professional skills such as communication, creativity, and collaboration (Eichelman, Clark & Bodnar, 2015).

To satisfy this demand, universities need to develop better ways to instruct students to prepare and help them to retain acquired knowledge and develop soft skills. According to Cheville (2012), many engineering students start their degrees without a high level of motivation and engagement. But, even the motivated, if the learning approaches adopted are not appropriate, this motivation may decrease. According to Souza et al. (2016), it is of paramount importance for universities the capability to captivate students so they can successfully acquire the desired skills, with the support of innovative methods of knowledge dissemination.

However, the traditional teaching approaches have not been demonstrated the most appropriate way to engage students and are, therefore, prone to lower levels of teaching and knowledge retention (Souza et al., 2016). Thus, to improve student performance and prepare them the best for the job market, active teaching-learning methodologies can be used in this process. However, some authors argue that even the PBL methodology, used in its traditional form, may prove to be insufficient to meet the demand of industry 4.0. Therefore, the use of games can come as a support to the teaching of concepts and abstracts and a way to motivate students to be consistent in their studies (Daba, Rosmansyah & Dabarsyah, 2019).

Therefore, this work aims to present a study on the use of games in the context of teaching engineering, highlighting the applications, advantages, and difficulties of its use. In general, the article seeks to answer and analyse how games can be applied as a teaching tool in the context of Industry 4.0. The authors carried out an extensive literature review to achieve this goal, and, as a result, presented a model of application of games in the context of the skills demanded by Industry 4.0.

2 Methodology

To achieve the research objective, a literature review was conducted using a method presented by Reis et al. (2020), which is an adaptation of the methods of Vieira & Gomes (2009), Borrego et al. (2014), Reis et al. (2017) and Mariano & Rocha (2017). This adapted method was chosen to conduct the research because, according to Reis (2020), they illustrate literature review procedures related to interdisciplinary fields, such as the investigation carried out by this present research, which goes through several areas related to Games and Active Learning in the context of Industry 4.0. This adapted method is divided into three stages, as presented by Reis et al (2020): definition of the research object; selection of the relevant articles to the purpose of the study; and deepening and developing the study.

In the first stage, based on Mariano & Rocha (2017), Borrego et al. (2014) and Vieira & Gomes (2009), it is necessary to define the scientific research databases and the research strings/terms. Therefore, the scientific databases chosen were Web of Science (WoS), Scopus and IEEE Xplore, as they are among the most important scientific databases, and their exclusion could negatively impact research. (Vieira & Gomes, 2009; Reis et al., 2017; Mariano & Rocha, 2017). The terms "game" AND ("problem-based learning" OR "project-based learning" OR "active learning" OR "active methodolog*") AND "engineering" were the strings used, filtering by the last five years. Thus, the research returned a total of 404 articles on the subject, being 182 from Scopus, 114 studies from WoS and 108 from IEEE Xplore.

The second stage is the step in which the relevant articles for the purpose of the study are selected. For that it is necessary to fix duplicate results, in other words, articles found in more than two databases (Reis et al., 2020). This duplication can be seen mainly between the Scopus and WoS bases. Then, the most relevant papers were separated according to the theme to be analysed separately.

The third stage is characterized by deepening and developing the study. Thus, according to the adapted methodology of Reis et al (2020), the 52 articles resulting from the second step were analysed in detail to allow a better understanding of the subject and to detach relevant elements for teaching engineering based on the use of games for learning, namely: how the use of games is being applied for active learning; focusing on the benefits and difficulties of this application; how game-based teaching is impacting the learning of future engineers; and how the advancement of industry 4.0 is impacting the formation of this new era of education.

3 The use of games as a tool to support active learning in the context of industry 4.0

3.1 Industry 4.0 challenges

The challenges of the job market are gradually more elaborated, in order to respond to the different needs that arise and walk along with the innovations. According to Sancho, Torrente, Marchiori and Fernández-Manjón (2011), the companies that follow the market have started to focus on their way of working in integrated activities instead of activities where professionals work alone.

The skills required for this generation are more complex and more essential skills are expected for the role of an engineer (Bermúdez, Rodríguez, Nistal, de Carvalho & Nogueira, 2015). Considering the current scenario, based on Andrade, Gouveia, Nogueira, Russo, and de Carvalho (2015), employers are looking for newly graduated engineers who have the skills to learn throughout life, key competencies that can influence the work environment, resourcefulness to solve real problems and advanced proximity to the digital environment.

The features skills presented by Sancho et al. (2011), De Graaf, E., & Kolmos, A. (2003), Karre, H., Hammer, M., Kleindienst, M. & Ramsauer, C. (2017), Kolmos et al. (2007) and Kolmos, A., Dahms, M.-L., & Du, X. (2010), could be grouped in five main skills that represent the majority ideas of the cited abilities. These main skills are presented and defined underneath:

- **Problem-solving skills** - an ability to identify, analyse, and solve applied science problems, through analytical skills and critical thinking based on knowledge of contemporary issues.

- **Management skills** - involves the ability to deal with constant changes, self and time management, organizational and processual understanding, and failure analysis.
- **Communication skills** - an ability to communicate clearly and effectively orally and written form, as also disseminating the knowledge in an intercultural team.
- **Professional skills** - an ability to use the techniques, skills, and modern scientific and technical tools necessary for professional practice, also the ability to interact with modern interfaces and have the resilience to adapt to new and different situations. These abilities would be combined with interdisciplinary competencies and an understanding of professional and ethical responsibility.
- **Social skills** - development of social abilities as leadership, responsibility, reliability and ability to work in multidisciplinary teams.

3.2 Game-based teaching-learning methodologies

The professional identity of students begins to be developed in the university environment; therefore, this environment must bring real experiences of the needs of the industry (Zajc & Starcic, 2017).

Project-Based Learning (PBL), is a teaching approach in which each student plays the fundamental role for their learning by being actively involved in the process (Cain & Cocco, 2013). In this process students develop some important skills for the future profession such as: communication, leadership, effectiveness, professionalism, management skills (Monteiro, Lima, Junior & Mariano, 2019).

In the literature review by Junior et al (2019), the authors found two predominant strands of methodologies in the application of games in education. The first was Game-Based Learning (GBL) which uses games as a way to improve the learning process, and the second was Gamification which uses game elements to motivate learning.

The GBL, in order to keep students motivated in learning, makes activities more engaging, in addition, due to this attractive and interactive method, some students tend to learn better in these scenarios (All, Castellar & Van Looy, 2015). According to All, Castellar, and Van Looy (2015), the use of the GBL methodology helps to create additional motivation which, in turn, can help to improve the effectiveness of teaching skills to students.

According to Abdool, Ringis, Maharajh, Sirju and Abdool (2017), Gamification is the process of applying elements of social games (such as role-playing, scoring systems) to real-world situations, which has long been time used in the educational system to promote the involvement of participants, seeking a balance between rigor and clemency.

However, in some cases, the motivation and involvement of participants decreases over time, if the mechanics of gamification are applied incorrectly (Hanus & Fox, 2015). For this reason Deterding (2012) suggests that, in addition to the elements of the game, the game design should also be used to successfully capture the interest of the participant, so that they should be incorporated into the course curriculum in some attractive and meaningful way to maintain the student's interest.

When used well, both the use of games and gamification can be excellent teaching tools, preparing engineers so that they feel more motivated and involved in the learning process. Also, according to Souza et al. (2016), using Games can make students not feel bored and/or anxiety states, maintaining the learning flow.

Besides, Pantelidis (1996) argues that virtual reality can also be used in teaching and, more specifically, in engineering teaching. Virtual reality allows students to enjoy real problem simulations, in addition, to be an immersive and highly engaging system. Nelson and Ahn (2018), address the use of virtual reality as a tool for teaching engineering students, with a focus on professional development skills. Nelson and Ahn (2018) also comment on the study by Abulrub, Attridge, and Williams (2011), which discusses how virtual reality can lead students to more creative solutions to the problem they are trying to solve, as it allows students to explore different solutions in a reasonably secure space that they couldn't do in the real world.

3.3 The use of games in the context of industry 4.0

Case studies regarding the application of games have been growing in engineering, the result of interest on the subject. These works mainly demonstrate the benefits of their application in the classroom or in the course.

With the growing importance of teaching the fundamentals of database and the need to incorporate ideas of design, administration and maintenance, as well as data analysis and knowledge discovery, an elective course on postgraduate database systems at the University of the West Indies sought in games the solution for under-enrolment of students in the course (Abdool et al., 2017). To solve these questions, a game based on RPG and references from pop culture was developed in the delivery and evaluation of the course to increase students' interest and motivation. According to Abdool et al. (2017), RPG cards were used, using pop culture references to specific animation series and fantasy game genres, with game elements such as experience points (XP) and teammates. According to student feedback, there was a significant increase in interest in the course, in addition to indicating a strong positive feeling about the DATARPG system, the name given to the game, which also contributed to the retention and mastery of the content (Abdool, Ringis, Maharajh, Sirju & Abdool, 2017).

In Brazil, there was also an attempt to encourage students to develop their programming skills at the Federal University of Rio Grande do Norte. In 2013, the university underwent a structural change in the Information Technology (IT) courses that increased the number of vacancies in the university admission process. Considering the rising failure rate in introductory subjects, teachers began to adopt a new approach to teaching methodology for first-year students. This approach needed to encourage students to practice programming, considering a game-based approach as the preferred method for engagement strategies in addition to: providing problem-based learning; be accessible from any computer; be adaptable to the course schedule defined by the teachers; and, be useful throughout the academic period. After some research and historical studies of methodologies previously used at the University, they decided to develop an internal solution (Kodesh) that introduced game mechanics to the programming learning process. During the process they also performed group dynamics based on games. In the Kodesh environment and dynamics, they used elements of games such as teammates, points, virtual coins, leaderboards, clues and instant feedback. This work was done in an introductory programming course and there was a significant improvement in student performance (Campos, Batista, Signoretti, Gardiman and Madeira, 2015).

Another format for the use of games was presented in the case study of the article "Proposal of Global PBL Education for Engineers using Sequence Learning Kit" by Yajima et al. (2018) held at KIMTL college -Thailand, in partnership with Sendai college -Japan, in its engineering courses. The objective of the study was to investigate the result of the implementation of a basic kit of a sequence of controls, the central problem of a project stimulated by the techniques of games and spirit of competition, for the development of knowledge and generic skills. To carry out the experiment, an e-Learning system was used to transmit theoretical knowledge and a basic kit for assembling an electrical circuit as a pinball game. First with the delivery of the material and prior explanation; Then with the application of a class to align the student's level of knowledge and the lack of preliminary learning to configure the task; and finally, with e-Learning available weeks before, for learning. After the end of the estimated time for carrying out the activity, the groups presented themselves as a competition, worth points for the conclusion, originality, and design. It was observed that the students were able to learn in a pleasant way, in cooperation with friends and with good efficiency through the learning kit and the method. This conclusion, in addition to being confirmed and exposed by the students, was also estimated from a report to identify the students 'skills, being done before and after the experiment, it was possible to prove the growth of the students' skills.

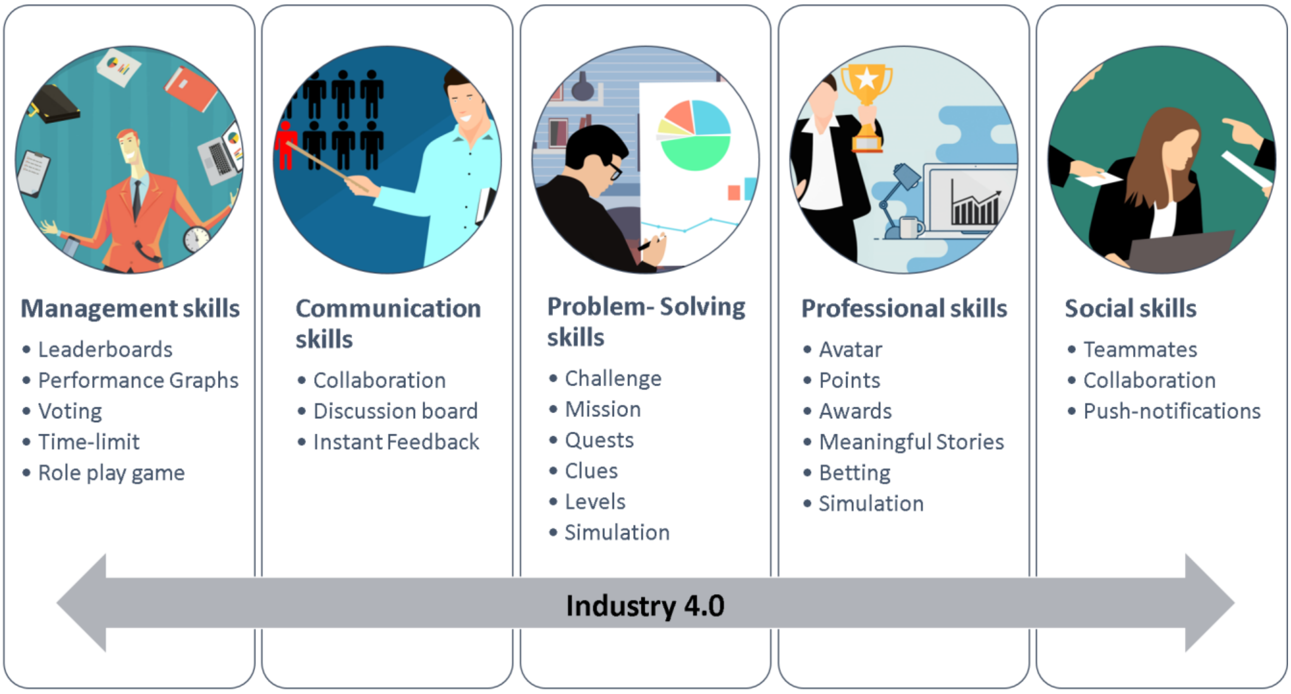
The use of games in the educational context presented itself as a more interactive method, helping to create additional motivation that, in turn, helps to improve the effectiveness in teaching skills and professional development (Nelson & Ahn, 2018; All, Castellar & Looy (2015) From the literature review, it was possible to elaborate a table to identify the elements that presented results in the process of developing competencies related to those required by industry 4.0 (Table 1).

Table 1. Skills developed from the use of games in active methodology.

Methodologies	Paper	Elements or types of game used	Skills developed
Game-Based Learning and Problem-Based Learning	Ustyuzhanina, Plotnikova and Efremova (2017)	Individual activities; Group activities.	Self-improvement; Teamwork; Communication; Decision-making; Assimilation of content
	Topalli and Cagiltay (2018).	Real-life game development projects. Visual Programming and Projects.	Perform better in programming
	Maksimova, Kutrunova, Maksimov and Voronov (2017). Andrade, Gouveia, Nogueira, Russo and de Carvalho (2015)	Serious game (not virtual). Teammate. Reality simulation. Serious game (eCity); Virtual simulation.	Increase the communication and the motivation of students; Proactivity; Assimilation of content; Motivation; Solution of real problems with strategies.
	Abdool, Ringis, Maharajh, Sirju and Abdool (2017)	Role-Playing; Game (RPG).	Motivation; Time management; Assimilation of content
	Campos, Batista, Signoretti, Gardiman and Madeira (2015)	Learning platform (Rules, levels, quests, ranking, time-limit, point, virtual coins, buy helpful items).	Motivation; Teamwork; Communication; Self-improvement; Assimilation of content; Cooperation; Self-management; Computational thinking.
	Nelson and Ahn (2018)	Virtual Reality Game (avatars, virtual world, puzzle games, multiplayer).	Communication; Teamwork; Decision-making; Leadership; Collaboration; Solution of problem; Computational thinking
	Bermúdez, Rodríguez, Nistal, de Carvalho and Nogueira. (2015)	Serious game (eCity); Virtual simulation.	Leadership; Teamwork; Communication
E-learning	Datta and Bhattacharyya (2018)	Levels; Time-Limit; Puzzles.	Assimilation of contents
Gamificação and Problem-Based Learning	Sousa, Stadnicka, Dinis-Carvalho, Ratnayake and Isoherranen (2016)	Graphic Design; Simulation.	Motivation; Assimilation of contents
	Campos, Batista, Signoretti, Gardiman and Madeira (2015)	Learning platform (Rules, levels, quests, ranking, time-limit, point, virtual coins, buy helpful items).	Motivation; Teamwork; Communication; Self-improvement; Assimilation of content; Cooperation; Self-management; Computational thinking.
	Daba, Rosmansyah and Dabarsyah (2019)	Boards, video games, story-club, puzzle, canvas.	Performance; Engagement; Motivation; Assimilation of content
	Sagirani, Sunarto, Hariadi, Amelia and Lemantara (2018)	Story, challenge, curiosity, character, interactivity, feedback e freedom to fail.	Motivation; Engagement; Performance; Assimilation of concepts and content.
	Yajima, Maneerat, Sugaya, Nitta, Takeichi and Sato (2018)	Construction of a Pinball game; Competition.	Teamwork; Collaboration; Solution of problems; Motivation; Self-improvement; Logical reasoning; Assimilation of concepts and content; Communication.
	Yajima, Okumura, Sugaya, Takeichi and Sato (2015)	Competition; High score.	Teamwork; Motivation; Self-improvement; Logical reasoning; Assimilation of concepts and content; Communication.
	Abidin and Zaman, (2017). Rich et al (2018)	Points; Competition.	Engagement; Motivation; Concentration; Satisfaction; Assimilation of content

Considering the perspectives presented by Reis et al (2020) and the skills presented in Chart 1, it is clear that the use of games as an active methodology has been collaborating, mainly, in the perspective, training, and learning. The latter seeks to improve employees and students in complex concepts and subjects, in addition to encouraging the development of personal skills necessary in the industry, such as conflict resolution, communication, teamwork, and leadership.

Figure 1. Elements of games that bring skills required by Industry 4.0.



The Figure 1 presents the five more cited skills by industry 4.0 and some elements of games that, based on this literature review, help to develop the required skills since the university period of engineers. For instance, when the element of games chosen is a simulation or role-playing game or another kind of virtual simulation, skills as professional, problem-solving and management are developed and improved, whereas collaboration is an element of games most used to develop and improve communication and social skills.

4 Conclusions

The movement of industry 4.0 and technological advances, consequently, brought changes and new requirements for engineering professionals forcing the universities to adapt their teaching methodology and contents. One of the methodologies that are being used by universities is the use of games to teach and, in this paper, the use of this approach as an active learning support tool was evident.

The employers and companies are looking for minds that could handle the evolution of the market and, for that, more than theory is necessary, they are searching for people that have skills to adapt in different environments, establish new processes and products, effective communications, capability to grow and expand their business. The use of games in engineering courses proved to be very efficient in contributing to the development of abilities required by the job market, pointed by this literature review, as: management, communication, problem-solving, professional, and social skills. Furthermore, games act as a tool to keep students motivated for learning, increase satisfaction, and the ability to retain knowledge, as the games' interface allows for greater student interactivity with course content and contributes to professional training through innovation.

Thus, it was verified the importance of developing engineering knowledge and skills throughout the period of study at the university. The study brought the analysis of the game elements that are capable to improve the skills required, these elements can be seen in the case studies presented in this paper. In this new era based on advances in industry 4.0, the job market requires professionals to be capable of putting in practice their skills developed in the academy through their daily tasks and evolve transversal skills. The technologies associated with the use of games are an insertion factor for a generation focused on the frequent use of digital devices.

Game-based methodologies and gamification are capable of boosting learning but are still underutilized in universities. As challenging as its application may be, its introductions should be stimulated due to its benefits and advantages for education. This paper brought the elements of games used in active methodologies that help the development of industry 4.0 required skills using the game as a support tool for active learning in the universities.

5 References

Abdool, Azim & Ringis, Daniel & Maharajh, Aniel & Sirju, Lynda & Abdool, Hannah. (2017). DataRPG: Improving student motivation in data science through gaming elements. 1-5. 10.1109/FIE.2017.8190442.

