# Industry – academia cooperation support for creative thinking skills strengthening of undergraduates' students in electrical engineering


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***Abstract* —training a new generation of engineers, who will create new enterprises and new products for market in the field of electrical engineering is achieving through supporting of individuals creative thinking. In this work, introduction of the innovation management course for undergraduate students of the Institute of Electrical Engineering and Electronics, the top down and bottom up approach related cooperation with an industry is described. Teaching methods such as a project – based method, mentoring approach, double supervision of scientific research, industrial internships and final prototyping are discussed in this work. The case of visiting students training in a frame of the ERASMUS+ project, applied testing methodology and analysis of the results are discussed in this work.**



***Keywords—education of undergraduate students, creative thinking; product development; electrical engineering.***


## I. Introduction

The technological development, industry interests and availability of new developers, as well as support of experienced academic staff open new opportunities for the testing of new ideas and development of construction and prototyping skills in groups of undergraduate students is the basic motivation for strengthening of creative thinking. Availability of laboratory resources and flexibility of students' time planning provides an opportunity to introduce market oriented prototyping and industry – academia internships from very early stage of education of electrical engineering students. The training of students in new products design is a very good opportunity to connect entrepreneurs with students and at the same time to teach students to realise new ideas and fulfil market needs. Such approach helps to increases motivation of the students in a learning process. The formal improvement of study programme will be introduced in accordance with the taxonomy of education objectives [1]. The innovation of study programs for undergraduate students and introduction of the concrete courses are planned in accordance with these precise conclusions as well as on the basis of the evaluation of students' final results.

The creation stat-up companies by the students' teams is also expected outcomes from activities planned during the introduction of innovation management course for electrical engineers. The specific profile of the technical higher schools usually is based on a traditional approach to the planned types of the classes and students' activities or assignments. Most often they are lectures, seminars, practical classes, laboratory works, practical training at the enterprises, course engineering projects, writing and defence of diploma or qualification paper. The traditional approaches at these classes at the Riga Technical University and some other similar higher technical institutions can be considered more as teacher-oriented [2][3]. However, introduction of the Project Based Learning (PBL) [4] method is one of the most important methodological issues for acquisition of transferable skills by the students of electrical engineering branch. The PBL approach in RTU is extremely important, because it supports idea of developing of creative thinking for innovations and supports industrial sector in Latvia.

PBL in general provides complex tasks derived from challenging questions or problems that involve the students in problem solving, decision making, investigative activities, and reflection that include teacher facilitation, but not direction. PBL is focused on the questions that drive students to encounter the central concepts and principles of a subject hands-on. The practical introducing of project-based education approach in groups of technical students gives a first positive feedback. RTU faculties provides a positive input for extension of this approach by creating interdisciplinary groups for development of self – standing products, based on application of electrical engineering, electronics, embedded system approach and market needs.

The development of creative thinking for undergraduate students through introduction of an innovation course aims to acquire such competences:

- The course focuses on the integration of the marketing, design and manufacturing functions of the company in order to create a new product/service. The course is intended to ensure students with a set of tools and methods for product design and development. During the course students develop a real prototype of a new product/service.
- The goal of the course is to systematize and broaden knowledge and develop practical skills in new product development with an aim to apply this knowledge and skills in professional situations and everyday activities.
- The main task of the course is to develop competences in a new product planning and development, and to apply this in practice, to stimulate skills of creativity, planning and presentation.
- The introduction of agile [5] method in project pools shorten time from the idea development till market product.

The independent thinking and leadership, direct collaboration with an industrial partner, as well as understanding of market oriented product development process, including promotion instruments like e – commerce solutions, foster fast movement of a product to the market. In the students training process, the RTU supports this methodological approach.

## II. INNOVATIVE APPROACH

The promotion of industry – academia collaboration, and ability to implement novel technological approaches in the industrial training, rise the needed level of student's self-motivation and put them in an active position against of academic staff. This encourages to change teaching paradigm to the mentoring approach, and transfers responsibility of education from a teacher to a student.

Research and students training at RTU is organized around six technology and research platforms: Energy and Environment, Cities and Development Information and Communication, Transport Materials, Processes, and Technologies and Security and Defence (see Fig.1). The objective of the platforms is to ensure multi-faculty and interdisciplinary research in the areas of great significance for the national economy and society.  Active and continuous analysis of market needs and commercial potential takes place within the research platforms.