Abidin, H. Z., & Zaman, F. K. (2017, November). Students' perceptions on game-based classroom response system in a computer programming course. In 2017 IEEE 9th International Conference on Engineering Education (ICEED) (pp. 254-259). IEEE.

All, A., Castellar, E. P. N., & Van Looy, J. (2015). Towards a conceptual framework for assessing the effectiveness of digital game-based learning. Computers & Education, 88, 29-37.

Andrade, A., Gouveia, D., Nogueira, F., Russo, P., & de Carvalho, C. V. (2015, June). Games to support problem-based learning. In 2015 10th Iberian Conference on Information Systems and Technologies (CISTI) (pp. 1-4). IEEE.

Barrows, H. S., & Tamblyn, R. M. (1980). Problem-based learning: An approach to medical education. Springer Publishing Company.

Bermúdez, M. R., Rodríguez, M. C., Nistal, M. L., de Carvalho, C. V., & Nogueira, F. (2015, March). eCity: Virtual city environment for engineering problem-based learning. In 2015 IEEE Global Engineering Education Conference (EDUCON) (pp. 159-166). IEEE.

Blackwell, C. K., Lauricella, A. R., Wartella, E., Robb, M., & Schomburg, R. (2013). Adoption and use of technology in early education: The interplay of extrinsic barriers and teacher attitudes. Computers & Education, 69, 310-319.

Borrego, M., Foster, M. J., & Froyd, J. E. (2014). Systematic literature reviews in engineering education and others developing interdisciplinary fields. Journal of Engineering Education, 103(1), 45-76. http://dx.doi.org/10.1002/jee.20038.

Cachim P., (2015). Procedia Engineering, vol 117, pp. 431.

Cain, K., & Cocco, S. (2013). Leadership development through project-based learning. Proceedings of the Canadian Engineering Education Association (CEEA).

Campos, A., Batista, E., Signoretti, A., Gardiman, R., & Madeira, C. (2015, October). Gamifying activities in a higher education course. In European Conference on Games Based Learning (p. 117). Academic Conferences International Limited.

Cheville, R. A. (2012). Engineering education today: Capturing the afterlife of sisyphus in five snapshots. Proceedings of the IEEE, 100(Special Centennial Issue), 1361-1375.

Daba, J. B. R., Rosmansyah, Y., & Dabarsyah, B. (2019, October). Problem-Based Learning Using Gamification: A Systematic Literature Review. In 2019 International Conference on Informatics, Multimedia, Cyber and Information System (ICIMCIS) (pp. 125-130). IEEE.

Datta, S., & Bhattacharyya, S. (2018, October). Simple Spirited Scalable E-Learning System. In 2018 IEEE 5th International Congress on Information Science and Technology (CiSt) (pp. 368-373). IEEE.

Eichelman, K. M., Clark, R. M., & Bodnar, C. A. (2015, January). Assessing the impact of game-based pedagogy on the development of communication skills for engineers. In ASEE Annual Conference and Exposition, Conference Proceedings (Vol. 122, No. 122nd ASEE Annual Conference and Exposition: Making Value for...).

G. Abulrub, A. Attridge, and M. A. Williams, "Virtual reality in engineering education: The future of creative learning," International Journal of Emerging Technologies in Learning, vol. 6, no. 4, pp. 4–11, 2011.

Junior, E., Reis, A. C. B., Mariano, A. M., Barros, L. B., de Almeida Moysés, D., & da Silva, C. M. A. (2019). Systematic literature review of Gamification and Game-based Learning in the context of Problem and Project-Based Learning approaches. In 11th International Symposium on Project Approaches in Engineering Education (PAEE) 16th Active Learning in Engineering Education Workshop (ALE). Hammamet, Tunisia.

Karre, Hugo & Hammer, Markus & Kleindienst, Mario & Ramsauer, Christian. (2017). Transition towards an Industry 4.0 State of the LeanLab at Graz University of Technology. Procedia Manufacturing. 9. 206-213. 10.1016/j.promfg.2017.04.006.

Kolmos, A., Kuru, S., Hansen, H., Eskil, T., Podesta, L., Fink, F., de Graaff, E., Uwe Wolff, J. & Soylu, A. (2007). Problem Based Learnig.

Kolmos, A., Dahms, M.-L., & Du, X. (2010). Problem-based Learning. Engineering, 337–340.

M. D. Hanus and J. Fox, "Assessing the effects of gamification in the classroom: A longitudinal study on intrinsic motivation, social comparison, satisfaction, effort, and academic performance," Computers & Education, vol. 80, pp. 152–161, 2015.

Maksimova, Svetlana & Kutrunova, Zoya & Maksimov, Lev & Voronov, Andrey. (2017). Experience in the use of modern educational technologies in teaching professional disciplines of training direction "Civil Engineering". MATEC Web of Conferences. 106. 09020. 10.1051/matecconf/201710609020.

Mariano, A. M., & Rocha, M. S. (2017). Revisão da literatura: apresentação de uma abordagem integradora. In XXVI Congreso Internacional AEDEM: Economy, Business and Uncertainty: Ideas for a European and Mediterranean Industrial Policy. Reggio Calabria, Italia: AEDEM International.

Miloradova N., & Savina E. (2015). Procedia Engineering , vol 117, pp. 252

Monteiro, S. B. S., Lima, A. C. F., Junior, E., & Mariano, A. M. (2019) Experience of Project-Based Learning-PBL applied to the context of a Project Management discipline at the University of Brasília.

Nelson, M. E., & Ahn, B. (2018, October). Virtual reality activities for teaching engineering student's professional development skills. In 2018 IEEE Frontiers in Education Conference (FIE) (pp. 1-5). IEEE.

Nikiforov, V., Chernenkaya, L. (2015). Alma Mater Scien. J. (VestnikVyssheyShkoly), vol 3, pp. 8.

Pasławski J., et al. (2016). Procedia Engineering vol. 161, pp. 1043.

Radlak, K., & Fojcik, M. (2015, October). Integration of robotic arm manipulator with computer vision in a project-based learning environment. In 2015 IEEE Frontiers in Education Conference (FIE) (pp. 1-4). IEEE.

Reis, A. C. B., Silva Júnior, E., Gewehr, B. B., & Torres, M. H. (2020). Prospects for using gamification in Industry 4.0. Production, 30, e20190094. https://doi.org/10.1590/0103-6513.20190094.

Rich, B. M., Kretschmer, D., Goldmann, C., Hettling, L., Brandt, A., & Woll, R. (2018, December). Praxis-Oriented Teaching of Project Management Skills for STEM Students in Higher Education. In 2018 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE) (pp. 829-834). IEEE.

Sagirani, T., Sunarto, M. D., Hariadi, B., Amelia, T., & Lemantara, J. (2018, November). Prototype of Mobile Learning Application (MoLearn) by Utilizing the Gamification Concept. In 2018 IEEE 6th International Conference on MOOCs, Innovation and Technology in Education (MITE) (pp. 1-5). IEEE.

S. Deterding, "Gamification: designing for motivation," interactions, vol. 19, no. 4, pp. 14–17, 2012.

Sancho, P., Torrente, J., Marchiori, E. J., & Fernández-Manjón, B. (2011, April). Enhancing moodle to support problem-based learning. The Nucleo experience. In 2011 IEEE Global Engineering Education Conference (EDUCON) (pp. 1177-1182). IEEE.

Slavin, R. E. (1991). Synthesis of research of cooperative learning. Educational leadership, 48(5), 71-82.

Sousa, R. M., Stadnicka, D., Dinis-Carvalho, J., Ratnayake, R. M. C., & Isoherranen, V. (2016, December). Gamification based lean knowledge dissemination: A case study. In 2016 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM) (pp. 164-168). IEEE.

Topalli, D., & Cagiltay, N. E. (2018). Improving programming skills in engineering education through problem-based game projects with Scratch. Computers & Education, 120, 64-74.

Ustyuzhanina, A., Plotnikova, I., & Efremova, O. (2017, April). Business games in quality control for students of technical universities (active methods to improve motivation). In 2017 IEEE Global Engineering Education Conference (EDUCON) (pp. 44-48). IEEE.

V. S. Pantelidis, "Virtual reality and engineering education," Computer Applications in Engineering Education, vol. 5, no. 1, pp. 3–12, 1996.

Vieira, E. S., & Gomes, J. A. N. F. (2009). A comparison of Scopus and Web of Science for a typical university. Scientometrics, 81(2), 587-600. http://dx.doi.org/10.1007/s11192-009-2178-0.

Yajima, K., Maneerat, N., Sugaya, J., Nitta, A., Takeichi, Y., & Sato, J. (2018, July). Proposal of Global PBL Education for Engineers Using Sequence Learning Kit. In 2018 International Conference on Engineering, Applied Sciences, and Technology (ICEAST) (pp. 1-4). IEEE.

Yajima, K., Okumura, T., Sugaya, J., Takeichi, Y., & Sato, J. (2015, October). Development of sequence control kit and a proposal of global engineering PBL education. In 2015 7th International Conference on Information Technology and Electrical Engineering (ICITEE) (pp. 162-166). IEEE.

Zajc, M., & Starcic, A. I. (2017, April). Designing educational tablet games with the interdisciplinary team of students: Developing university-industry partnerships. In 2017 IEEE Global Engineering Education Conference (EDUCON) (pp. 1058-1061). IEEE

Assessment of Student Performance in the Context of Active Learning

Ana Carla Bittencourt Reis1, Milena Rodrigues Santos2, Ronaldo Rodrigues Pacheco1, João Mello da Silva1

[1] Master Program in Applied Computing University of Brasília (UnB), Brasília, Brazil;
[2] Department of Industrial Engineering, Faculty of Technology, University of Brasília, Brasília, Brazil

Email: anacarlabr@unb.br, milena.mrsantos@gmail.com, ronaldo.pacheco07.rp@gmail.com, joaomello@unb.br,

Abstract

The growing adherence to the use of active learning methodologies brought to light the discussion of the challenge related to the forms of student assessment used and the performance measurement, expressed by the grades. In this type of approach, team projects are very common, where students are expected to collaborate equitably. For these cases, the forms of assessment practiced involve individual and group assessments, concomitantly or not. For both cases, the challenge remains to extract the contribution of each student from the work developed and express it through evaluations (grades). Given the above, this paper aims to bring a discussion about the theme and the proposal of alternatives that best suit the context of active learning. As a result, in addition to an extensive literature review, presenting the challenges experienced by professors, an evaluation model for Industrial Engineering courses is presented.

Keywords: Active Learning; student performance, student assessment, PBL

1 Introduction

The evaluative practices in active methodologies of education in engineering are the target of discussions by scholars on the subject. On the one hand, there is testing, commonly used in traditional teaching methodologies, with direct ways of assessing the student's knowledge on a given topic. On the other hand, there are active methodologies, which work on the development of so-called soft skills and have in their design a strong appeal for group work, and anticipation of experiences that would be experienced in the labor market.

A report by the American Society for Engineering Education (ASEE, 2009) highlights that, in order to address the growing list of interconnected and complex global problems, it is necessary to train engineers capable of dealing with the multifaceted nature of the challenges of 21st century. It means that the most important thing is not only the technical content learned, but also to be able to properly have ethical attitudes and behaviors, which requires changing traditional classrooms into learning environments, in which contextualized activities are developed and based mainly on active learning (ABENGE, 2018).

It is believed that the traditional classroom approach does not offer engineering students so-called social skills, such as communication, collaboration, personal skills and design skills (Nguyen, 1998). According to Reis et al. (2017), engineering education has been the subject of studies to provide better results in terms of learning. In general, the results point to the development of soft skills, but what has been learned in terms of technical content? How to measure the learning of these contents individually, considering the development of group work? How to measure the development of soft skills by each student? What forms of assessment can be conducted in an active learning environment that safeguard the technical quality (individual) of the engineer? These are some of the questions that researchers and professors who adhere to these methodologies seek to answer and solve in order to promote the best of active learning, ensuring the learning of soft skills and technical concepts.

In order to answer the aforementioned questions, the main objective of this article is to propose a model for assessing student performance, in an active learning context, considering technical aspects and developed skills, and group and individual performance. For this, a systematic literature review is carried out and based on the observation of existing models and the teaching experience in engineering, an evaluation model is proposed.

The article is structured as follows: after the introduction (section 1), the research methodologies (section 2) are presented. Then, the consolidation of the systematic literature review on performance assessment in active learning is presented (Section 3). Subsequently, the proposed model is presented (Section 4). Finally, the final considerations are presented (Section 5).

2 Research methodology

This section presents the methods and structure used in the study to achieve the objectives. The research strategy is classified as a systematic literature review, which, through a qualitative approach, seeks to understand the main elements of the scientific literature to propose a model for assessing performance in active learning.

2.1 Research Structure

Step 1. Research Preparation

In this stage, four essential requirements were established to guide the bibliographic research: the databases used; the terms or keywords; the knowledge areas targeted by the research; and the space-time coverage for selecting works.

As for databases, Web of Science (WoS) was chosen because it is internationally recognized as one of the most complete and reliable. In addition, the Scopus database was used because it is multilingual and has a greater coverage than the first (Zupic and Cater, 2015).

The search terms used were ("PBL" OR "PjBL" OR "project based learning") AND ("assess *" OR "evaluat *" OR "calculat *") AND ("grad *" OR "scor *") AND ("individual" OR "group *" OR "team *") AND ("student *" OR "project *" OR "course *") in order to return only articles that include the integration of terms. The use of the logical operators AND and OR and the elements asterisk (*) and quotation marks (“”) is perceived, as they allow greater coverage on the topic while delimiting the findings by the intersections between the terms.

The "research areas" field was defined by Engineering with the timeframe delimited between 2010 and 2020.

Step 2. Survey data

After collecting the data, filtering was performed to eliminate duplicate articles between the bases. Subsequently, the abstracts were read in order to keep only the articles pertinent to the research scope. In addition, for the selection of articles, only the most cited article (given the impact factor) and the most relevant ones published since 2018 were selected.

Step 3. Performance evaluation in active learning

Thus, the main elements present in the main models on performance evaluation of students in active learning environments found in scientific literature were listed. Based on this literature review, a performance evaluation model is proposed.

In Figure 1, the steps carried out in the Research are presented.

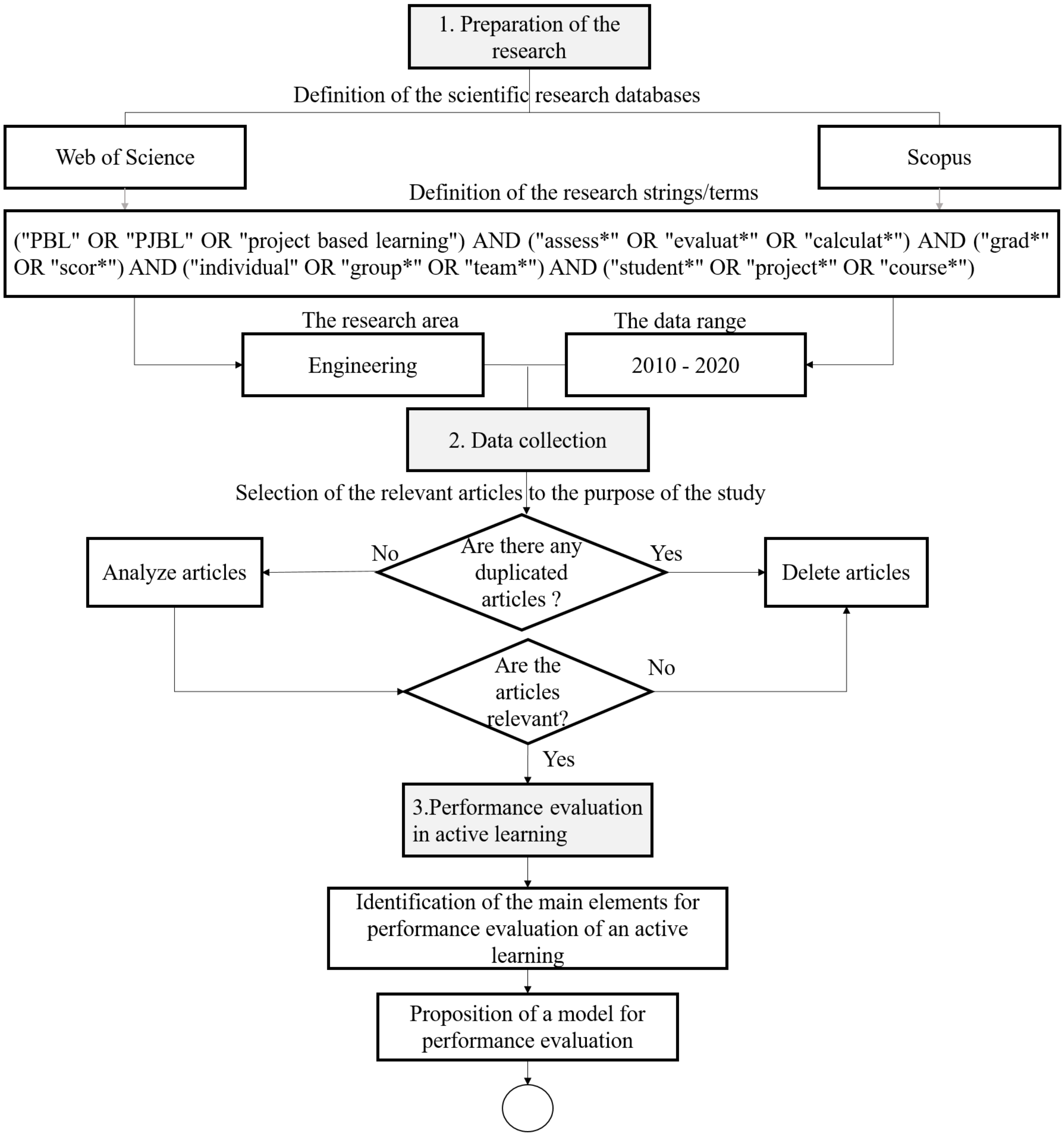


Figure 1. Research Structure

3 Performance Evaluation in Active Learning

The importance of assessing student performance is well known, given that assessments, as well as adequate assessment processes, contribute to an effective educational process (Garcia et al, 2008). This need extends to the context of active learning, which is based on the principle that the learning process, unlike traditional teaching, occurs by removing the point of focus from teachers and passing it on to students.

However, despite the many benefits arising from active learning, challenges in assessing individual performance are implied by group projects, since there is a possibility that some individuals could assume a greater workload and, final grades, therefore, may not reflect individual performance (Fernandes, 2014).

3.1 Elements for performance evaluation of an active engineering learning

There are several models developed to assess student performance in subjects and other activities involving active learning. This topic presents some elements found in the literature on the topic, which provided support for the development of the proposed model.

The composition of groups to carry out activities, as mentioned, is a common practice in the active learning disciplines and is observed in several works such as, for example, Arbelaitz et al (2015), Malheiro et al., (2015), Setiawan (2019), Ashworth (2015), De los Ríos-Carmenado et al., (2015), Tao et al (2015), Nguyen et al (2013), Chang et al. (2011), Krpalkova et al (2015).

In the work of Arbelaitz et al (2015), in addition to the group project, individual activities were carried out (15% of the grade composition) focused on assessing knowledge about the subject in question, in the case of this study, programming in C. In group (25% of the grade composition), the core was collaboration using the presentation and the project developed to compose the grade. In addition, it is necessary to obtain at least 30% in the knowledge test.

Chua et al (2013) introduces a method used to assess students composed of three stages: (1) written test to assess knowledge about the topic, (2) oral exams focused on problem solving based on scenarios and, finally, (3) quality testing of the final product project's to assess performance and results.

The case study developed by Fernandes et al (2014), contemplates the development of the project in 17 weeks with well-defined deliveries containing the presentation of the project, a team management strategy, project report (in different phases), formal presentation, written test, discussion and delivery of a poster. The authors confirm the importance of the participants themselves being involved in the evaluation of the project, through peer evaluation, based on criteria, to compose the final grade of each member of the project team.

Malheiro et al., (2015) follow the same line as Fernandes et al (2014), however, in addition to including a product or prototype, they use self-assessment and peer review to fill the gaps in group assessments. The evaluations involve seven dimensions: quality, quantity of technical contribution, openness to new ideas, teamwork performance, leadership, attitude and initiative, with a rating ranging from 1 to 5. Thus, the final grade is made up of both verification of deliveries in groups, corresponding to 35% of the final grade, as well as for individual ones, which is composed of the weighted average of all attributed. These same evaluation criteria were observed in the work of Ashworth (2015), with group evaluations (three oral presentations, at the beginning, middle and end of the project) and individual evaluation to compose the final grade of each student. The author also used peer and self-assessment (35% of the grade).

A work with interesting methodology was presented by Gweon et al., (2015) where the evaluation of two actors was used: the observer and the evaluator. For the grade composition, the average of the weekly evaluations was measured, each evaluation was composed of questions related to five areas (participation, group work, progress, knowledge co-construction and definition of goals).

The methodology proposed by De los Ríos-Carmenado et al., (2015) included 10 types of evaluation (individual and group), each one having a specific weight in the composition of the final grade, they are: lectures, group work outside class, participation in PBL workshops, cooperative learning activities, problem-based learning, relevant activities to the case study, information technology support, group tutoring, online tutoring, self-assessment and continuous assessment.

Unlike most of the reported authors, Tao et al (2015) adhered to the use of written tests to individually assess the student, in addition to the evaluation activities related to the project, such as: abstract, theoretical questions, used methods, project evolution, work in groups and completion of the project. In several other methodologies found in the literature, individual evaluations were used (Kosloski, 2019, Tao et al., 2015, Nguyen et al., 2013, Chang et al., 2011, Herráez & Claver, 2011), oral presentations (Kosloski, 2019), peer review (Chang et al., 2011, Krpalkova et al., 2015)), group work (Tao et al., 2015, Nguyen et al., 2013), self-assessment (Nguyen et al., 2013 , Krpalkova et al., 2015), project evaluation (Krpalkova et al., 2015), activities involving the active learning methodology (Herráez & Claver, 2011) and also, project evaluation through software (Chang et al ., 2011).

Many of the authors presented above, despite using several evaluation criteria, exhibited difficulties in appropriately assessing the individual performance of students correctly. Malheiros et al (2015) propose that self-assessment and peer review addresses the possible inequalities between grades and actual contributions. Arbeilatz et al (2015), discuss the opportunity to introduce, at the end of the course, some type of evaluation mechanism, which is optional, so that students can improve their final grades.

additionally, Fernandes et al (2014), Setiawan (2019) and Gweon et al (2015), demonstrate a difference between the final grades attributed by the evaluators and the students' perception of what their own should be final grade.

In view of the challenges and difficulties presented, an evaluation model is proposed, due to the composition of different evaluation dimensions, in order to attribute the student's final grade more assertively.

4 Proposed Model for Performance Evaluation

The proposed model for student evaluation in the disciplines that use active learning methodologies is based on the workflow described by Barbalho et al., 2017 (Figure 2). Preliminary Project (PP), Intermediate Project (PI) and Final Project (PF), are used for evaluation in the discipline Production Systems Project 4 (PSP 4) of the Industrial Engineering course at University of Brasília (UnB).

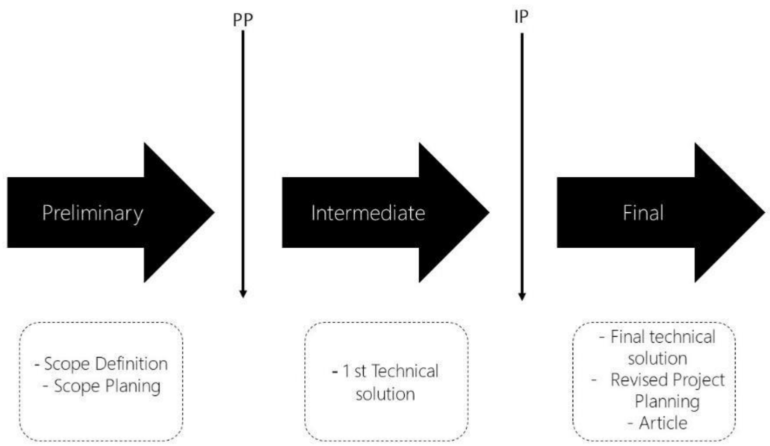


Figure 2. Basic structure of PSP4 (Barbalho et al., 2017).

The proposed model is composed of the elements presented in Table 1 composed by individual, group and peer evaluations. Individual assessments aim to identify students' involvement in projects, as well as their technical development. Group assessments aim to assess what the group was able to develop with the contribution of each individual.

In the three phases (PP, IP, FP) there are three types of assessment, individual, in groups and by peers. In this way, we seek to safeguard individual involvement, but also to value what the group was able to develop together.

Table 1- Elements of proposed model

PP			IP			FP		
Aspects evaluated	**Assessed subject**	**Evaluation**	**Aspects evaluated**	**Assessed subject**	**Evaluation**	**Aspects evaluated**	**Assessed subject**	**Evaluation**
Scope Definition	Group	2,5	Proposition of the technical solution	Group	2,5	Technical solution developed (written project)	Group	15
Goal setting	Group	2,5	Description of the company studied	Group	2,5	Formal Presentation	Individual	10
Work Breakdown Structure (WBS) Preparation	Group	2,5	Description of the problem analyzed	Group	2,5	Individual QUIZ	Individual	17,5
Risk Analysis	Group	2,5	Preliminary results of the technical solution	Group	5	Skills development	Individual	2,5
Stakeholder identification and analysis (expectations, power and interest)	Group	2,5	Compliance and adequacy of the schedule	Group	2,5	**Final score**		**45**
Development of Communication Artefacts	Group	2,5	Formal Presentation	Individual	5			
Schedule Formulation	Group	2,5	Oral argumentation	Individual	7,5			
Formal Presentation	Individual	2,5	Skills development	Individual	2,5			
Skills development	Individual	2,5	**Final score**		**30**			
Oral argumentation	Individual	2,5						
Final score		**25**						

As noted, in each phase of the discipline (PP, IP and FP) the three forms of assessment are considered. The presentation of the project and the oral argumentation (or QUIZ) results in individual evaluations, for the three phases. The PEER assessment is used to measure the skills development (Table 2). In this case, the perceptions of peers, the professor and the student self-assessment are considered.

The development of skills is related to the objective of the discipline in which the use of active methodologies occurs. The proposal presented in this work is based on the PSP4 (Production Systems Project 4) adapted from Reis et al. (2018) and can be adapted according to the context and methodology presented in the proposed discipline. The scope of PSP 4 involves the elaboration of a project with knowledge developed in the anchor discipline, Production Planning and Control (PCP), which is your corequisite at the 7th semester of the Industrial Engineering course.

Table 2 - List of skills to be developed during research project

Skills development (self evaluation / peer evaluation / professor evaluation)		
Team Work	Adaptability	Monitoring and Control of Deliveries
Collaboration	Conflict Management	Communication
Creativity	Relationship Building	Building Trust in the Team
Proactivity	Self-Management	Troubleshooting
Leadership	Self Confidence	Strategic Thought
Negotiation	Result Orientation	Technical contribution
Ethics and Values		

Source: Adapted from Reis et al. (2018)

This proposal contains dimensions of individual, group and peer evaluation, which were identified in the literature review. The gathering of these dimensions in this model seeks to bring a little of each methodology observed and compose a model with the expectation of considering individual technical and competence development, a gap commonly observed in active methodologies.

5 Final Considerations

Active learning has been widely supported by universities around the world. The works published on the subject point to positive results of learning and development of skills considered essential to the job market, such as leadership, teamwork, autonomy, problem solving, among others. However, there are some challenges to be overcome regarding the performance evaluation of students enrolled in disciplines with an active learning approach. Individual assessment in subjects with group projects is strongly mentioned, due to the difficulty in measuring the individual contribution of students to the projects.

In view of the above, this paper presents a literature review on the evaluation methodologies and criteria used and proposes an evaluation model that considers group activities, individual activities, self-evaluation, professor and peer evaluation. These dimensions were defined based on bibliographic research, teaching experience and in order to cover those different dimensions.

It is expected to provide a more reliable assessment result to the students' merit and also greater involvement in the activities to be developed. As a future work it is proposed to use games as a tool for evaluating technical content.

6 References

Arbelaitz, O., Martı, J. I., & Muguerza, J. (2014). Analysis of introducing active learning methodologies in a basic computer architecture course. IEEE Transactions on Education, 58(2), 110-116.

Ashworth, D. W. (2011). Project Based Learning in International Teams–Monitoring the Effectiveness of Teamwork. In Key Engineering Materials (Vol. 450, pp. 581-584). Trans Tech Publications Ltd.

CANALETA, Xavi et al. Master in teacher training: A real implementation of active learning. Computers in human behavior, v. 31, p. 651-658, 2014.

Chang, S. H., Chen, M. L., Kuo, Y. K., & Shen, Y. C. (2011). A Simulation-Based LED Design Project in Photonics Instruction Based on Industry–University Collaboration. IEEE Transactions on Education, 54(4), 582-589.

Chua, K. J., Yang, W. M., & Leo, H. L. (2014). Enhanced and conventional project-based learning in an engineering design module. International Journal of Technology and Design Education, 24(4), 437-458.

De los Ríos-Carmenado, I. G. N. A. C. I. O., Lopez, F. R., & Garcia, C. P. (2015). Promoting professional project management skills in engineering higher education: Project-based learning (PBL) strategy. International journal of engineering education, 31(1), 184-198.

Herráez, M. A., & Claver, J. M. (2011). Assessment technique to encourage cooperative learning in a computer programming course. The International journal of engineering education, 27(4), 867-874.

Krpalkova Krelova, K., Krpalek, P., & Kolarova, D. (2015). Developing entrepreneurial skills using project teaching. In Rural Environment. Education. Personality.(REEP). Proceedings of the International Scientific Conference (Latvia). Latvia University of Agriculture.

FERNANDES, Sandra. Preparing Graduates for Professional Practice: findings from a case-study of project-based learning (PBL). 2014.

Fernandes, S., Mesquita, D., Flores, M. A., & Lima, R. M. (2014). Engaging students in learning: findings from a study of project-led education. European Journal of Engineering Education, 39(1), 55-67.

GARCIA, Isabel; DURAN, Alfonso; CASTRO, Manuel. Comparing the effectiveness of evaluating practical capabilities through hands-on online exercises versus conventional methods. In: 2008 38th Annual Frontiers in Education Conference. IEEE, 2008. p. F4H-18-F4H-22.

Gweon, G., Jun, S., Finger, S., & Rosé, C. P. (2017). Towards effective group work assessment: even what you don't see can bias you. International Journal of Technology and Design Education, 27(1), 165-180.

Krpalkova Krelova, K., Krpalek, P., & Kolarova, D. (2015). Developing entrepreneurial skills using project teaching. In *Rural Environment. Education. Personality.(REEP). Proceedings of the International Scientific Conference (Latvia)*. Latvia University of Agriculture.

Leslie, L. J., & Gorman, P. C. (2017). Collaborative design of assessment criteria to improve undergraduate student engagement and performance. European Journal of Engineering Education, 42(3), 286-301.

Malheiro, B., Silva, M., Ribeiro, M. C., Guedes, P., & Ferreira, P. (2015). The European Project Semester at ISEP: the challenge of educating global engineers. European Journal of Engineering Education, 40(3), 328-346.

Nguyen, D. M., Truong, T. V., & Le, N. B. (2013, March). Deployment of capstone projects in software engineering education at duy tan university as part of a university-wide project-based learning effort. In 2013 Learning and Teaching in Computing and Engineering (pp. 184-191). IEEE.

Reis, A. C. B., Barbalho, S. C. M., de Araújo, F. L., Brito, L. S., Ishihara, S. E. M. P., & Teixeira, V. P. F. (2018). Project-Based Learning: development of PBL-based competencies under the pupil's perspective. In 10th International Symposium Project Approaches in Engineering Education (PAEE).

Setiawan, A. W. (2019, April). Detailed Comparison of Instructor and Student-based Assessment in Project Based Learning. In 2019 IEEE Global Engineering Education Conference (EDUCON) (pp. 557-560). IEEE.

Tao, J., Zhang, S., Yuan, Y., & Wen, X. (2015). Extending engineering specialty course concepts in electrical engineering education. International Journal of Electrical Engineering Education, 52(1), 39-51.

Development of transversal skills in an extracurricular academic research project through active learning in healthcare - a case study

Ana Carla Bittencourt Reis[1], Gabriela M Esteves Fonseca Franco[1], Ronaldo Rodrigues Pacheco[1], Ana Clara Albuquerque de Miranda[1]

[1] Department of Industrial Engineering, Faculty of Technology, University of Brasília, Brasília, Brazil

Email: anacarlabr@unb.br, francoegabriela@gmail.com, ronaldo.pacheco07.rp@gmail.com, anaaclaraam@gmail.com

Abstract

Active learning has been widely used by engineering courses to boost the absorption of knowledge through the transition from theoretical content to practical contexts. The idea defended by much research is based on the anticipation of professional life, experienced in the first years as an engineer, for the undergraduate period. Increasingly, engineers are expected to have skills related to solving real company problems, such as eliminating waste, rework, excessive spending, and unnecessary steps in processes. Given this, this paper aims to evaluate how the application of Lean Healthcare tools in the context of a research project contributes to the development of active learning, and, consequently, to the professional practice of the students involved. To this end, a case study was executed in a hospital organization, to list the advantages and challenges faced during this academic experience, and moreover, the main skills and knowledge acquired by students. In addition, aspects of the active learning methodology used are highlighted, more specifically, the Problem and Project Based Learning (PBL) method. The results point to or develop transversal skills, greater involvement, and a sense of responsibility on the part of the students. Lastly, it was observed a great adaptability of the students to the experienced scope increases.

Keywords: Active Learning; Engineering Education; Lean healthcare; Project Based Learning; Problem based learning

1 Introduction

Several universities around the world have been looking for new teaching methodologies to prepare their students to face real experiences. Engineering courses are constantly challenged to innovate their teaching methods, and therefore, undergo extensive changes towards the development of skills and competencies (Andersson, 2015).

In the search for alternative teaching methods that differ from the traditional ones, that is focused on the teacher and the classes are mostly theoretical, the number of studies with approaches focused on the Problem and Project Based Learning (PBL) is growing. This active teaching-learning method aims to offer students opportunities to develop their skills and competencies, through the execution of projects that center on real challenges and problems (Elahi, 2019).

The idea defended by studies related to this type of learning is based on anticipating the students' professional experience, aiming to stimulate the development of skills related to real problems faced in organizations (Carvalho, 2016).

Although these methodologies have been applied in the most diverse contexts, the vast majority of studies are centered on research projects and in the classroom, guided by teachers and having the student as the main element (Althoff, Silva, Milhomem, & Reis, 2019).

There is a large scientific literature on studies dedicated to assessing the skills developed through active methodologies (Althoff et al., 2019; Natsis, Papadopoulous, & Obwegeser, 2018; Jacques, Bissey, & Martin, 2016; Krelová, Krpálek, & Kolarová, 2015; Projektové vyučování, 2011; Králová & Novák, 2014). However, it was not found any study which sets out to investigate the links between advantages, challenges and competencies developed through extracurricular and curricular research projects.

The Industrial Engineering undergraduate program at the University of Brasilia (UNB) promotes teaching through disciplines called Production Systems Projects (PSP) which have Problem and Project Based Learning (PBL) approaches. In addition, the course also reconciles theory and practice through extracurricular projects developed in partnership with public or private organizations from the most varied sectors.

In such context, considering the identified gap in the literature, the main objective of this article is to evaluate how the execution of an extracurricular research project, focusing on the application of Lean Healthcare tools as an active learning approach, contributes to the development of competencies of the students involved. Furthermore, such competencies are compared to those developed by the same students in the PSPs disciplines over the course in Industrial Engineering at UNB.

To enable this study, this research was structured in five sections: the first section introduces the study; the second presents the bibliographic review; the third describes the method used in the study; the forth presents the case study and, lastly, the fifth section exposes the conclusions. Hopefully, the results found in this study may contribute to the reformulation of active methodologies applied to contexts of intra and extracurricular academic research projects.

2 Active Learning Methodology and Research Projects

Active methodologies can be applied in different contexts, especially in research projects and classroom, by the use of different learning elements, such as workshops, work groups, peer-tutoring sessions, active group dynamics, oral presentation, seminars (Althoff et al., 2019; Natsis et al., 2018; Jacques et al., 2016; Krelová et al., 2015).

All around the world, engineering universities are often challenged to propose new teaching methods to find better ways of assessing students' competencies and improve the educational process. In this context, research projects and their management are one of the most effective ways to assess curricular and cross-curricular competencies developed by students (Jacques et al., 2016).

The literature indicates a wide application of active methodologies in research projects, showing different results obtained. According to Fox, Blake, & Jacobs (2018), research projects are important to students since they are designed to develop the skills needed for experimental design, data collection and statistical analysis.

Natsis et al. (2018), Baluarte-Araya (2020), Lozano, & Trillo-Lado (2015) e Elahi (2019) relate a research project experience developed over a discipline of a university program (course-based research project), where students work on a complex research project and are expected to submit a report at the end of the semester (Mena, Schmitz, & McLaughlin, 2015). Students have revealed that their participation in research projects during undergraduate Engineering programs led them to improve their skills to achieve a much more comprehensive view of the problems and how to analyze them (Murray, Matsuno, Montes, & Bejarano, 2015).

On the other hand, Althoff et al. (2019) explore a research project developed through a cooperation between a public organization and a university. Overall, research projects are used to resolve complex problems in real procedures' practice (Kovac, & Stare, 2014).

Kogtikov, Dukhanov, & Bochenina (2016) confirm the benefits of the students' engagement in transdisciplinary projects. Fox et al. (2018) also ratify that combining the output from multiple research projects has also proven an effective approach in many studies.

Among the active methodologies, Problem and Project Based Learning (whose acronym is PBL) is one of the most widespread (Bessa, Santos & Duarte, 2019; Fernandes, Fuchter Júnior, Daleffe, Fritzen, & Alves de Sousa, 2020). The PBL provides the development of several competencies related to three aspects: cognitive learning, content, and collaborative learning (Du, Su, & Liu, 2013). Cognitive learning assumes that learning is organized around problems and involves the following skills: problem-solving, project management, contextual analysis, and presentation skills. Content is related to interdisciplinary learning and includes disciplinary knowledge, interdisciplinary skills, and information management. In turn, collaborative learning is associated to team-organized learning and involves collaboration and knowledge sharing, communication (oral and written) and project management and planning. In short, PBL, as a teaching and learning method, can successfully facilitate participative learning, critical reflection, systemic thinking, and creativity (Du et al., 2013).

The benefits of this methodology are quoted in several works and mention elements such as it links theory to practice, in order to be used in real life; it involves challenging questions and problems; stimulates creativity (students present their own ideas and solutions) to solve problems, which can be approached in different ways; it is student-centered; generates learning through experience; seeks to develop work and study habits; develops a sense of responsibility on the part of the students; promote student involvement in decision-making and problem-solving; develops self-confidence, allows teamwork; develops human relationships and a sense of responsibility; generates a result / final product; the teacher acts mainly in the role of advisor (Projektové vyučování, 2011; Králová & Novák, 2014; Krelová, et al., 2015).

The literature points other types of active learning methods that may or not be used in conjunction with PBL. Among them, we can mention the TBL (team-based learning), a strategy that aims to create opportunities and gain benefits by working in small learning groups. Some skills that TBL seeks to develop are encouraging active participation, acquiring notions of self-management, stimulating the exchange of experiences among participants, and promoting involvement in the team's collaborative skills (Althoff et al, 2019).

Table 1 below presents relevant studies (the most cited studies) that address skills developed in research projects carried out using several active learning methodologies.

Table 1. Relevant studies and developed skills.