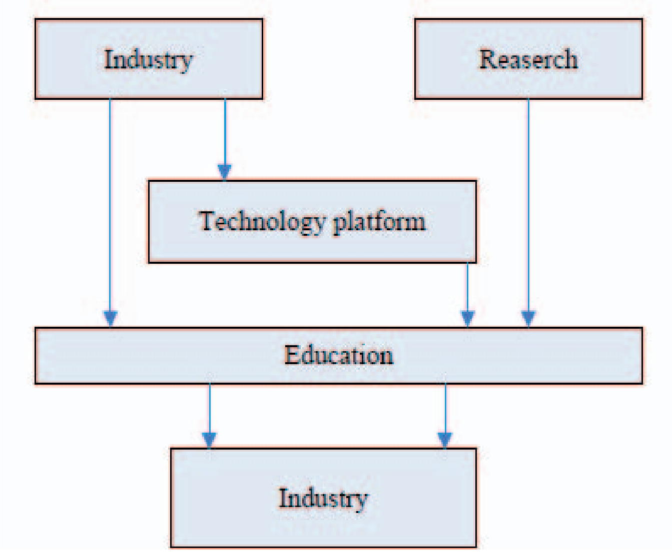


Fig. 1. Industry – academia cooperation structure in Riga Technical University

This innovative approach is supported by the national legislation, namely by the Regulations of the Cabinet of the Ministries of Latvia, which stated that this approach will be introduced in the higher education system from September 2018. In order to formalise this initiative RTU plans to introduce new study subjects in all undergraduate study programs.

*Learning general outcomes of module (course unit)*

- Promote the development and growth of University – industry cooperation in the field of innovation and technology transfer, as well as to enhance the recognition and competitiveness of intellectual potential, to encourage the formation of environment that is positive and open to new technologies.

*Developed skilss:*

- To know: the new product development: idea generation and it's evaluation. The development of prototype. The product management and marketing process development.
- To be able to propose different approaches to realise product idea, evaluate product ideas, compose betta prototype, introduce new product on market.
- Possess: the students can provide an product idea, its economic analysis and to build new offers to market bringing supporting processes.

On the later stage students may join RTU research teams and develops control, diagnostics, management, analysis and forecasting technologies and instruments for stable, qualitative, and optimal energy supply system performance. The diagnostics methods for power networks, transformers, and electric engines are being developed, as well as semi-conductor transformers for electric drive and combustion process control technologies in thermal energy production equipment.

The use of Project Based Learning in the beginning of the education time is an important methodological issue for acquisition of transferable skills by the students of electrical engineering branch and to open new opportunity to students from the begging of the career. Acquisition of the cognitive skills via PBL is associated with increased capability of the part of the students for applying of learnings in novel, problem-solving contexts.

PBL approach supports students learning and practicing skills in problem solving, communication, self-management, it encourages the development of habits of mind associated with lifelong learning, civic responsibility, and personal or career success. PBL integrates curriculum areas, thematic instruction, and community issues, it helps to assesses performance on content and skills using criteria similar to those in the work world, thus encouraging accountability and improved performance. However, the main problem of introducing PBL in RTU is changing the thinking way of academic staff and students.

## III. Methodology

The use the PBL method is one of the most important methodological issues for acquisition of transferable skills by the students of electrical engineering branch. The PBL approach in RTU is extremely important, for developing innovations and technical progress in Latvia. PBL in general provides complex tasks derived from challenging questions or problems that involve the students in problems solving, decisions making, and investigative activities. The PBL is incorporated in RTU research/ academic structure and encourages students to continue a career in the academia or research.

PBL is focused on the questions that drive students to encounter the central concepts and principles of a subject hands-on. PBL approach supports students learning and practicing skills in problem solving, communication, self-management, it encourages the development of habits of mind associated with lifelong learning, civic responsibility, and personal or career success. Application of PBL in RTU encouraged creation positive communication and collaborative relationships among diverse groups of students, because it met the needs of learners with varying skill levels and learning styles.