References	Active Learning Methodology	Developed skills
Du, X; Su, L; Liu, J (2013)	Problem Based Learning	Participative learning, critical reflection, systemic thinking, creativity, and cultural awareness
Jacques, S; Bissey, S; Martin, A (2016)	Problem Based Learning	Autonomy, creativity, openness, collaboration. responsibility.
Murray, V; Matsuno, C; Montes, H; Bejarano, A (2015)	Project Based Learning	Leadership, teamwork, communication skills, creativity, proactivity.
Thomas, I; Depasquale, J (2016)	Problem Based Learning	Systems thinking, Anticipatory, Normative, Strategic and Interpersonal competencies (five key competencies identified as important to sustainability professionals)
Adams, J; Kaczmarczyk, S; Picton, P; & Demian, P (2010)	Problem Based Learning	Problem-solving skills and creativity related to engineering.
Letouze, P; de Souza, J; da Silva, VM (2016)	Project Based Learning	Active role in choosing tools and strategies. Responsibility to make choices, propose solutions and to defend them.

Despite the countless benefits, active methodologies also bring common challenges. According to Yasin, Rahman, & Ahmad (2012), monitoring students' learning is a major challenge in the Problem-oriented Project-based Learning (POPBL) method, since the use of pencil and paper tests is not a good evaluation approach. Therefore, they proposed a portfolio based on journal reflection as a means of monitoring students' learning. While monitoring their learning, coaching, and giving feedback are seen more appropriate. Krelová et al. (2015) also point out the challenge of assessing student performance in the Problem and Project Based Learning (PBL) approach. Kaur (2010) cites alternative assessment modes for active methodologies such as journal writing, classroom observation and conferencing, and self-assessment.

Shekhar, Prince, Finelli, Demonbrun and Waters (2018) argue that active learning requires additional participation from students, which often conflicts with their expectations, resulting in resistance to participate in the active learning exercises. Krelová et al. (2015) also point out another challenge related to teachers who do not have enough teaching skills for project-based learning implementation.

Du et al. (2013), in a study which aimed to understand and analyse culture change toward a sustainability curriculum that employs PBL, list challenges around its implementation: how to change the existing grading system, how to provide both teaching staff and students' with prior knowledge about the new PBL methods, how to gain institutional support, and how to change the broader society and cultural values.

3 Active Learning Methodology in Industrial Engineering at University of Brasília

The Industrial Engineering's program at University of Brasília presents an innovative curriculum, by offering seven regular disciplines and one eventually offered, labelled Production Systems Projects (PSP) which have a Problem and Project Based Learning (PBL) approach, along the program twelve semesters length (Monteiro, Reis, Silva, & Souza, 2017).

These disciplines were created as a way to foster the development of new competencies in students (e.g., problem-solving skills, autonomy, creativity and teamwork) through real-world problem-solving supported by specific project management methodologies (Barbalho, Reis, Bittencourt, Leão, & Silva, 2017). Each of the subjects has anchoring courses, which are taught at the same academic semester, promoting support of teaching technical content (Reis, Mariano, Silva, Amoras, & Moysés, 2019).

The anchoring courses consist of: Information Systems in Production Engineering (SIEP), Production Planning and Control (PCP), Production Quality Management (GQP), Product Engineering (EP) and Strategic Management (GE), each one related to a PSP discipline (Reis et al., 2019).

The results of this approach are mentioned in several studies (Barbalho et al., 2017; Monteiro et al., 2017; Reis, Barbalho, & Zanette, 2017; Reis, Barbalho, de Araújo, Brito, Ishihara, & Teixeira., 2018; Reis et al., 2019). It stimulates students' learning by offering them the opportunity to search for solutions (Barbalho et al., 2017).

The projects developed in these disciplines are based on problems faced by real-world public and private organization. In each semester, students are stimulated to study a new range of themes which support the development of these projects. In turn, the projects allow students to face challenges, solve problems, make decisions based on data and produce results through management skills, soft skills, among others (Monteiro et al., 2017).

In addition, the University of Brasília also develops extracurricular research projects, involving problems of public and private organizations from the most diverse branches of activity. Professors, researchers and undergraduate, master's and doctoral students work together as a way of solving these real problems of organizations and to encourage active learning of those involved.

4 Methods

The study consists of exploratory research with qualitative approach developed through a case study (Yin, 2011). It was carried out in the context of a research project in a hospital environment and focused on two phases of the project (planning and execution).

Throughout each of them, it was evaluated the contribution of this academic experience as an active learning approach for the development of the professional practice of the students involved. The advantages and challenges were evaluated, as well as the skills developed, and knowledge acquired. It was done through three stages:

> **STAGE 1) Bibliographic review:** in order to identify research projects used as a form of active learning and establish relationships between research projects and methodologies used in undergraduate disciplines - PBL (Problem and Project Based Learning);

STAGE 2) Collection of the students' opinion (by applying a questionnaire adapted from Reis et al. (2018) with 37 competencies): in order to capture the report of the students involved in the research project regarding the challenges, difficulties and learning provided by the learning experience at each stage;

STAGE 3) Students' perspective analysis: in order to extract information from the students' report and their perception of how the characteristics of the extracurricular academic research project resemble as active learning disciplines.

The bibliographic review (presented in section 2) was performed in Scopus®, Web of Science (WoS®) and ScienceDirect databases. The keywords were used in the following format: ("research project") AND ("skills" OR "competencies") AND (("active learning" OR "active methodology" OR "problem based learning" OR "project based learning" OR "pbl" OR "pjbl")). Initially, duplicate articles were eliminated and then, by reading their abstracts, 25 articles that best fit the context studied were selected.

The collection of the students' opinion was done through a structured questionnaire, released through Google Forms platform between 06/12/2020 to 06/14/2020, with 15 questions (section 4.2) to evaluate learning aspects and experiences lived throughout the extracurricular academic research project.

5 Case Study

5.1 Context

The case study describes an academic research project context which was developed in a public hospital organization. The project consisted of a study and application of Lean Healthcare principles in order to formulate a methodology for improving hospital processes.

The hospital organization faces major challenges, which are essentially related to creating an environment favorable for continuous improvement, working with the correct references of procedures and management and, planning improvement implementation processes.

By this context, the objectives of the research project were outlined in to build the organization's Value Chain, identify and prioritize critical macro processes, build the Value Stream Map for one of the prioritized macro processes and propose action plans and methods for monitoring and continuous improvement.

The construction of the Value Chain enabled the understanding of the hospital's macro processes and provided a holistic view of the Institution. Based on the prioritization of critical macro processes and meetings with the hospital managers, it was decided that the Value Stream Map would be built in the hospital inpatient sector. In an extensive literature review, the VSM was widely mentioned as an important tool used in Lean Healthcare context. The flows of patients, materials and information were mapped for the flow of inpatient sector. In addition, the process lead time was measured, and the inefficiencies related to each waste of time were identified. The VSM showed the main problems faced in the inpatient sector activities, and thus, short, medium and long-term action plans were established. Most of the action plans involved multidisciplinary meetings mediated by the students, where the health professionals involved discussed how they could turn their activities more efficient. Some short-term improvements were implemented, provoking great satisfaction for the professionals involved and for the hospital's managers.

The implementation of the action plans to solve problems were monitored by the project team and the progressive solution to the problems, previously identified, provided improvements to the hospital inpatient processes.

The research project lasted 12 months and was developed through five phases: initiation, planning, execution, monitoring and controlling and closure. Only planning and execution are part of the case study' scope.

The case study was carried out from the questionnaire application to the nine students of the Industrial Engineering program at University of Brasília (seven undergraduate and two master's degree students) under the guidance of three PhD professors, who participated in the research project.

5.2 Student Experience Report

The student experience report sought to list the developed competencies, faced difficulties and challenges throughout the phases of the extracurricular research project; and to evaluate differences between aspects of the research project and the curricular projects developed in the PSP disciplines of the Industrial Engineering program at UNB. An instrument for data collection was elaborated, whose aspects are presented in this item, through the qualitative analysis of the students' responses.

The collected data indicate that all students involved in the extracurricular research project have already taken at least one PSP discipline. In addition, it was identified that 66.7% of these students have already participated in other extracurricular research projects. The competencies developed in each phase of the project (planning and execution) were evaluated and classified into three dimensions: Management, Soft skills and Technical, according to Table 2.

Table 2 shows the result of the descriptive statistics on the students' responses. For each set of competencies (management, soft skills and technical) students pointed out which ones they thought they had developed in the planning and execution phases.

Table 2. List of 37 competencies developed during research project

Management			**Soft Skills**			**Technical**		
	Planning	Execution		Planning	Execution		Planning	Execution
1. Schedule Formulation	44,4%	66,7%	13. Communication	77,8%	88,9%	29. Value Chain elaboration	22,2%	77,8%
2. Scope Definition	44,4%	77,8%	14. Formal Presentation	55,6%	88,9%	30. Multicriteria Analysis	11,1%	55,6%
3. Definition of working subgroups	66,7%	77,8%	15. Building Trust in the Team	77,8%	66,7%	31. VSM elaboration	22,2%	77,8%
4. Stakeholder Identification	77,8%	77,8%	16. Conflict Management	55,6%	66,7%	32. Process Flowchart	22,2%	33,3%
5. Stakeholder Analysis (expectations, power and interest)	77,8%	55,6%	17. Troubleshooting	66,7%	88,9%	33. A3 elaboration	11,1%	55,6%
6. Development of Communication Artefacts	44,4%	66,7%	18. Relationship Building	77,8%	88,9%	34. Graph Theory application	0,0%	22,2%
7. Risk Analysis	44,4%	33,3%	19. Self-Management	77,8%	77,8%	35. Mudge diagram application	22,2%	66,7%
8. Strategic Thought	66,7%	77,8%	20. Self Confidence	66,7%	66,7%	36. Data Analysis	33,3%	77,8%
9. Monitoring and Control of Project Indicators	22,2%	22,2%	21. Collaboration	77,8%	77,8%	37. SIPOC tool application	33,3%	77,8%
10. Monitoring and Control of	44,4%	66,7%	22. Creativity	55,6%	55,6%			
11. Political and Cultural Knowledge	44,4%	33,3%	23. Proactivity	55,6%	77,8%			
12. Result Orientation	55,6%	88,9%	24. Leadership	33,3%	44,4%			
			25. Negotiation	33,3%	66,7%			
			26. Teamwork	77,8%	88,9%			
			27. Ethics and Values	44,4%	33,3%			
			28. Adaptability	66,7%	77,8%			

Regarding management competencies, in the planning phase, with 77.8% of the responses, *Stakeholder Identification* (4) and *Stakeholder Analysis (expectations, power and interest)* (5) were indicated as the main competencies developed by students. In the execution phase, with 88.9% of the responses, *Result Orientation* (12) was indicated. For soft skills, in the planning phase, with 77.8% of the responses, *Communication* (13), *Building Trust in the Team* (15), *Relationship Building* (18), *Self-Management* (19), *Collaboration* (21) and *Teamwork* (26) were indicated as the main competencies developed. In the execution phase, with 88.9% of the responses, *Communication* (13), *Formal Presentation*, *Troubleshooting* (17), *Relationship Building* (18) and *Teamwork* (26) were indicated. Finally, for technical competencies, in the planning phase, it was not observed the development of many competencies since technical competencies are usually developed in the execution phase. On the other side, in the execution phase, it was observed the development of various Lean Healthcare related skills, such as *Value Chain elaboration* (29), *VSM elaboration* (21), *Data Analysis* (36) and *SIPOC tool application* (37), with 77.8% of the responses.

Difficulties and challenges perceived in each phase of the extracurricular project (planning and execution)

For the students, in the planning phase of the research project, they experienced difficulties related to ambiance in the project, as the students only started their activities in the project after the beginning of the partnership with the hospital and did not participate in the phase that preceded the agreement, in which the work plan was elaborated (initiation phase); the engagement of stakeholders, as the importance of the project was not passed from the strategic level of the hospital to the operational one; unavailability of the stakeholders; adaptation to teamwork, due to the fact that the team was getting to know each other; adaptation to the content required by the activities, due to the absence of previous contact with some subjects; difficulty in understanding the deliveries, due to lack of knowledge about the project's scope.

In the execution phase, students experienced challenges related to the following aspects: to approach hospital staff, as many of them had difficulty understanding the purpose of the project; intense schedule of on-site activities; large volume of acquired information; difficulty in mediation between health professionals involved; to associate the application of multidisciplinary tools (SIPOC tool - acronym of Supplier, Input, Process, Output, Customer -, data mining tools, graph theory, multicriteria analysis, among others); to maintain a constant alignment between the team; to maintain communication and alignment between stakeholders; to reconcile expectations and what will actually be delivered; difficulty on scheduling some on-site meetings.

Difficulties and challenges experienced in the extracurricular project and not experienced in curricular project (PSP discipline)

Regarding the difficulties experienced in the extracurricular research project that were not previously experienced, it can be mentioned: changes in scope; to maintain a pace of productivity, as there were many contents; communication and alignment between stakeholders; difficulty in scheduling on-site meetings.

Some students stated that they did not have any additional difficulties because the PGP (Project Management Plan), in PSP disciplines, is always carried out by the student and for execution, they claim that they have experienced the same difficulties.

An important view is that in PSP disciplines, there is not the same charge from customers because if there are no results, there will be no major problems. In the extracurricular research project, there was a contract and the payment of a research grant, so the results needed to be delivered. For some students, the responsibility was immensely greater during the extracurricular project than in curricular projects done in PSP disciplines, as there were deadlines and commitment to the customer. Furthermore, in the extracurricular research project, students feel that they are charged and constantly monitored for the execution of activities.

Evaluation of the difference between the extracurricular research project and the curricular research project (PSP discipline) in the following factors

(i) Schedule

Students consider that the schedule of an extracurricular project is much longer, and can last for years, while projects developed in PSP discipline take place in just 1 semester. Thus, the challenge of making a schedule in an extracurricular project is greater, given the scope's dimension; the time of execution; the need to align with different stakeholders; the better definition and constancy of deliveries.

In addition, some students consider the extracurricular project timeline to be inflexible, but with more execution time, and the schedule is discussed among all of the teamwork.

For students, in projects developed in PSP disciplines, the schedule usually follows a period of one semester, regardless of the complexity of the project's scope, thus they were easier to be followed.

(ii) Quality of deliveries

Students consider the quality of deliveries much higher in the extracurricular research project, when compared to projects of PSP disciplines, because time for planning and execution is much longer in the first case; it is based on a contract with a real customer and the deliveries are better prepared and professional.

For students, in projects on PSP disciplines the quality of deliveries must meet the requirements necessary for the student to be approved and has a study bias.

Other students think that the quality of both must follow a standard of excellence. But in the extracurricular project, charging is higher because it involves a formal schedule and expectations of more people.

(iii) Interaction with stakeholders

For students, the interaction with stakeholders is higher and more organized in the extracurricular research project because the project duration is longer, requiring more meetings, validation and presentation of results, on-site visits, etc.

Students believe that in PSP disciplines, because they are "free of charge" projects, a little less formal, developed in less time, there is less charging from stakeholders and also less interaction, where students go in search of the client.

(iv) Type of performance evaluation

The students' perception of performance evaluation brings interesting aspects. They state that in the extracurricular project performance evaluation suffered a greater impact from stakeholders, since all deliveries were evaluated by them, while in the projects of PSP disciplines many deliveries are only evaluated by teachers. In addition, in PSP disciplines, teachers are rarely evaluated by stakeholders, unlike an extracurricular project where teachers are also evaluated.

For students, the performance evaluation on the extracurricular project came from the client, what made the evaluation more faithful to the job market and the efforts were really perceived by project leaders. Furthermore, the assessment was based on the productivity of each member (individual) and on their own self-assessment, built from their perception of the work done, teammate opinions, criticism, or praise from clients.

In PSP disciplines, students argue that the group is usually evaluated as a whole, and the motivation of the students is around the grade. Moreover, they believe that the PEER evaluation, which happens in some PSP disciplines, does not always reflect the performance of the others. Students do not like to misjudge their "peers", even though they haven't worked. In extracurricular projects it is different, you get a research grant for what you do, and the result ends up being charged in a more formal way.

(v) Training

The number of training in the extracurricular project is considered by the students to be greater than in the PSP disciplines, which in many cases do not even accomplish, there is only guidance. In addition, anchor disciplines do not always address topics of interest in the exact moment the student needs the content. In the extracurricular project, the training is more intense and contributed to the best development of the project, resulting in better quality of deliveries.

(vi) Learning

For some students, the extracurricular project brought many more lessons, due to its duration; to the deepening that must be done on the subjects to accomplish deliveries; to the great number of research and training carried out and to the need to overcome new challenges.

They mentioned that learning in PSP disciplines is based on trial and error, while in the extracurricular project, there was time for students to prepare themselves.

Many agree that both experiences are significant. It is usually through PSP disciplines that students have the first contact with real world problems. In the extracurricular research project, the learning is more intense, the training raises the level of work and can be classified as a level closer to a graduated engineer.

(vii) Preparing for the job market

According to the students, the extracurricular research project provides greater preparation for the market job (without excluding the importance of PSP discipline, mentioned as very positive), a real experience, due to the formal nature of the contract, the experiences lived, through intense interaction with the customer, through the demand for higher quality of delivery, through a schedule that must be strictly adhered to, by the charging of stakeholders.

(viii) Interdisciplinary technical learning aspect

For students, extracurricular and curricular projects (developed in PSP disciplines) drive interdisciplinary technical learning, but PSP disciplines give a lot of technical baggage that applies to the extracurricular research projects.

As already mentioned, students, in the extracurricular project, needed to seek the knowledge to outline the deliverables, experiencing a very large interdisciplinary technical learning, due also to the broad scope of the project where students needed to know a little bit of everything.

Other students reported that in PSP disciplines they need to go in search of all the tools they needed to use, there were no training, which, in some way, develops autonomy.

6 Conclusion

Active learning approaches bring, with different focuses, ways to develop skills in students that go beyond technical knowledge. Engineering education brings the challenge of keeping up with technological developments and preparing students for the job market with the required skills.

This research presents a case study that involves the participation of undergraduate and master students in an extracurricular academic research project, developed in the hospital environment, with a focus on application of Lean Healthcare tools to improve the studied processes. As an active learning experience, we sought to report learning and to identify transversal skills developed in this learning context and compare it with what was experienced in the disciplines called PSP, which involve active learning during students' graduation.

As a result of the students' reports, a complementary relationship was observed between the experiences reported in PSP disciplines and extracurricular projects, as if the PSP disciplines were an initial step and the extracurricular projects configured an experience closer to the real world.

Students reported a lot of learning in PSP disciplines, teamwork, short schedules, narrower scope, less interaction with external agents (customers) and greater flexibility regarding deliveries. For the extracurricular project, they reported more experience with the customers; the realization of training; broader scope; longer schedule, but not very flexible; more rigorous evaluations, but self-assessment seems a natural process; more charging and more challenges.

The skills developed in each phase were evaluated and classified into three dimensions: Management, Soft skills and Technical. First, while the main competencies developed during the planning phase were related to stakeholder identification and analysis, the execution phase showed that the main competence developed was result orientation. Second, it was observed the development of the same competencies in both phases, such as communication, relationship building and teamwork, although during the planning phase, students related the development of building trust in the team, collaboration and self-management skills. Also, during the execution phase, students related the development of formal presentation and troubleshooting skills. Finally, it was observed that most of the competencies were developed in the execution phase, considering that it requires more in-depth technical knowledge.

In fact, extracurricular research projects are a form of active methodology which comes closer to what the student will face after graduation, with similar challenges to the real professional practice. Also, for master's students, learning was perceived, and transversal skills were developed that could boost their careers.

7 References

Althoff, L. S., Silva, C. M., Milhomem, P. M., & Reis, A. C. B. (2019). Exploring Active Learning Resources for Team Training in a Multidisciplinary Research Project.

Adams, J., Kaczmarczyk, S., Picton, P., & Demian, P. (2010). Problem solving and creativity in engineering: conclusions of a three-year project involving reusable learning objects and robots. engineering education, 5(2), 4-17.

Andersson, K. (2015). Evaluation of a model-based learning approach for engineering design. In *ASME 2015 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference*. American Society of Mechanical Engineers Digital Collection.