The most advanced students could be authorized to independently manage a project team. Therefore, student step by step moves forward starting from the projects to commercialization of own developments. The task of the course /program developer [2] is to plan the classes so that the applied activities could involve students into more active roles even up to they could take their initiative and design/create ideas themselves, making the studies more learner-oriented. Therefore, we come to the idea of so called learner-outcomes-oriented course design. The specific interest in this area is caused in the field of engineering higher education. In 1959, an American researcher Donald Kirkpatrick model proposed four-evaluate the effectiveness of learning, which is widely used today in classic approaches [6].

The levels of effectiveness of learning offered by D. Kirkpatrick:

- The first level - "The reaction of participants" aims to identify, the participants enjoyed the training. To assess this level use standard profiles.
- The second level - "Education" determines how the knowledge of the participants changed as a result of training and whether they have changed at all. To assess this level of use specially designed tests and assignments that allow to quantity progress in the competence and motivation of participants
- The third level - "Application" identifies whether to apply participants received during the training knowledge and skills in the workplace? Is there a real difference in their work? Evaluation at this level is usually performed by tools developed on the principle of "360 degrees".
- The fourth level - the "Results" has the objectives to determine the changes in the economic activities of the company, as a result of learning. This level is usually the most difficult to measure, particularly given the fact that also affected business performance and other factors, and to isolate them practically impossible to effect.

However, the model of D. Kirkpatrick [6] despite the simplicity and easy use suffers from a high degree of subjectivity and does not provide quantitative indicators of the effectiveness of learning. In 1991, another American investigator - J. Phillips - added the fifth level to the Kirkpatrick's model evaluation - ROI (return on investment in learning). His model is now recognized as "American Association of Training and Development" (ASTD) and is used around the world.

Thus, to evaluate the effectiveness of training, you can use different models, each of which has its own advantages and disadvantages. The choice of a model depends entirely on the objectives set by the professionals involved in the assessment. D. Kirkpatrick model allows to quickly get a clear picture of the effectiveness of training activities. Model "A Taxonomy Bloom" allows to make a more detailed assessment of the efficiency, as well as the choice of specific learning strategies. Model of J. Phillips aimed to assess the financial side of learning.

## IV. Implementation of approach

RTU has a proud history of providing education over 150 years. At present RTU is one of the oldest and largest technical universities in the Baltic Sea region it gathers nearly

16,000 students at eight faculties in various study programmes. Along with local students, the university is a home for students from around 30 countries, which number grows constantly. Riga Technical University is a regional centre of excellence in 7 areas, including a research platform «Energy and environment». RTU researchers study and develop control, diagnostics, management, analysis and forecasting technologies and instruments for stable, qualitative, and optimal industrial system performance.

Although many of no-EU countries do not have legal obligation to introduce common international standardization of education programs, many of international students participate in international exchange via Erasmus plus activities and pursue to have a mutually recognised international diploma. The deployment of study subjects is planned in several steps. For example, the faculty of Mechanics and Aeronautics of RTU developed the study curses for international students in a frame of Erasmus + Physics project [7]. The testing of the new study courses and training methodology was arranged in small groups during short visits of international students. Apart of national standards, which are mandatory for all study programs, the mutual recognition of innovation implementation approach is important for international education approach, programs, since it supports international students career.

During Erasmus plus Physics projects RTU develops new study courses and increases efficiency of education technologies. In particular, research in the field of industrial electronics allows to decrease electric energy consumption in the industry and transport. The possible synergy among these power supply systems is analysed, for example, the complex usage of wind power station produced electric energy in the centralized heat supply systems for heat production and in electric transport. Training of the students was provided, using laboratories of the research based educational programme “Computer control of electrical technologies” [8]. Every day research activities are an integral part of the routine work of the staff of the Institute of Industrial electronics and electrical engineering (IEEI). This study and research program comprehends the broad area of industrial electronics and electrical engineering with the specializations in power electronics, adjustable electric drives, automation of electrical technologies and electric transport, and it meets the needs of the industry and makes the graduates being competitive at the world labour market.

In many cases Bologna process [9] gives a background for mutual recognition of study subjects obtained abroad, however it is not guaranteed that the study subjects are assigned in the same way by semesters, and content of studies is equivalent in the partner institutions. The testing of new product development course was done with students from international department (Fig. 2) and with different background. The positive feedback, and the feeling, when students can make a prototype of innovative product from the scratch till a market product, encourage students to develop future products, with a good level of motivation.