Baluarte-Araya, C. (2019). Project based Learning Application Experience in Engineering Courses: Database Case in the Professional Career of Systems Engineering. International Journal of Advanced Computer Science and Applications 11.

Barbalho, S. C. M., Reis, A. C. B., Bitencourt, J. A., Leão, M. C. L. D. A., & Silva, G. L. D. (2017). A Project Based Learning approach for Production Planning and Control: analysis of 45 projects developed by students. Production, 27(SPE).

Bessa, B. R., Santos, S., & Duarte, B. J. (2019). Toward effectiveness and authenticity in PBL: A proposal based on a virtual learning environment in computing education. Computer Applications in Engineering Education, 27(2), 452-471.

Carvalho, A. (2016). The impact of PBL on transferable skills development in management education. Innovations in Education and Teaching International, 53(1), 35-47.

Du, X., Su, L., & Liu, J. (2013). Developing sustainability curricula using the PBL method in a Chinese context. Journal of Cleaner Production, 61, 80-88.

Elahi, B. (2019) Implementation of a Project-Based Learning Approach: Case study of "Measurement and Evaluation Techniques in Industrial Engineering" Course.

Fernandes, F. A., Fuchter Júnior, N., Daleffe, A., Fritzen, D., & Alves de Sousa, R. J. (2020). Integrating CAD/CAE/CAM in Engineering Curricula: A Project-Based Learning Approach. Education Sciences, 10(5), 125.

Fox, M., Blake, D., & Jacobs, D. (2018). Veterinary parasitology teaching at London–Meeting the 'Day-One Competency'needs of new veterinarians. Veterinary parasitology, 254, 131-134.

Jacques, S., Bissey, S., & Martin, A. (2016). Multidisciplinary Project Based Learning Within a Collaborative Framework: A Case Study on Urban Drone Conception. International Journal of Emerging Technologies in Learning (iJET), 11(12), 36-44.

Kaur, B. (2010). Towards Excellence in Mathematics Education–Singapore's Experience. Procedia-Social and Behavioral Sciences, 8, 28-34.

Kogtikov, N., Dukhanov, A., & Bochenina, K. (2016). Modeling knowledge transfer and the transdisciplinary effect on project-based learning activities. Procedia Computer Science, 80, 1989-1999.

Kovač, P., & Stare, J. (2015). Challenges of the administrative consultation wiki research project as a learning and competences development method for MPA students. Teaching Public Administration, 33(3), 273-291.

Králová A., & Novák J. (2014). Teoretické aspekty racionalizace ekonomického vzdělávání. (Theoretical Aspects of Economic Rationalization Education). Praha, Press 21. 2014. p. 534. ISBN 978-80-905181-5-5. (In Czech and Slovak)

Krelová, K., Krpálek, P., & Kolarová, D. (2015). Developing entrepreneurial skills using project teaching. In Rural Environment. Education. Personality. (REEP). Proceedings of the International Scientific Conference (Latvia). Latvia University of Agriculture.

Letouze, P., de Souza, J. I. M., & Da Silva, V. M. (2016, April). Generating software engineers by developing web systems: a project-based learning case study. In 2016 IEEE 29th International Conference on Software Engineering Education and Training (CSEET) (pp. 194-203). IEEE.

Lozano Albalate, M. T., & Trillo Lado, R. (2015). From a research project to an Information System course: a professional approach. In 1ST INTERNATIONAL CONFERENCE ON HIGHER EDUCATION ADVANCES (HEAD'15) (pp. 83-89). Editorial Universitat Politècnica de València.

Mena, I. B., Schmitz, S., & McLaughlin, D. (2015). An Evaluation of a Course That Introduces Undergraduate Students to Authentic Aerospace Engineering Research. Advances in Engineering Education, 4(4), n4.

Monteiro, S. B. S., Reis, A. C. B., Silva, J. M. D., & Souza, J. C. F. (2017). A Project-based Learning curricular approach in a Production Engineering Program. *Production*, *27*(SPE).

Murray, V., Matsuno, C., Montes, H., & Bejarano, A. (2015). Proceedings from research as a new learning outcome in undergrad engineering programs. In 2015 IEEE 7th International Conference on Engineering Education (ICEED). IEEE.

Natsis, A., Papadopoulos, P., & Obwegeser, N. (2018). Research Integration in Information Systems Education: Students' Perceptions on Learning Strategies, Skill Development, and Performance. Journal of Information Technology Education: Research, 17(1), 345-363.

Projektové vyučování. Metodická příručka. (2011). (Project-based learning. A Guidebook). Channel Crossing s.r.o. [online] [14.06.2020]. Available at http://www.kurzyproucitele.cz/downloads/metodiky/Metodika_4_ProjektoveVyucovani.pdf

Reis, A. C. B., Barbalho, S. C. M., & Zanette, A. C. D. (2017). A bibliometric and classification study of Project-based Learning in Engineering Education. *Production*, *27*(SPE).

Reis, A. C. B., Barbalho, S. C. M., de Araújo, F. L., Brito, L. S., Ishihara, S. E. M. P., & Teixeira, V. P. F. (2018). Project-Based Learning: development of PBL-based competencies under the pupil's perspective. In *10th International Symposium Project Approaches in Engineering Education (PAEE)*.

Reis, A. C. B., Mariano, A. M., Silva, J. M., Amoras, R. C., & Moysés, D. D. A. (2019). Proposal of a collaborative interaction in an engineering discipline with an active approach based on problems and projects.

Shekhar, P., Prince, M., Finelli, C., Demonbrun, M., & Waters, C. (2019). Integrating quantitative and qualitative research methods to examine student resistance to active learning. European Journal of Engineering Education, 44(1-2), 6-18.

Thomas, I., & Depasquale, J. (2016). Connecting curriculum, capabilities and careers. International Journal of Sustainability in Higher Education.

Yasin, R. M., Rahman, S., & Ahmad, A. R. (2012). Framework for reflective learning using portfolios in pre-service teacher training. *Procedia-Social and Behavioral Sciences*, *46*, 3837-3841.

Yin, R. K. (2011). *Applications of case study research*. sage.

A Gap Analysis between the Expectation of Industry 4.0 and the Ability of the Current Industrial Engineering Graduates in Khon Kaen University

Sirorat Pattanapairoj[1], Thitipong Jamrus[1], Rujapa Nanthapodej[2], Kanchana Sethanan[1]

[1] Department of Industrial Engineering, Khon Kaen University, Khon Kaen, Thailand.
[2] Department of Industrial Engineering, Nakhon Phanom University, Nakhon Phanom, Thailand.

Email: siropa@kku.ac.th, thitja@kku.ac.th, nanruja@npu.ac.th, skanch@kku.ac.th

Abstract

Thailand has entered Industry 4.0 era, which is the recent trend in automation and data exchange in organization. The digital transformation of manufacturing processes based on intelligent machines and devices is crucial in manufacturing industries. To be an effective industry 4.0, it requires cooperation between various sectors and higher education sector is one of those. For engineering department, especially Industrial Engineering, the curriculum must be improved to conform the industrial sector requirements. Therefore, the purpose of this research is to find a gap between the qualifications of graduate students that the industry needs and the abilities of the current graduate students from Industrial engineering, Khon Kaen University. Gap analysis was used to determine the skills that the graduate students need to improve. The result shows that the current graduate students still need to improve in the skills of systematic thinking and understanding of processes related to Industry 4.0, automation technology and the big data analysis.

Keywords: Industrial Engineering Curriculum; Gap Analysis; Industry 4.0.

1 Introduction

Industry 4.0 refers to a new phase in the industrial revolution that focuses on big data, automation, machine learning, and real-time data. It also referred as internet of things (IoT) or smart manufacturing, marries physical production and operations with smart digital technology, machine learning, and big data to create a more holistic and better connected ecosystem for companies that focus on manufacturing and supply chain management. Thailand 4.0 economic model was launched by the government in May 2016. This policy is expected to complement the 12th National Economic and Social Development Plan, for 2017-2021, and support the government's new 20-year National Strategy. Thai government had set out three objectives for the Thailand 4.0 strategy: to elevate Thailand to the high-income nation status; to reduce inequality; and to promote environmentally sustainable growth and development (Wittayasin, 2017). Thailand 4.0 has the potential to leads many Thai businesses into the digital age. While several Thai organizations are already on their way to digital transformation, the challenge will be shifting the entire economic focus of the nation together with its people towards the full potential of the digital world.

To be an effective industry 4.0, it requires cooperation between various sectors, and higher industrial engineering education sector is one of those. Industrial engineers use principles of engineering, mass production and technology to help companies find the ways to offer service or create a product efficiently. This requires knowledge of economics, workplace safety standards and industrial practices (Kádárová, Kováč, Durkáčová, & Kádár, 2014) and the industrial engineer, who obtained higher-level degree, plays a decisive role as transmitter or introducer of progress. The balanced combination of a solid scientific and technical education, different applied technologies and disciplines within the economic-business and social-humanistic areas, the understanding that comes from the reality of the industrial sector and the ability to interrelate various disciplines involved in complex systems, makes these studies a current and innovative model. Industry 4.0 took up a pioneering role in industrial IT, which is currently revolutionizing the manufacturing engineering (Coşkun, Kayıkcı, and Gençay, 2019). Many industrialized countries had already adapted their industrial infrastructure to meet the requirements of the Industry 4.0 vision. An important task in the preparation for Industry 4.0 is the adaption of the higher education, in particular the industrial engineering education, to fulfil the requirements of this vision. The Industry 4.0 concepts are implemented with a content of curricula into existing courses and new study modules are designed for the engineering education.

Khon Kaen University (KKU) is a public research university in Thailand. It is the first university established in north-eastern region of Thailand and remains the oldest and largest university in the region up to this day. The university is a hub of education for north-eastern Thailand and widely recognized in Asia. The Industrial Engineering (IE) department of KKU focuses on equipping the students with knowledge, process and technology involving the industrial engineering occupations. The course offers the content of manufacturing engineering and the engineering management. The computer-aided system such as CAD, CAM and CIM are emphasized. Ideas on design and production tools are also scrutinized. However, the industrial engineering curriculum must be improved to conform the industrial sector requirements. Thus, the purpose of this research is finding a gap between the qualifications of graduate student that the industry needs and the ability of the current graduate student from Industrial Engineering department of Khon Kaen University (refer as graduate IEKKU students). We use the gap analysis to determine the skills that the graduate IEKKU students need to improve.

2 Literature reviews

In this section, a brief literature review on the influence of Industry 4.0 on higher education and gap analysis applications are provided.

There are several previous studies on the relevant of industry 4.0 and higher education institute. The importance of industry 4.0 in education had demonstrated with statistical data by Baygin et al. (2016), the data confirmed that it is necessary to train and prepare the qualified employees for the company. The rise of digital technology makes disruptive innovation, which is a huge change in industrial world. Alternative communication completely transforms the working platform and industrial production. New skills, new learning and training concepts, up-to-date and flexibility curriculum are necessary in educational system. Industry 4.0 readiness in education sector needs a strong partnership between industry and academic for human resources improvement (Ciolacu et al., 2017). Azmi et al. (2018) studied the non-technical skills required by employers in Industry 4.0 based on previous researches by using meta-analysis technique as well as interviewing employers to clarify the meta-analysis results. The results revealed that communication skills especially in English language, teamwork skills, critical thinking skills, problem-solving skills, entrepreneur skills and computer skills are essential. Higher education institution should train their students with plenty interdisciplinary teaching, research, innovation, and valuable industrial training to reach current industries' needs. Given the rise of changes in industry requirements, the education system now focused on training their students as the Engineer of Future. Aleyeva et al. (2020) applied qualitative data analysis and showed the need of soft skills development for the engineering education under the influence of the Industry 4.0 as follows: (i) IT skills, which is the role of ownership of information technologies (ii) Working with information skills, which comprises searching for information, assessing the quality and reliability of information sources, as well as the ability to effectively use the information received and share it (iii) Teamwork skills, which is the role of an interdisciplinary approach to problem solving, which refers to the possession of professional interaction and teamwork skills (iv) Flexibility, adaptability and learning. The high speed of transformations will lead to the need to retrain and change the profession, which implies that the role of self-development skills increases based on the principles of lifelong learning (v) Cognitive skills. The development of the above skills is impossible without the development of the cognitive sphere, including reflection, meta cognition and critical thinking.

Higher education institutions are now more interested in the decision-making tools development that enable them to evaluate the industry expectations and perceptions of engineering graduates' skill with the purpose of attracting and keeping them satisfied. Ramadi et al. (2016) applied gap analysis to explore the gaps between industry expectations and perceptions of engineering graduates' skill sets in the Middle East and North Africa (MENA) region. Importance and satisfaction levels were used to calculate skill gaps for each skill. Results revealed the skills that graduates needed most improvement were communication, time management, and continuous learning. Pimentel et al. (2016) demonstrated a gap analysis amongst employers and engineering against non-engineering students to identify the main gaps between competencies provided by the traditional education system and the missing competencies valued by the labour market. Results showed that the employers expect higher level of personal competencies than the level that students thought they have. Furthermore, Patacsil and Tablatin (2017) presented the skills gap methodology that utilized the respondent experiences in the internship program to measure the importance of the Information Technology (IT) skills gap as perceived by IT students and the industry. The questionnaires were formulated, modified, validated and tested. Respondents of the study were the IT students enrolled in internship while industry partner respondents were the internship supervisors of the IT students. In this case the internship IT students were chosen because of they have a strong background on the company requirements based on their experience which confirm that teamwork and communication skills are highly crucial soft skills. However, there was a big range of conflict on the hard skills since IT students understood that hard skills were very important while industry understood that hard skills were somehow important. Thus, education institute should promote the soft skills and hard skills component into the curriculum. There are widely successful studies implementing gap analysis tool to find the gap skills amongst expectations of industry and higher education students' potential under Industry 4.0 era.

3 Methodology

This study is a quantitative research and questionnaire-based survey in finding the gap between the qualifications of graduate student that the industry needs and the ability of current graduate IEKKU students.

3.1 Population and Samples

This research collected the data from two population groups and analyzed the gap between the data from those two groups. The first population group was the top 100 industrial factories in Thailand that hired the graduated IEKKU students. The sample size of the first group was equal to 50, calculated from Yamane formula with 90 percent confidence interval. The stratified random sampling methods was used to find the sampling proportion of factories located in each region of Thailand as follows: central region 19 factories, North region 8 factories, Northeastern Region 9 factories, East Region 7 factories, South region 5 factories and West region 2, totaling 50 factories. The second population group was the graduate students who are currently study in Industrial Engineering, KKU. The sample size of this group was 45 since there were 80 graduate students at the research period.

3.2 Data Collection and the Interpretation of Data

This research used a questionnaire for data collection. The questionnaire details for the factories were about the expectation skills of the graduate student from the Industrial engineering under Thailand Industry 4.0 policy. The questionnaire details for the students, who were currently study at Industrial engineering, KKU, were about their current ability in each skill.

There are 10 skills considered in this research as shown in the Table 1.

Table 1. The considered skills of the graduate student from the Industrial engineering under Thailand Industry 4.0 policy

No.	Skills
1	have a systematic thinking and understanding of processes related to Industry 4.0
2	have knowledge of research and development to operate in accordance with the framework of Industry 4.0
3	be able to implement the Industry 4.0 strategy in the operations
4	capable of automation technology related to Industry 4.0
5	be able to analyze big data and evaluate data in real time
6	be able to use cloud technologies as scalable IT
7	be able to apply mobile end devices for in the operations to Industry 4.0
8	have knowledge in smart logistics to operate in the framework of Industry 4.0
9	have knowledge in sensor or relevant equipment for practice in the framework of Industry 4.0
10	have knowledge of smart service to operate in the framework of Industry 4.0

The respondents from both groups could answer the question by rating a score of 1-5 for each question, where 1 means the lowest level and 5 means the highest level. The range of the answers is equal to 5 - 1 or equal 4, and the distance of the criteria used to define the perceived level score range at each level is 4/5 or 0.80. Therefore, the average score range for data level interpretation can be specified as follows:

The lowest level has average score collected from the questionnaire between 1.00 - 1.80. Between 1.81 - 2.60 for low level, between 2.61 - 3.40 for middle level, between 3.41 - 4.20, for a high level, and between 4.21 - 5.00 for the highest level.

Then, the gap analysis can be done by considering the difference between the average scores from the first sample group and the second sample group.

4 Results

4.1 Quantitative Survey Result

The 50 factories or employers were asked to rate the expectation skills of graduate students from Industrial Engineering under Thailand Industry 4.0 policy according to each skill aspect via 10 questions. The 45 graduate IEKKU students were asked to rate their ability using the same 10 questions. The average scores of each skill from both sample groups were shown in Table 2.

Table 2. The average scores from the factories and current students of Industrial Engineering, Khon Kaen University.

No.	Skills	Factories		Students	
		Avg. Score	Level	Avg. Score	Level
1	have a systematic thinking and understanding of processes related to Industry 4.0	4.31	highest	3.98	high
2	have knowledge of research and development to operate in accordance with the framework of Industry 4.0	4.18	high	4.02	high
3	be able to implement the Industry 4.0 strategy in the operations	4.16	high	4.04	high
4	capable of automation technology related to Industry 4.0	4.42	highest	4.02	high
5	be able to analyze big data and evaluate data in real time	4.36	highest	3.89	high
6	be able to use cloud technologies as scalable IT	4.02	high	3.82	high
7	be able to apply mobile end devices for in the operations to Industry 4.0	3.96	high	3.78	high
8	have knowledge in smart logistics to operate in the framework of Industry 4.0	4.20	highest	4.24	high
9	have knowledge in sensor or relevant equipment for practice in the framework of Industry 4.0	4.11	high	3.96	high
10	have knowledge of smart service to operate in the framework of Industry 4.0	4.02	high	3.87	high

The results from Table 2. show that the factories or employers expect students to have all skills at least in the range of high level or above. The highest-level skills are the Industry 4.0 related automation technology, big data analyzing and real time data evaluation, having a systematic thinking and understanding of processes related to Industry 4.0.

4.2 Gap Analysis

The difference among the average scores from the factories and the students is shown in the last column of Table 3.

Table 3. the difference between the average scores of the factories' expectations and the current abilities of Industrial Engineering students, Khon Kaen University.

No.	Skills	Factories	Student	Diff
1	have a systematic thinking and understanding of processes related to Industry 4.0	4.31	3.98	0.33
2	have knowledge of research and development to operate in accordance with the framework of Industry 4.0	4.18	4.02	0.16
3	be able to implement the Industry 4.0 strategy in the operations	4.16	4.04	0.12
4	capable of automation technology related to Industry 4.0	4.42	4.02	0.40
5	be able to analyze big data and evaluate data in real time	4.36	3.89	0.47
6	be able to use cloud technologies as scalable IT	4.02	3.82	0.20
7	be able to apply mobile end devices for in the operations to Industry 4.0	3.96	3.78	0.18
8	have knowledge in smart logistics to operate in the framework of Industry 4.0	4.20	4.24	-0.04
9	have knowledge in sensor or relevant equipment for practice in the framework of Industry 4.0	4.11	3.96	0.15
10	have knowledge of smart service to operate in the framework of Industry 4.0	4.02	3.87	0.15

The results show that the most different average scores are the skill of being able to analyze big data and evaluate data in real time. Having a systematic thinking and understanding of processes related to Industry 4.0 was the second and the third different average scores was capability of automation technology related to Industry 4.0. The line graph of the average scores from factories and students were shown in Figure 1.

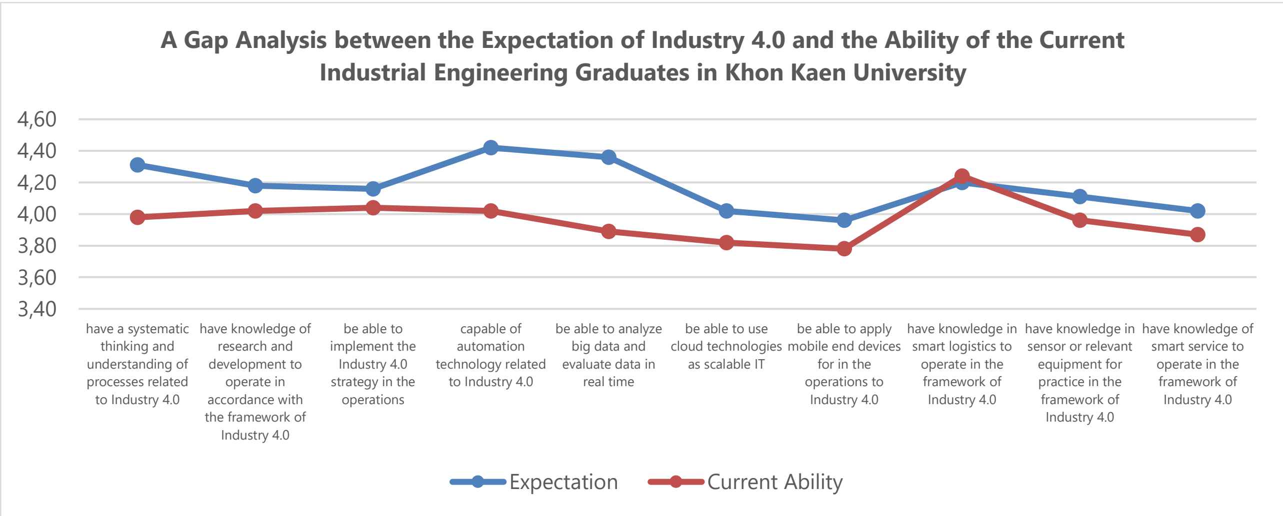


Figure 1. Image of a gap between expectation of Industry 4.0 and the abilities of the current Industrial Engineering Graduates in Khon Kaen University.

It can be seen that the graduate IEKKU students still need to improve the skills in term of systematic thinking and understanding of processes related to Industry 4.0, automation technology and the big data analysis.

5 Conclusion and Discussion

Many industrialized countries already started to adapt their industrial infrastructure to meet the requirements of the Industry 4.0 vision. It is an important task for the higher education sector to adapt and fulfil the requirements of the Industry 4.0 concepts. The gap between the qualifications of current graduate students and the industry needs is highly important issue for industrial engineering program. Therefore, the aim of this research is to find a gap between the qualifications of graduate students that the industry needs and the ability of the current graduate IEKKU students. By using the same set of question, factories and graduate students were asked to rate the expectation and current skills. The Gap analysis results show that there are three skills which have the highest gap as follows: 1) a systematic thinking 2) automation technology and 3) big data analysis and real-time data evaluation.

From the industry 4.0 vision, graduate student is expected to be the researcher who can analyse big data and use that data to improve the industry further. However, from the Gap analysis results, the research and development skill considered to be only a high-level skill, due to Thailand industry environment that does not support researching and still depend on foreign technology.

In future studies, we aim to conduct a large-scale analysis which include both undergraduate and graduate students.

6 References

Aleyeva N.S., Kupriyanov R.V., Valeeva E., Kraysman N.V. (2020) Influence of the Fourth Industrial Revolution (Industry 4.0) on the System of the Engineering Education. In: Auer M., Hortsch H., Sethakul P. (eds) The Impact of the 4th Industrial Revolution on Engineering Education. ICL 2019. *Advances in Intelligent Systems and Computing*, vol 1135. Springer, Cham

Azmi, A., Kamin, Y., Noordin, M., & Nasir, A. (2018). Towards Industrial Revolution 4.0: Employers' Expectations on Fresh Engineering Graduates. *International Journal of Engineering & Technology*, 7(4.28), 267-272. doi:http://dx.doi.org/10.14419/ijet.v7i4.28.22593

Baygin, M., Yetis, H., Karaköse, M., & Akin, E. (2016). An effect analysis of industry 4.0 to higher education. *2016 15th International Conference on Information Technology Based Higher Education and Training (ITHET)*, 1-4.

Ciolacu, M., Svasta, P., Berg, W., & Popp, H. (2017). Education 4.0 for tall thin engineer in a data driven society. *2017 IEEE 23rd International Symposium for Design and Technology in Electronic Packaging (SIITME)*, 432-437.

Coşkun, S., Kayıkcı, Y., & Gençay, E. (2019). Adapting engineering education to industry 4.0 vision. *Technologies*, 7(1), 10.

Kádárová, J., Kováč, J., Durkáčová, M., & Kádár, G. (2014). Education in Industrial Engineering in Slovakia. *Procedia-Social and Behavioral Sciences*, 143, 157-162.

Patacsil, F. F., & Tablatin, C. L. S. (2017). Exploring the importance of soft and hard skills as perceived by IT internship students and industry: A gap analysis. *Journal of Technology and Science Education*, 7(3), 347-368.

Pimentel, C., Silva, H., Ferreira Dias, M., & Amorim, M. (2016). Transversal entrepreneurial competencies for youth employability: A GAP analysis. *Proceedings of Business Sustainability*, Póvoa de Varzim, Portugal, 2100.

Ramadi, E., Ramadi, S., & Nasr, K. (2016). Engineering graduates' skill sets in the MENA region: a gap analysis of industry expectations and satisfaction. *European Journal of Engineering Education*, 41(1), 34-52.

Wittayasin, S. (2017). Education challenges to Thailand 4.0. *International Journal of Integrated Education and Development*, 2(2), 29-35.

Experiential learning through students non-profit organizations: ESTIEM case study

Duarte Oliveira[1], Maria Serodio[1], Carina Pimentel[2], Anabela C. Alves[3]

[1] ESTIEM, Groene Loper 3, 5612 AE, Eindhoven
[2] GOVCOPP, DEGEIT, University of Aveiro and UNIDEMI, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, 3810-193, Aveiro, Portugal
[3] ALGORITMI R&D Center, Department of Production and Systems, School of Engineering, University of Minho, 4800-058 Guimarães, Portugal

Email: Duarte.Oliveira@estiem.org; maria.serodio@estiem.org; carina.pimentel@ua.pt; anabela@dps.uminho.pt

Abstract

European Students of Industrial Engineering and Management (ESTIEM) is a non-profit organization of Industrial Engineering and Management (IEM) students that was founded in 1990 to support common activities and relations across Europe. Through it, students engage in activities that promote a combination of technological understanding with management skills. Belonging to this type of organization during their graduation time, gives students a plethora of competences that are learned beyond the classes, outside the university walls. These competences are acquired through experiential learning. The objective of this paper is to present ESTIEM creation, evolution and organization. Also, projects participation, events organization and meetings organized are presented as outcomes of ESTIEM students' engagement. This paper intends also to explore how the participation on this type of organization allows students to develop competences and contribute to the IEM student's education. Following the key competencies for lifelong learning recommended by the Council of European Union, some examples of key competences acquired from the experience of the authors are given. Results showed that being member of ESTIEM allows them to develop such competences and they felt better prepared for the labour market.

Keywords: Engineering education, experiential learning, Industrial Engineering and Management, non-profit organizations.

1 Introduction

Experiential learning is founded in many authors contributions from different sources (Kolb, 1984), namely, Dewey ideas of democratic education (Dewey, 1938), action research theory (Lewin, 1946) and Piaget (1973). Both are based on the learning from experience or "learning by doing" concept that advocates learning resulting naturally from doing. By doing, students learn because it demands engagement in significant situations where he/she generates, supports, and clinches ideas, perceiving the meanings and make connections. Experiential learning is an instructional approach in which students learn through direct experience (either spontaneous or designed and organized by the teacher) and reflection (McComas, 2014). Thus, experiential education first immerses learners in an experience and then encourages reflection about the experience to develop new skills, new attitudes, or new ways of thinking (Lewis & Williams, 1994). Itin (1999) adds that in experiential education, carefully chosen experiences supported by reflection, critical analysis, and synthesis, are structured to require the learner to take initiative, make decisions, and be accountable for the results, through actively posing questions, investigating, experimenting, being curious, solving problems, assuming responsibility, being creative, constructing meaning, and integrating previously developed knowledge. Most of the time, the students are autonomous and independent to learn by their own terms and rhythm.

These situations could be promoted in academia by active learning methodologies (Felder & Brent, 2006; Prince, 2004) and/or promoted by non-formal education environments such as student non-profit organizations or unions. In these students' unions, students develop a range of functions for their members such as organization of events; social and training activities; support of academic and welfare issues; students representation on local and national issues, among others (Brooks et al., 2015).

This is the kind of activities that Industrial Engineering and Management (IEM) students, members of European Students of Industrial Engineering and Management (ESTIEM), develop by being members of this organization. This paper is about this participation and how these students learn in this non-formal context through experiential and independent learning.

By developing such type of activities, students acquire key competencies related to the development of essential interpersonal, communicative and cognitive skills (ability and capacity to carry out processes and use the existing knowledge to achieve results) such as: critical thinking, analytical skills, creativity, problem solving and resilience (Council of the European Union, 2018). These skills are embed in the key competences that are listed by Council of the European Union (2018) as: 1) Literacy; 2) Multilingual; 3) Mathematical, science, technology and engineering; 4) Digital; 5) Personal, social and learning to learn; 6) Citizenship; 7) Entrepreneurship and; 8) Cultural awareness and expression (2018, p. 15). Beyond the skills, competencies implies knowledge (facts and figures, concepts, ideas and theories which are already established and support the understanding of a certain area or subject) and attitudes (disposition and mind-sets to act or react to ideas, persons or situations) (Council of the European Union, 2018; Rychen & Salganik, 2000). These facilitate the transition to adulthood, active citizenship and working life, establishing better cooperation between different learning settings and promoting a variety of learning approaches and contexts(Council of the European Union, 2018).

This paper is organized in five sections. After this first introduction, a brief theoretical background approaching the students' union contribution to independent learning and competencies development will be presented. The third section gives an overview of the ESTIEM creation and evolution and main projects, events and training sessions organized by ESTIEM. The fourth section presents the ESTIEM activities contribution to the key life-long learning competencies, as recommended by the Council of the European Union (Council of the European Union, 2018), development in ESTIEM members. Last section draw some final considerations.

2 Students' unions contribution to independent learning and competencies development

Independent learning, or similar terms such as autonomous learning, self-directed learning, student-centred learning, self-regulated learning, self-instruction has been defended and promoted as an important educational goal (Bolhuis & Voeten, 2001; Leathwood, 2006; Meyer, 2010), helping to promote autonomous, and thus lifelong learners (Lau, 2017). Grounded in the literature, Hockings et al. (2018) describe independent learning as:

- Taking responsibility for one's own learning;
- Choosing and setting one's own objectives;
- Deciding what, as well as, when and how to learn;
- Monitoring one's own progress;
- Developing an ability for inquiry and critical evaluation;
- Evaluating and reflecting on what has been learnt;
- Within the context of programme of study, facilitated by an academic.

According to Broad (2006) independent learning aims to teach students to learn for themselves and in turn empower them in their learning whatever the context. No matter the individual definition, the overall consensus appears to be responsibility or ownership of learning on the part of the learner (Mckendry & Boyd, 2012). According to Meyer (2010) the models of independent learning build on the theoretical notion of learning styles such as experiential learning of Kolb (1984). Kolb (1984) proposes a learning model formed by four related stages, where learning starts from a "concrete experience", that passing through a phase of "observation and reflexive processing" allow to assimilate a new set of "abstract concepts and generalizations". This together with an "active experimentation" allow to apply what each one have learned for future experiences.

Independent learning can be promoted through formal curricula in a teacher-student relationship (Itin, 1999; Meyer, 2010; Hockings et al., 2018). Nevertheless, the shift of responsibility for the learning process from the teacher to the student can also be achieved through students autonomous learning (Itin, 1999; Thomas, Jones, & Ottoway, 2015), namely, through the participation in students unions.

Astin (1999) defines a students' organization as an organization run by college students where student growth and development influenced by peer-groups. Vieira (2019) adds that student unions are a group of students enrolled in higher education who come together with the goal of developing activities that enrich the academic experience of the college in which they operate. Moreover, Holzweiss et al. (2007) emphasize that through students unions students can get personal benefits directed towards their goals, such as gains in field knowledge, providing them the opportunity to learn and broaden their awareness of their specific academic discipline or interest (Fakharzadeh & Todd, 2010). Participation in student unions can also be a useful indicator of leadership training, communication skills, and personal qualities (Fakharzadeh & Todd, 2010), and research suggests that social networks made through clubs and societies can help graduates find jobs and progress in their careers (Andrewartha & Harvey, 2017).

Since always that the main students' involvement in higher education has been related to their work in forming higher education communities through student representation (Ashwin & McVitty, 2015). Student unions are responsible for representing the interests of students, communicating student views to university management, and providing extra-curricular opportunities through clubs and societies, thus representing students and advocating for their rights and interests (Andrewartha & Harvey, 2017).

Students' unions have a long history and tradition in Higher Education. In Portugal, the oldest students' union dates back 1887 and was established at University of Coimbra (Fernandes, Cunha, Torres, 2020). Nowadays, in every Higher Education Institution (HEI) several broad and specific students' unions coexist. Despite that fact, the role of students' unions seems to have remained largely unexplored within academic research (Brooks et al., 2015).

More and more, besides representing students and advocating their rights and interests, students unions are helping to ensure that students receive the best possible experience during their time in higher education, provide several services in the interest of students (Brooks et al., 2015; Guan et al., 2016), develop projects in institutions, identify experienced student representatives for project work or carry out reviews of learning processes at the institutional or faculty level (Attard et al., 2010). In this way students are exposed to several experiences that promote independent learning.

In a recent study, through a survey research, Vieira (2019) concluded that the set of competences that students most develop during their involvement in students organizations are those related to the ability to work in different teams, to communicate with others and also to the leadership capacity, being developed mainly through activities such as the organization of events, participation in multidisciplinary teams and team management. Furthermore, the same author could also conclude that student organizations are felt as an alternative means for the development of skills required by the labour market.

In another recent study, Haines (2019) adds that students consider that being involved with student organizations allow them to apply what they learn academically to "real-world" settings and allow them to develop skills that prepare them for future success. Furthermore, for the students that were involved in her study, where focus group interview was used as research instrument, student organizations serve as a gateway to developing one's leadership skills because holding a leadership role within a student organization provide them opportunities for acquiring, developing, and practicing specific skills. All the referred skills are embed in the key competencies lifelong learning recommended by (Council of the European Union, 2018), referred in the introduction section.

3 ESTIEM context and organization

This section briefly presents the ESTIEM origins, context and organization, highlighting the most important events since the creation to the current projects and events.

3.1 Creation and evolution

European Students of Industrial Engineering and Management (ESTIEM), started in 1990, with its first Council Meeting being in Berlin, where the first statues were signed by the 14 Universities at the time. The first big project of ESTIEM internationally was the big travel that was organized to Japan in 1993, where many ESTIEMers went to Japan to discover new trends in Total Quality Management and made a report out of it to present to their friends once back to Europe. Besides, many other initiatives where developed, like the first edition of the official ESTIEM Magazine (1991) and the appearance of the flagship Case Study Competition Europeanly in 1994, Tournament in Management and Engineering Skills (TIMES) a competition that remains, until today, as one of the biggest in any NGO Europeanly.

On a more intermediate stage of its history, ESTIEM started in 2005 to have its first Summer Academic Events, something that opened ESTIEM to the sector of personal development of its students, where in the time-span of 2 weeks, students were guided by a professor in a topic of self-reflection and self-leadership to define long-term goals for their lives. Thus, following, ESTIEM started to have, in 2009 and 2010, Braintrainer and Academic Days, respectively, being the first project focused in soft-skills and the latter in research and hard-skills knowledge that the Universities could offer the best. Also, during these times, in 2009, ESTIEM started its ESTIEM Student Guide Project, a project that consisted of creating a massive compilation of knowledge about the curriculum and Universities of ESTIEM and put it displayed on the ESTIEM portal.

As for bigger external relations and in the field of Education as well, ESTIEM started its journey in 2010, with the establishment of the position of Vice-President of Education. Since then, ESTIEM had many great opportunities at a large scale that shows its own development. Here, ESTIEM developed, for three straight years, from 2015-2017, EMTA (European Master Thesis Award), a European Competition of Master Thesis that students of IEM could apply for. Moreover, ESTIEM developed great relationships with many partners like *Société Européenne pour la Formation des Ingénieurs* (SEFI), PREFER Project, European Institute of Industrial Leadership (EIIL) and European Professor of Industrial Engineering and Management (EPIEM), that allowed it to develop research tools that are now allowing ESTIEM to become a great platform for professionals to get valuable information on the Industrial Engineering and Management field (IEM). On an event based performance, ESTIEM developed in 2016 and 2017 the IEM Education Forum, an event that had the purpose of getting together professors, students and companies to improve the current state of the curricula of IEM in Europe and the Industry proximity to the IEM curricula. ESTIEM in 2018, also started partnering with Inchainge, a Dutch company that develops an education simulator about Supply Chain and, thus, ESTIEM uses it for a competition on Supply Chain Management. In Figure 1 a summary of the association history is presented.

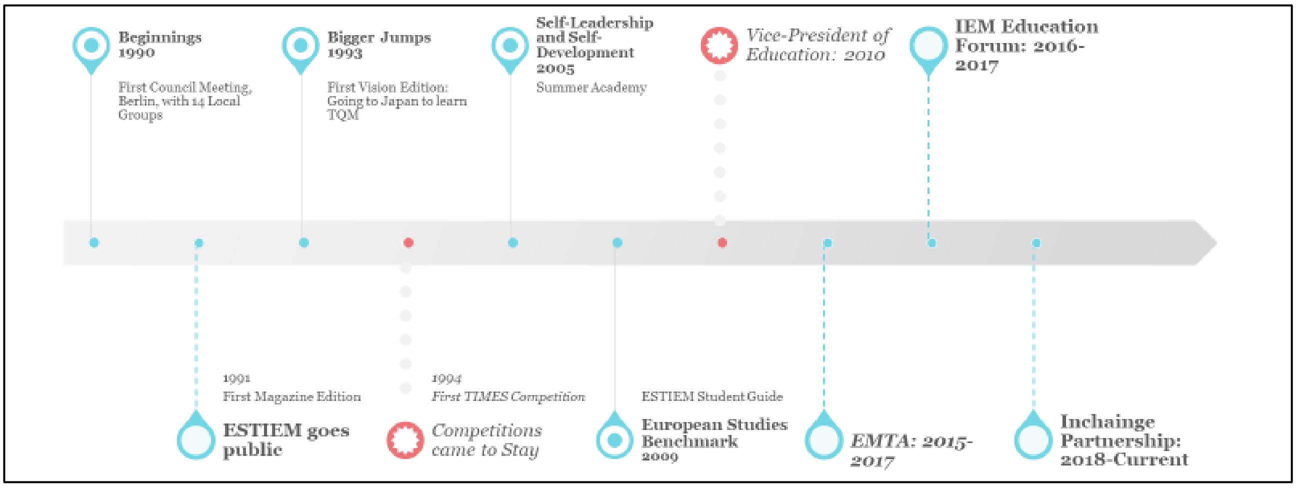


Figure 1: ESTIEM history milestones

Regarding the European Management of the Association, ESTIEM develops its functions through two main structures: Central ESTIEM Teams and Local Groups, being thus a confederation of associations under a big umbrella, the European one. In Europe, ESTIEM is officially represented by six Board Members, accountable for everything that happens both centrally and locally in ESTIEM. As for the control of the regions in ESTIEM, there are eight Regional Coordinators, people that support and develop the Local Groups organization. As for the events and innovation processes Europeanly in ESTIEM, the Board sends every three months Open Calls for the Local Groups to organize events and every month an Open Call for Local Members to join the European Teams and be part of the Committees and Departments.

Thus, every Local Group has opportunities to perform events made available by the Central Teams and also to develop their own people Europeanly. All of this event coordination is monitored by the Vice-President of Activities and all the Educational Projects where Local Groups can have an impact are coordinated by the Vice-President of Education. ESTIEM arrived here nowadays after a great effort of its Members Committee during its history, a Committee in ESTIEM focused in acquiring new Local Groups and as well as in maintaining them sustainable and happy, through the Local Group Support System, an internal team of consultants ready to help when in need. ESTIEM started with 14 Universities, having today 75+. Figure 2 presents the map with the local groups.