The increasing of international student’s number in RTU is a strategical goal of the university, however the day by day working strategy in groups of international students is different in comparison with national ones. The topic-based bottom up voluntary standardization approach is a good background, which could to be used for future.

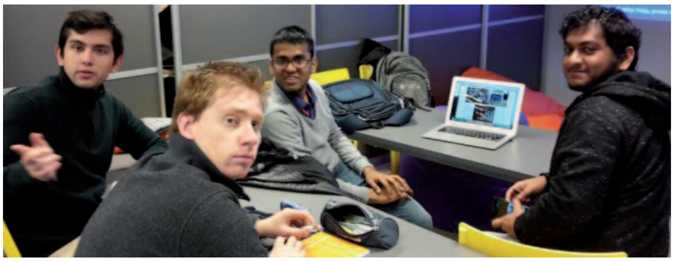

Fig. 2. During the prototype design process

The standardization of different topics allows creating the best practice, based training materials and lecturing notes. This approach is already partially used in Riga Technical University for foreign students training. For example, a study course “Elements of automation” have been taught to the students in three different study programs. During the course students had to develop a real prototype of a new product or service (fig.2). The goal of the course is to systematize and broaden knowledge, and develop practical skills in new products development with an aim to apply this knowledge and skills in professional situations and everyday activities.


Fig. 3. Pitch presentation

In this course, the involvement of students in the idea development process through individual contribution and group training was tested. As a result, a product on technology readiness level 3 was developed by the student groups. The ideas were presented in the pitch presentation (Fig. 3). The best ideas usually are presented in the annual pitching event Research Slam [10]. Research Slam is a contest for students of RTU. The aim of the contest is to inform students, researchers and a society about research and scientific work of young Latvian researchers in an interesting, engaging and understandable way. To make the competition more exciting, participants have to compete not only for the top prizes, but also for different nominations. The best pitchers are awarded by money price – stipend. The later stage of prototypes should be developed by students in Design Factory of RTU [11] for free. The RTU Design Factory is a lively place that brings together research, education and the industry, creating a new hands-on learning culture and opportunities for radical innovation. It is hosted under the RTU Vice-Rector for Science, and is open to all faculties of the university.

Design Factory provides access for researchers and students to facilities, tools and services for prototyping that allow creating new and complex solutions. The proper technologies are offered in needed range from laser cutting and engraving, 3D printing and scanning to high speed CNC machining and post-processing. This is an opportunity to work with interdisciplinary student and researcher teams to solve real-life challenges from various industries. RTU is a part of the Design Factory Global Network with some of our partners from Switzerland, Chile, Korea, China and, of course, the very first Design Factory in Aalto University, Finland.

## V. Assessment of approach

The proposed approach was tested with a group of visiting students in frame of the Erasmus plus "Physics" project. Project Physics aims to reform training programs in applied physics disciplines nanotechnology, nanomaterials and photonics and to promote the emergence of innovation and economic growth in Belarus. Academic institutions and industrial partners' cooperation will result in creation of new master level study programs, training courses and appropriate teaching materials. The project has to set up a virtual platform, where all partners have access to training materials, virtual lectures and the electronic library. The project scope is to modernize academic programs in the several topics of applied physics, the project will contribute to education process in such aspects of this topics as photonics and nano-materials. The student straining at the Riga Technical University was done in a frame of Work Package *Development and modernizing of curricula – Students training*. The testing of compatible/unified curricula and a description of a progress on development of study programs in partner universities where made with teams from each Erasmus+ Physics partner university. The project involves leading higher education institutions of Belarus: BSU - Belarusian State University, GrSU - Grodno State University, GoSU - Gomel State University, and BSTU - Belarusian State Technological University.