Figure 2: Localization of Local Groups (https://estiem.org/localgroups)

3.2 Projects, events and partners

As for the projects and events that are developed, ESTIEM is divided in four main departments: Academic, Career, Intercultural and Personal.

Not focusing completely on the last two, just to mention they encompass a great percentage of ESTIEM's portfolio and through them, ESTIEM delivers language courses and Self-Leadership and Reflection Camps, through the services "Language Programme" and "Summer Academy", respectively. These are two areas of ESTIEM that allow IEM Students to personally develop and improve their intercultural awareness and thus developing a more united Europe.

On the first two, instead, is where ESTIEM creates more external value and delivers as well the necessary complementary hard-skills for students in Europe. In Career Department, ESTIEM holds its landmark of competitions: Tournament in Management and Engineering Skills (TIMES), a case study competition hold since 1994 and that shows the best team of IEM Students in Europe in solving case studies, being it the biggest competition in this category in any possible NGO in Europe. Furthermore, Career Department also develops entrepreneurship events, a Business Booster, that allow, later on, if the participants want, to incubate their ideas in partner Startup Incubators of ESTIEM. As for the Academic Department, this is the one that holds the more hard-skills related events and offers a great variety of events to raise students voice and be able to exchange valuable opinions with professionals in the area of Education.

As examples, ESTIEM offers, in this department, a Green Belt Certification in the field of Quality Management, with scientific revision of the content being done by professor Gregory Watson, being this the service ESTIEM has as best value proposition. As a follow-up, ESTIEMers can apply their knowledge on companies and develop a project and get a Green Belt Certificate. Alongside this, ESTIEM also develops a Worldwide Competition on Supply Chain Management, sponsored and supported by a Dutch company, called Inchainge, that allows students to simulate the operations of a Supply Chain and take strategic decisions in groups. Lastly, in this department, ESTIEM also has the IEM Summit, an event that has the purpose of gathering students, professors and companies together to improve an aspect of our educational systems, such as the Curricula of IEM in the Universities.

So, in conclusion of the last paragraph, most of the opportunities of the Career and Academic Department offer students great critical thinking and core knowledge on IEM matters, relevant for their future as professionals. Besides, many students, through these opportunities, also develop relevant networking contacts that prove to be relevant for getting their first jobs internationally, as many students get in contact with multiple companies in these experiences. Regarding the quantity of offer of the events in ESTIEM, it has usually more than 180 events per year (Figure 3).

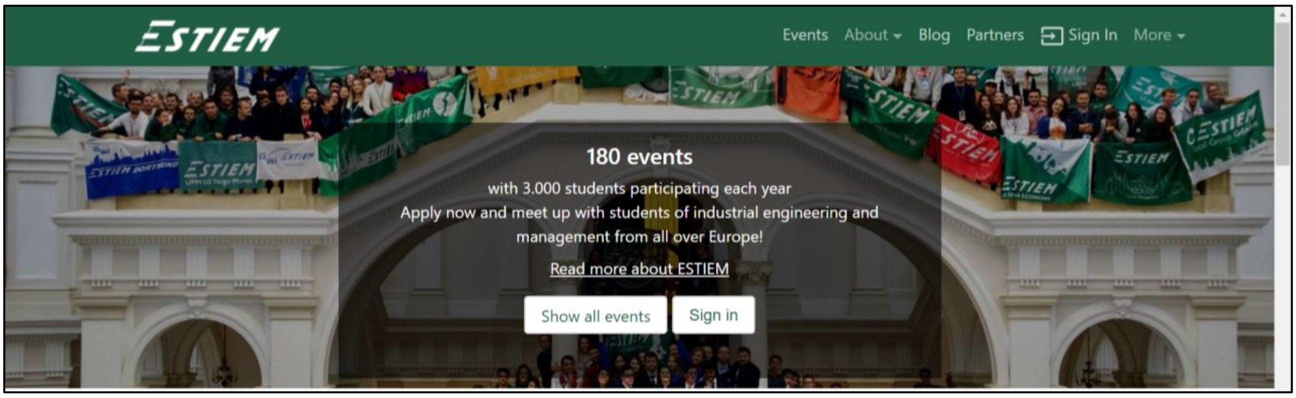


Figure 3: ESTIEM web site main page (https://estiem.org/)

Finally, it is worth to mention the Council Meetings and the IEM Conference. The Council Meetings happen twice a year, with around 250 active members of ESTIEM, where the 75 Local Groups gather to take democratic decisions and benchmark between each other to improve themselves. This is usually considered the biggest and most important event for the network improvement. On the other hand, for external and professional purposes, ESTIEM also develops the IEM Conference. The IEM Conference it is a one week event that aims to gather Universities, Companies and Students around IEM topics, to not only discuss them, but as well as to make progress on those, such as Data Science and Supply Chain Management. These events allow students to develop their public speaking techniques, often required in front of big crowds and as well as their adaptation skills, as many times insecure questions arise in these events.

Currently, ESTIEM make partnerships with 18 organization, among them there companies that support the projects and events, universities and others non-profit organizations (Figure 4).

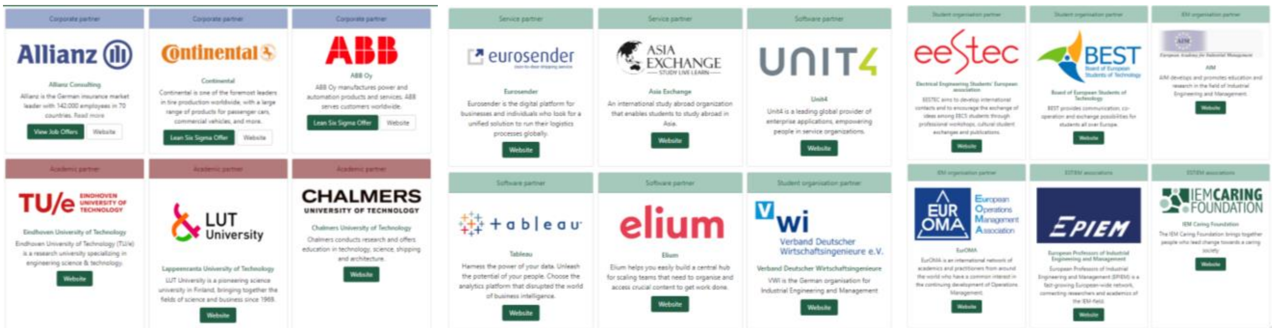


Figure 4: ESTIEM partners (https://estiem.org/partners)

4 ESTIEM contribution to IEM students' education during their graduation

Attending to the key life-long learning competencies defined in the introduction, the authors provide some examples of knowledge, skills and attitudes of each competency implicitly or explicitly acquired by the students by organizing, performing and/or being involved in the activities of ESTIEM. Table 1 presents such examples.

Table 1: Competencies developed by ESTIEM students

Competencies	Knowledge	Skills	Attitudes
Literacy	Process and framework of writing a scientific paper	Ability to design a scientific research process	Interest in writing or analysing scientific papers; interest in developing scientifically and educationally IEM
Multilingual	English language	Language development; proficient use of the English language	Initiative to speak to everyone inside the network and work in teams in English language; initiative to join events where new languages are taught by the members of the LGs
Mathematical, science, technology and engineering	Lean Six Sigma; Supply Chain Management, curriculum and career analysis	Problem-solving, critical thinking; data collection, treatment and visualisation and reporting of the information concluded	Initiative to make informed decisions and to understand and influence the European IEM context
Digital	Be aware of new tools to communicate and work	Digital tools use (e.g. elium, tableau, google drive and forms, skype, slack, whatsapp, …)	Initiative to use different tools, to share, process and store information
Personal, social and learning to learn	Plan a project and activities, distribute individual and team tasks, establish contacts with a company; Public presentation, facilitation	Negotiate and solve conflicts, Initiative to present a topic and answer to questions, development of interpersonal relationships	Initiative to take an active role inside a project or team; initiative to better communicate and interact in public
Citizenship	Actions on how to impact the Sustainable Development Goals	Development of social environmental campaigns	Initiative to plan, execute and participate in social impact activities
Entrepreneurship	Manage projects and collaborate in multidisciplinary team; Applied management theoretical knowledge	Mobilize resources; usage of strategic frameworks (e.g. SWOT, Porter's 5 forces, Root Cause Analysis, etc)	Stimulus and motivation to make the project, initiative to perform strategic analysis on problems and situations
Cultural awareness and expression	Context of cultures in a political, educational and economic scenario	Intercultural awareness	Culture exchange, sensibility for the cultural differences

In ESTIEM, IEM Students end up acquiring many skills that Universities' Educational System can't provide at first sight. As for a first easy division of thoughts, ESTIEM delivers a vast majority of soft-skills that the Universities can't deliver, something that makes the services ESTIEM offer attractive products at the very end for students.

As for the variety of soft-skills ESTIEM delivers, some deserve highlighting, as the following: intercultural awareness – ESTIEM is a great ecosystem that enables students to get to know other cultures in a deeper perspective, not only by getting to know their traditions on social and personal life, but also by integrating international teams that work remotely on various topics of the organization; team management and leadership – ESTIEM offers a unique opportunity to lead teams and work on an international setup, something Universities do not offer on a daily basis. Moreover, once in the Board of an association, students develop skills similar to top managers of international multinational firms, something that stands out right away in a CV selection/filtering process; last but not least, analytical thinking – it's been one of the trends of the past years that ESTIEM is becoming a data-centric organization, where many of its processes are being monitored both in dashboard and in process maps, allowing the top management layers to take decisions based on perceived trends. This allows students to apply data analytics skills in an organization environment, something Universities can´t offer at such scale and not even with similar real use cases.

On another perspective, ESTIEM offers as well, as other NGOs do so, great skills of facilitation, Training and Working Session Delivery and brainstorming. These skills need to be highlighted as in ESTIEM, these are developed in a structured and hands-on approach, by applying certified theories that make its members a great addition to companies when student enter the labour market, proving to be efficient employees in situations of presentations and meetings within their own teams or with external partners.

On a final note, the involvement in these International associations has to be pondered upon what each student wants out of his/her professional life. It is 100% recommended for students seeking an international environment in their lives, as well as for the ones looking for jobs that demand a high pace of business meetings. Regardless, it is an experience every student recalls as one of their best in their student life.

5 Conclusions

This paper presents ESTIEM students 'union as an experiential and independent learning provider of competencies to their members. ESTIEM is a non-profit organization whose members are IEM students from all Europe. Being a member of such organization bring many advantages to the students that acquire important competencies that prepare them to work in a global and multi-cultural environment. Such informal learning could provide technical and transversal competencies, nevertheless the transversal ones are the most practised such as learning a different language. There are a lot of skills embed in the key competencies referred that could not be learned in lectures, as good as they could be prepared, such as culture exchange, be aware of social and political issues of different countries, citizenship involvement, among others. As a future work, it is proposed to develop a survey that inquiries ESTIEM members about the competencies they think that they acquire with this membership.

Acknowledgments

This work has been supported by FCT – Fundação para a Ciência e Tecnologia within the R&D Units Project Scope: UIDB/00319/2020 and UIDB/04058/2020.

6 References

Andrewartha, L., & Harvey, A. (2017). Student voice and influence on employability in Australian higher education. *Journal of Teaching and Learning for Graduate Employability*, *8*(1), 202–214.

Astin, A. W. (1999). Student involvement: A developmental theory for higher education. *Journal of College Student Development*, *40*(5), 518–529.

Attard, A., Iorio, E. Di, Geven, K., & Santa, R. (2010). *Student-Centred Learning: Toolkit for students, staff and higher education institutions*.

Bolhuis, S., & Voeten, M. J. . (2001). Toward self-directed learning in secondary schools: what do teachers do? *Teaching and Teacher Education*, *17*(7), 837–855. https://doi.org/10.1016/S0742-051X(01)00034-8

Broad, J. (2006). Interpretations of independent learning in further education. *Journal of Further and Higher Education*, *30*(2), 119–143. https://doi.org/10.1080/03098770600617521

Brooks, R., Byford, K., & Sela, K. (2015). The changing role of students' unions within contemporary higher education. *Journal of Education Policy*, *30*(2), 165–181. https://doi.org/10.1080/02680939.2014.924562

Council of the European Union. (2018). *Proposal for a Council Recommendation on Key Competences for Lifelong Learning*.

Dewey, J. (1938). *Experience & Education*. Kappa Delta Pi.

Fakharzadeh, C., & Todd, M. (2010). *Student Organization Leadership: Starting, running and improving a student group* (2nd ed.). Infinity Publishing.

Felder, R. M., & Brent, R. (2006). *Active Learning*. University of West Florida.

Fernandes S., Cunha R., Torres D., P. C. (2020). JELA: An Alternative Approach to Industrial Engineering and Management student's Lean Management Education. In: Rossi M.,. In T. S. (eds) Rossi M., Rossini M. (Ed.), *Proceedings of the 6th European Lean Educator Conference. Lecture Notes in Networks and Systems, vol 122.* (pp. 79–87). Springer, Cham.

Guan, L., Cole, M., & Worthington, F. (2016). University students' unions: changing functions, a UK and comparative perspective. *Studies in Higher Education*, *41*(12), 2095–2109. https://doi.org/10.1080/03075079.2015.1010076

Haines, K. (2019). *Student Perspectives On Joining Student Organizations*. Northeastern University Boston.

Hockings, C., Thomas, L., Ottaway, J., & Jones, R. (2018). Independent learning – what we do when you're not there. *Teaching in Higher Education*, *23*(2), 145–161. https://doi.org/10.1080/13562517.2017.1332031

Holzweiss, P., Rahn, R., & Wickline, J. (2007). Are All Student Organizations Created Equal? The Differences and Implications of Student Participation in Academic versus Non-Academic Organizations. *College Student Affairs Journal*, *27*(1), 136–150.

Itin, C. M. (1999). Reasserting the Philosophy of Experiential Education as a Vehicle for Change in the 21st Century. *Journal of Experiential Education*, *22*(2), 91–98. https://doi.org/10.1177/105382599902200206

Kolb, D. (1984). *Experiential learning: Experience as the source of learning and development*. Prentice-Hall.

Lau, K. (2017). 'The most important thing is to learn the way to learn': evaluating the effectiveness of independent learning by perceptual changes. *Assessment & Evaluation in Higher Education*, *42*(3), 415–430. https://doi.org/10.1080/02602938.2015.1118434

Leathwood, C. (2006). Gender, equity and the discourse of the independent learner in higher education. *Higher Education*, *52*(4), 611–633. https://doi.org/10.1007/s10734-005-2414-3

Lewin, K. (1946). Action Research and Minority Problems. *Journal of Social Issues*, *2*(4), 34–46. https://doi.org/10.1111/j.1540-4560.1946.tb02295.x

Lewis, L. H., & Williams, C. J. (1994). *Experiential Learning: Past and Present* (R. S. (Eds. . In Jackson, L. & Caffarella (ed.); pp. 5–16). Jossey-Bass.

McComas, W. F. (2014). *The Language of Science Education: An Expanded Glossary of Key Terms and Concepts in Science Teaching and Learning*. Springer.

Mckendry, S., & Boyd, V. (2012). Defining the "Independent Learner" in UK Higher Education: Staff and Students' Understanding of the Concept. *International Journal of Teaching and Learning in Higher Education*, *24*(2), 209–220.

Meyer, W. R. (2010). Independent learning: a literature review and a new project. *British Educational Research Association Annual Conference*, 36.

Piaget, J. (1973). *Estudos Sociológicos*. Forense.

Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education*, *93*(3), 223–231.

Rychen, D. S., & Salganik, L. H. (2000). *Definition and selection of Key competencies*. https://www.oecd.org/edu/skills-beyond-school/41529556.pdf

Thomas, L., Jones, R., & Ottoway, J. (2015). *Effective Practice in the Design of Directed Independent Learning Opportunities*.

Vieira, F. (2019). *The Importance of Participation in Student Organizations for Soft Skills Development*. ISCTE - Instituto Universitário de Lisboa.

“EXTEND” to the “NEXT LEVEL”

Doina Irina Simion[1], Elisabeth Lazarou[1]

[1] University Politehnica of Bucharest (UPB), Romania

Email: darina.simion76@gmail.com, elisabeth.lazarou@upb.ro

Abstract

EXTEND is a project that assigned itself the aim of promoting student centred learning in Higher Education engineering institutions (from Russian Federation and Tajikistan) in a technologically enhanced framework by creating a sound pragmatic base i.e. the EXTEND Centres. The process of implementing such an aim requires a huge overhaul and development of a wide range of skills: designing, developing, implementing, managing, evaluating. In all this process, the organized mind has been a key prerequisite every step of the way. As the project deadline is drawing closer, a critical question has been hovering around: *what comes next*? The accompanying concern might be: can the organized mind play the same role in the post-project sustainability stage? What are the factors to be juggled into a new development format? The present paper sums up some of the tentative answers offered to this question in one of the project related workshops as well as considerations that pertain to the field of pedagogic change literature and project management. In an attempt to operationalize the solution, the initial question was changed into two preliminary questions. First: “*what came next*’ in similar projects of a developmental nature. Secondly, *what might come next* against the backdrop of the accumulated experiential learning of EXTEND participants and an increasingly pervasive digital culture. Both issues have the same aim in view: long term educational development.

Key words: sustainability, impact, organized mind, serendipity

1 Introduction

EXTEND (2017-2020) is an EU project subtitled **Excellence in Engineering Education through Teacher Training and New Pedagogic Approaches in Russia and Tajikistan (EXTEND** 586060-EPP-1-2017-1-RO-EPPKA2-CBHE-JP) and initiated under the ERASMUS + Programme, KA2, Capacity Building in Higher Education (CBHE). Projects of educational change like EXTEND hold a lot of promise for the future but also challenges. These challenges may become the object of concerns that are both legitimate and welcome at individual and institutional level. Some of these concerns were the object of one particular EXTEND workshop. This workshop was scheduled in the agenda of the EXTEND Dissemination Conference entitled **Development of Engineering Teaching through the New Pedagogy Approaches in Higher Education Institutions of Tajikistan -** 25 June (TNU) – 26 June 2019 (TUT), Dushanbe, Tajikistan. The workshop was delivered by Doina Irina SIMION as a representative of the University Politehnica of Bucharest (UPB), Romania, the institution in charge of the project coordination headed by Elisabeth LAZAROU. The main point of the workshop was to clarify development options the EXTEND participants might consider after the end of the project as an answer to their key question: *what will happen when EXTEND is over?* The present paper – on the one hand- largely draws upon the Dushanbe workshop activities and results. On the other hand, the paper broadens the scope for an answer in two ways. First, by looking into “*what happened*” in the post-project stage in a similar venture targeting long term gains. Secondly, by overviewing ways of ensuring sustainability that go beyond the promises of the organized mind. In other words, the paper looks into “*what might happen*” or “*the next level*”.

2 “What Happened?”

Long term success depends on a variety of factors sometimes not easy to predict. One such example of success was the Romanian-British project entitled PROSPER profiled in Table 1. The project targeted methodological update in the teaching/learning of English for Specific Purposes (ESP) in key Romanian engineering universities in the 1990 decade. The implementation and dissemination of the communicative approach ideology was seen as a benchmark of project success. This success was thoroughly documented in “The PROSPER Project, Innovation in Teaching English for Specific Purposes in Romania, A study of Impact”, 1999. The PROSPER project experience may be considered relevant on several accounts. First, PROSPER, alike with EXTEND, was a project for change. Secondly, its conclusions map out the key features which in Donald Freeman's opinion (1989) characterize *any* teaching situation: *teacher knowledge, skill, attitude* and *awareness*. Furthermore, although EXTEND is not confined to language teaching, it does include a language training component in the Module developed by NMSTU on Foreign Languages for Engineering and Academic WrIting. Down below is a selective choice of post-PROSPER spinoffs encountered at the level of *the teacher, the context, methodology* which might be considered a wake up call for EXTEND practitioners.

2.1 The Teacher as Learner

Educational change involves a complex software and hardware infrastructure: ideas, materials, activities. For the teacher open to change, the first contact with this new world is through language. Freema Elbaz makes an impactful analysis of the relation between language, the action capable of changing existing reality and power.

> 'language provides the conceptual categories which organize thought into predetermined patterns and set the boundaries of discourse' (Bowers 1987: 116 apud Elbaz, 1991, p.1). The ability to determine these conceptual categories constitutes power. As researchers we exercise such power; hence it is important to consider the categories in which research in our field has been organized, and to ask where these categories come from and what part of reality and whose reality they reflect (Freema Elbaz, 1991, p.1).

In tune with this approach, a micro-research in the professional environment of the English Department UPB staffers involved in the PROSPER[1] Project found that the scientific jargon of the communicative approach methodology had been in the beginning stage of the project a steady source of stress. A questionnaire based survey revealed the following items as being particularly sensitive: *input, output, realia, task, monitoring, peer, pair, teacher fronted, lock step, follow up.* It is easy to see that most of them are not so much institution related but rather teacher related. They concern the teacher's role (*teacher fronted, lock step*, with mostly the negative connotations of "the old school" or *monitoring, follow up* with the positive connotations of the "new school"); interactivity (*peer, pair), or* the learning by doing methodology (*input, output, realia, follow up)* (Simion, 2006).

The EXTEND project is open to a wide range of fields and subjects in Engineering Education. Consequently, the scientific jargon used is bound to vary too. However, the weight of educational jargon in a paradigm of educational change is probably comparable across fields. That is why being aware of the importance of assimilating the meta-language of change in a hands-on type of learning experience might or even should be embedded in the kind of materials, activities, decision making required in the post-EXTEND history. The key pre-requisites being: conceptual clarity, time for assimilation, meaningfulness of use.

2.2 The Context

In his seminal work Changing Teachers, Changing Times (1995) Andrew Hargreaves identified five types of work context for an educationalist: fragmented individualism, balkanization, collaborative culture, imposed collegiality, mobile mosaic. Individualism is defined by an attitude of isolation and defensiveness towards external interventions. Balkanization is defined by group related loyalties and lack of consistency; the collaborative culture context moves toward trust and mutual help relationships that may however face the risk of paternalism. The context of imposed collegiality features collaboration relationships induced and controlled by senior leadership via administrative measures; this kind of context poses no risks but engenders no novelty either. In the mobile mosaic work environment Group members carry out different functions by rotation which result in the emergence of dynamic, flexible groups despite the risk of uncertainty and vulnerability.

The DUSHANBE workshop took place at the end of the second year of the EXTEND project. It offered participants the possibility to assess the quality of their present professional environment by asking them the question: What kind of environment do you consider you are living in at present? (use Hargreaves' taxonomy). The results of the survey showed on the one hand a reluctance of considering the issue (46% no answers) as well as an awareness of the emergence of collaborative types, i.e. 33% *collaborative,* 13% *Imposed collegiality,* 0.66%, *moving mosaic*. Although no in-depth investigation was carried out into the reason for non-response, one might assume that participants were either uneasy about assigning an inferior label to their present work environment or considered the very issue superfluous. These results are a signal that the quality of the work environment might prove critical for the sustainability of the EXTEND project in the future. The educational milieu of EXTEND has already become sensitized to context related issues by the participatory research involved in drafting the survey dedicated to the question "What is Good Teaching" (Outcome 1.1).

2.3 Methodology - from lock step to empowerment

The lock-step methodology to most Romanian engineering students of foreign languages were subjected before the introduction of the communicative approach is succinctly drawn up in the baseline study undertaken as part of the PROSPER Project. Here are some key findings regarding the main stakeholders, the teachers and the students.

> *The PRE-PROSPER teacher tended to be domineering in class, assuming the entire responsibility for the class and consequently allowing little opportunity for students to learn through contributing actively in class. The teacher-student relationship was generally good but some teachers were too rigorous and demanding, very strict on errors, intimidating students, as they offered no encouragement or possibility of self/peer correction. Very often only the students with a higher knowledge of English were involved by the teacher in class activities.*

Other important findings refer to: lack of clear lesson objectives and coherent pattern off classroom activities; heavy focus on grammar and accuracy, little emphasis on the four skills training; too much talking time about the language rather than opportunities for using it purposefully, in a contestualised, product based frame.; unbalanced lessons in terms of teacher input and student output with a heavy stress on teacher input. (Source: The PROSPER Project, Innovation in Teaching English for Specific Purposes in Romania, A study of Impact, 1999, p. 24).

As to students, the baseline study found-in the wake of 30 observation classes carried out in 1991-1992- that they were "not very motivated, behaving as passive recipients, used to being told what to do", *(op.cit*. p. 66).' often diligently writing things down, even when it was extremely boring', 'poor at asking questions', not familiar with pair work or group work.

In the wake of almost ten years of intensive investment in methodological training, the same study documented a change in the above situation both with respect to teachers as well as students. The key areas of teacher development were found in six directions: teacher-student relationship, better teaching skills, development of materials writing skills, provision of more opportunities for students to communicate, increased co-operation with colleagues (*op.cit*. p. 41). The student profile also changed in terms of the "learning experience, /…/ types of activities and patterns of classroom interaction, access to materials, and teacher-student relationship" (*op.cit*. p. 89).

The EXTEND Centres and the PROSPER Language Centres are both conceived as agents of educational change through a learner centred, humanized teaching methodology. The list of PROSPER activities and outcomes in Annex 1 is indicative of the kind of resources needed to successfully implement this goal.

3 The next level

In simple terms, project sustainability means building up and capitalizing on the project gains – after the fund flow has stopped - via such means like commercialisation, accreditation or mainstreaming. The above mentioned Impact study is good proof that educational change is both possible and sustainable. As far as the sustainability of the EXTEND Project is concerned, the project design has already provided for it. The third draft of the sustainability plan (last updated in March 2020) is a convincing example of what the "organized mind" can achieve. The plan overviews the exploitation strategy, tools, target audience, description of events and overall exploitation calendar in the post EXTEND stage. Furthermore, the plan makes a fine point of realistic philosophy by stating that "Not all parts of the project or results may be sustainable". Indeed, success is not a matter of push-button performance.

Nevertheless, beyond what the "organized mind" can forecast, there lies the land of practice. Donald Schon (1987) once stated that this land always poses a challenge because problems rarely have black and white answers, the answers lie in a sort of "grey", "marshy" area. That is the reason why any sustainability plan should not overlook one of the most important factors of change: the *quality* of the human factor. Here is a list of some of the issues that might challenge the human factor as an agent of change in the post–EXTEND stage. They stem from both theoretical and (auctorial) experiential insights.

The Ground. Antoinette Oberg (1989) has put forth a very important concept that accounts for the teacher's ability to face the changing educational reality: the ground of practice. The author claims that even before a teacher steps into the room she/he is equipped with a mental and emotional cast that informs current decision making. This entity expresses the individual practitioner's outlook on the "educational good", is multi-dimensional, complex, abstract, developing, personal, partially comprehensible and accessible only in specific instances (Oberg, 1989). The components of this complex entity are the practitioner's beliefs and intentions as well as the links between them and eventually, actions. Similarly, the EXTEND practitioner is also likely to impact her/his practice in a more or less conscious way with the values of the humanized approach to education promoted by EXTEND, as part of her/his new ground of practice.

Support. Change theorists have also emphasized the importance of steady support after a certain skill or technique has been assimilated. Support – as shared goals and tasks- may be provided at peer or group level. The ten year deployment and success of the PROSPER project is good proof of this finding. In the case of the UPB English Department for instance, the project investment spawned a range of initiatives, i.e., developing in-house text-books (i.e. *English for Professional Communication*, 2004), a testing team as well as other collaborative ventures. The bad news is that when support is deficient, work quality runs the risk of falling to levels that go even lower than the pre-change levels. So, one piece of warning might be: beware of isolation!

Self-monitoring. There is no universally agreed classification of the stages in the development of an educational practitioner. Day (1993) sums them up to three: launching, stabilization and experimentation. Kenneth Leithwood added a fourth one, the plateau stage, which may have either positive features, i.e. a heightened moral sense of responsibility and lessened competition focus or negative ones, i.e. stagnation and cynicism. These phases might be replicated in the case of a limited experiential exposure such as EXTEND. In other words, the EXTEND participant in the third project year might hold views, might be aware of values, might be capable of implementing educational procedures that were alien to the same participant who attended the EXTEND kick off meeting in 2017 (see Motto at the head of Conclusions). Mention should be made that the experimental stage may lead to diversification, assumption of more responsibilities, revelations or puzzlement (Day, *op.cit*). One possible danger-that might occur when the practitioner lacks adequate support – is over-experimentation for the sake of experimentation. The antidote in this case might be the quality self-monitoring based on reflective practice. Even if keeping professional diaries or any sort of logs was an optional decision for individual EXTEND participants, an overview of the archive of the EXTEND minutes drawn up in the wake of all project milestones might act as a strong reflection booster with both personal and collective benefits.

Imagination (and its off-spring, innovation *per se*), is considered one of the most formidable tools of progress, as Albert Einstein once claimed.

> *"When I examine myself and my methods of thought … I come close to the conclusion that the gift of imagination has meant more to me than any talent for absorbing absolute knowledge … All great achievements of science must start from intuitive knowledge"* (Albert Einstein apud Levitin, *The Organized Mind*, p. 381).

Serendipity. Attempts at capitalizing on this basically uncontrollable process which is imagination have led to the increased interest shown in the educational field to serendipity as a rich source for discovery. This latter concept rationalizes the path towards creativity by tapping at the associative power provided by instances of diversity. Nowadays, exposure to diversity for the sake of fortunate findings or discoveries has become a popular technique in online advertising, online search, scientific research (i.e. Stumble Upon – search engine- https://en.wikipedia.org/wiki/StumbleUpon), or entertainment: (i.e. Mood logic music).

Gamification, the transfer of (computer) game principles to other areas contexts promises to provide the interest, implication, learning challenge, and most of all instant feedback which Mihaly Csikszentmihaly (2015) associates with the sources of the state of flow or happiness. Up to now, gamification has found a wide range of applications in education (USA army, Bill and Melinda Gates Foundation 'Quest to Learn'), marketing (tablet game winners), health Industry, whether directly (see the good correlates of gaming elements and health self monitoring applications in Appstore 2014) or indirectly (Pokemon Go, 1500 steps), labour corporate training or public policy making (ex. social credit earned in China for good reputation scores). Nowadays, the most popular gamification inspired activities feature: score points, score tablets, story sequels Avatars, medals performance graphs, team work games; experience levels (RPG role play games). Future EXTEND off-springs can only benefit from capitalizing on this direction of educational methodology.

Feedback. Seen as a prerequisite/ follow-up of any dissemination plan, feedback data may eventually turn out into one of the most reliable sources of self and institutional improvement if pursued in a consistent way.

The old vs. the new rhetoric. THE EXTEND Consortium emerged in the wake of a common determination to implement the upgrading of local educational systems. Success, however, at any stage in the project development- pre-while-post - is most often a matter of context, i.e. rules and people. In the sustainability stage, as far as people – trainers or trainees- are concerned, one should not take for granted either an un-negotiated adoption of the new or a total rejection of the old before clarifying the boundaries of the new and the old. The eight EXTEND Modules that represent a major agent for change in the project design feature state of the art topics (especially ICT related) and incentives for a humanised teaching methodology. Hence, they target both competence and performance. The scope of the novelty impact is not restricted to trainers and trainees but engulfs the broader area of scholarly literature, administrators at various levels or even news media, etc. Nevertheless, the novelty of EXTEND, in the existing environments, should not necessarily be seen as a break-up trigger but rather as a build-up of valuable pre-existing expertise.

That is the reason why one should earnestly consider what the theoretical and pragmatic basis for this build-up might be. In other words: is there any place for the old? If yes, in what respect? And why? The why is easy to answer if we consider the human factor. Educational systems are reputedly reluctant to change, especially imposed top down change. The assumption of change opponents are most often than not the commonsensical outlook summed up under the slogan: if things have worked like that for decades and decades there must have been something good about them. Indeed, if we look at the history of educational practice and theory, we cannot overlook the existence of some perennial pillars which some theorists call "commonplaces".

The concept of a commonplace already received significant attention of quite a few educational theorists. In his "Guide to commonplaces: on the use of *loci* in educators' discourse", Henry Maurice' (1991) lists such contributors to the concept as R. Mc Keon, Kenneth Burke, J. Schwab, E. Eisner. His analysis overviews a variety of more or less surprising interpretations of this concept: J. Schwab collects under the umbrella term of the commonplace the very stock elements of education: the teacher, the learner, the milieu, the subject matter. K. Burke draws up an analogy between communication and education on the basis of such shared "commonplaces" like act, scene, agent, agency or purpose.

The previous references to the concept of commonplace support the theoretical validity of the question" is there any place for the old. Pragmatically, one could look into the transfer value of previous practice. Economy precludes an in-depth analysis of all possible transferable skills. As EXTEND trainers are expected to be experts of teaching, one can refer to the literature on expert teaching in this respect. The way subject/content knowledge and procedural knowledge merge into what is called "pedagogical content knowledge" (Schulman apud Gudmundsdottir, 1991) is a field still open to hypotheses. However, one key assumption is that teachers work out an individual, mostly thematic narrative that links up the key topics of their subject into a major idea ort story in order to provide continuity and meaningfulness for their students . It is easy to see that the challenge of developing a background narrative stays valid irrespective of topic or method novelty. The ability to tailor the teaching discourse in a direction likely to foster specialists in a certain field rather than a "fit for all pattern" recipe, or pivoting discourse on the kind of theory that ensures "depth" rather than "breadth" (Duschl., apud Meung, 1991) can also feature transferable values.

The EXTEND post project stage will not be carried out in the void. The future actors and stakeholders should be aware of the critical stakes of a digitalized world. Anderson (2016) made a convincing argument in support of the thesis that the educational future does not belong to developing an increasingly narrowly specialized expertise. He claims that the need that has led to the emergence of such educational offers like TED, the Khan Academy, MIT or Stanford online education is proof that the future is the world of knowledge and people interconnectedness. EXTEND might become a part of this new world making force.

4 Conclusions

Motto *"When I entered I knew one world but now I see we must be modern"* (participant's feedback in Dushanbe workshop, Technical University of Tajikistan, June 26, 2019),

The PROSPER project has been our backbone reference in digging up the problematic of post-project implementation. Over a span of one decade, the language teachers involved adopted the communicative approach in language teaching and gradually "humanized" their practice by actually moving in two directions. First, they looked at what ***can be done***. In this respect they embraced a certain range of values and the procedures that implement them. Here is a selective list applicable beyond the language class:

- providing the opportunity for choice (subject, time, method) as a path to autonomy;
- meaningfulness through:
    - real–life-tasks
    - top-down rather than bottom - up teaching/learning strategy
- authentic inputs
- information gap challenge
- contextualised tasks based on lead-in
- production stages as a way towards meaningfulness
- increased interactivitiy (pair/group work)
- changed teacher-student roles

Secondly, they looked at what ***cannot be done*** or the boundaries of change. In this respect, of particular value in the theoretical field have been the authors who embraced a limited paradigm of values and procedures with a long term rippling effect such as Kumaravadivelu, B. *Maximizing Learning potential in the communication classroom* (in Hedge Whithey's *Minimal approach Interaction*, 1996); Jon Taylor in *The Mini- Max Teacher* (2004).

As far as the EXTEND project is concerned, an inspiring answer to the question heading the Dushanbe Workshop was probably given by the Dushanbe workshop participants themselves. When asked *What word do you associate with the EXTEND project?* they answered: *an interesting trip, education, exchange of students between European universities, progress, development, programs, study, qualification, engineering education development, communication, integration, craftsmanship, boost, pedagogy, innovation, I thought about what kind of project it is, "When I entered I knew one world but now I see we must be modern".* Indeed, a quality dissemination of the kind of the expected gains listed by the Dushanbe participants might ensure its further sustainability alongside with an open mind ready to change, discover and further innovate.

To conclude, the answer to the post-EXTEND future development of the HE Institutions involved lies not only in the hands of the decision makers but mostly in the hands or rather mind and heart of an EXTEND trainee who can find truth in the following statement: *The key to change is having faith that when we get rid of the old, something or someone more magnificent will take its place*" (Levitin, 2014, p. 383).

Table 1. The PROSPER Project in a nutshell

Timeline	1990-1999
Partnership	British Council, UK and the Romanian Ministry of Education
Aim	Upgrading the teaching/learning of English for Specific Purposes (ESP) in Romanian tertiary education
Target	English Departments in five major technical universities and Academy of Economic Studies (initially); English Departments in other economic academies and medical schools
Activities	in-country training courses (1/2 weeks); 10 week training course at the Institute for English Language Education, Lancaster University (78 teachers, 1991-1995); short course training sessions on requested topics; workshops; materials development, test development; course evaluations, course observations, mobilities**,** newsletter**,** distance masterships (15 teachers, Manchester University)**;**
Outcomes	1. 124 teacher trainees from 18 institutions 2. Improved classroom experience 3. Textbooks: English for Science and Technology; English for Business Administration. 4. Newsletter 5. International Conferences: 1993 and 1996 6. Five Language Centres (self-sustainable) 7. Baseline study (in-house) 8. Impact Study (published)

(Source: "Innovation in Teaching English for Specific Purposes in Romania - A Study of Impact" (1999).

5 References

Anderson, C. (2016).*TED Talks. The official TED Guide to Public Speaking*.Nicolas Brealy Publishing, London, Boston, 227- 252.

Bardi M., Chefneux G., Comanetchi D., Magureanu M (editors), (1999). *Innovation in Teaching English for Specific Purposes in Romania - A Study of Impact,* The British Council, Cavaliotti Publishing House, Bucharest, 24, 41, 89.

Blandu, M. *(coord.), (2004). English for Professional Communication*, Printech, Bucuresti

Csikszentmihaly, M. (2015). *Flux, secretul fericirii*, Delta

Day C., Calderhead J., Denicolo P. (1993). *Research on Teacher thinking, Understanding Professional Development*, Falmer Press

Elbaz, F. (1991). Research on teachers' knowledge: the evolution of a discourse, in *Journal of Curriculum Studies*, vol.23, no 1, May-June, 1.

Freeman, D. Teacher Training, Development, and Decision Making: A Model of Teaching and related strategies for Language Teacher Education, *TESOL QUARTERLY,* Vol.23, No 1., March 1989, 27-44.

Gudmundsdottir S.,. Story maker, story teller: narrative structure in curriculum, , 1991J.Curriculum Studies, vol. 23.no 3, (eds. Lowyck and Clark) 207-218.

Hargreaves, A. (1995). *Changing Teachers, Changing Times*, Teacher Development Series

Kumaravadivelu, B. (1996). *Maximizing Learning potential in the communication classroom* (in Hedge and Whithey's *Minimal approach Interaction*, 1996)

Levitin, D. (2014). *The Organized Mind, Thinking Straight in the Age of Information Overload*, Penguin Books, 381, 383.

Maurice H. Guide to commonplaces: on the use of loci in educators' discourse, *J. Curriculum Studies, 1991, Vol.23, no1pp* 41-53

Oberg, A. (1989**).** *The ground of Professional Practice,* in Lowyck J., Clark M. C., 1989. *Teacher Thinking and Professional Action*, Leuwen University Press, 146.

Schon, D. (1987). *Educating the Reflective Practitioner, Toward a new design for teaching and learning in the Professions*, Jossey – Bass Publishers, San Francisco, London.

Simion, D. I. (2006) *Disponibilitatea educationala, Profesorul intre reflectie si experienta*, Editura Printech, Bucuresti, 326.

Taylor, J. (2004). *The Mini- Max Teacher*, Professional Perspectives, Delta Publishing

Young, J.M, (reviewer). RICHARD A.DUSCHL., Teachers College Press, 176 pp, ISBN0-8077-3006-8, *J. Curriculum Studies, 1991, Vol.23, no1*, 92-93.

http://www.elearningsuperstars.com/gamification-examples/