One of the Quality assurance elements is new courses, methodology and teaching materials testing, when the students from EU Partner' countries come to EU universities. Two weeks long students training courses provide a good opportunity to the team of EU and Partner' countries teachers to get very prompted feedback, to analyse success and faults and start corrective actions if needed. In a frame of Physics, a group of Belarusian students and professors participated in the second training course arranged by the Faculty of Power and Electrical Engineering of RTU in September - October 2017. One of the targets of this course was to evaluate some elements of new courses before to start two years testing in Belarusian universities. The second target was to introduce a new approach that promotes innovation competences acquisition by students. The students from 4 different universities with different background (engineering, theoretical physics and chemistry) had been divided in groups according to the Belbin test roles in teams. The students where trained in electrotechnics, project management, microcontrollers development and testing of the final product. The students had a free access to the student's laboratory, where prototyping was done. During a training course of Belarussian students, the testing of electromagnetics emission of equipment (Fig 4.) was arranged among other practical labs.

Fig. 4. During the electromegneting emission testing process

The testing of offered students training approach was finished with presentation of practical prototypes (Fig. 5). The students of non-engineering specialties integrated themselves in the engineering environment very well, and in two weeks where able to demonstrate prototype of market – oriented product. The development of mutually recognized approach for the development of new products, the testing of this approach for different groups of students, especially in international groups give a good solid background, which is useful for RTU, as well as for international partners and will be elaborated in the common report of recommendations, in a frame of the Physics project.

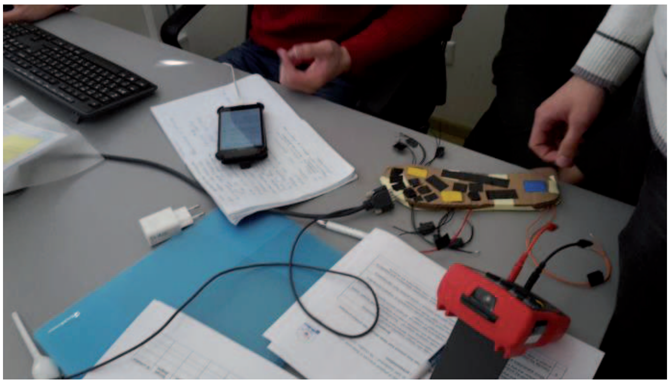

Fig. 5. During the discussing of electromegneting testing process

This approach is planned to implemented in Belarussian universities step by step. Firstly, analyses of partner's study programs revealed rather weak concordance among study programs used in different partner countries, moreover even partner universities with the similar study programs are not able to ensure students teaching the same courses as their homeland universities. Therefore, partner universities foreseen sharing joined e-learning platform that helps a student, which takes a course in the partner university, to feel more comfortable and to have easier adaptation after returning to a homeland university.

The project – based learning as a main methodological approach, for principles (PBL) has become an inherent part of student's education and in particular for final thesis research. Cognitive skills via PBL is associated with increased capability on the part of students for applying learnings in a novel, problem-solving context. A systematic bachelor, master and doctoral course students' involvement into collaborative projects appears as a more effective approach. Firstly, a student participates in a project as an assistant or sometimes as a young researcher among more experienced researchers. At the next step the students develop their skills in student project team headed by experienced senior researcher. Finally, the most advanced students could be authorized to independently manage a project team. Therefore, student step by step moves forward starting from the projects, in which he or she acts as an assistant, by the state when the student is authorized to manage an entire project.

## VI. Testing of Approach

The feedback evaluation after the testing of the approach was implemented. Belarusian partners were presented by 16 students, additionally, 6 Belarusian professors and lectors participated simultaneously as teachers, learners and evaluators (see distribution of learners at Fig.6).

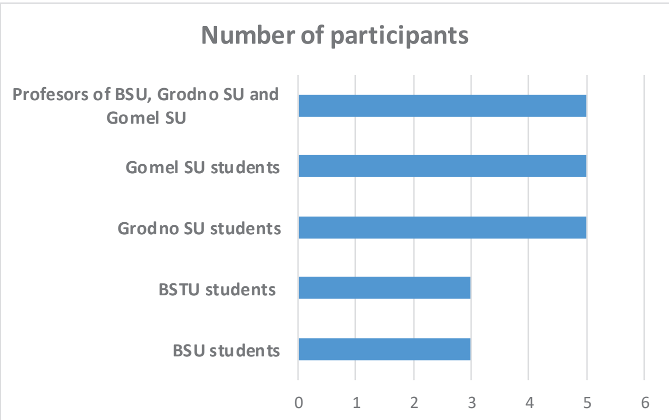


Fig. 6. Distribution of learners among universities

Nine professors and lectors of the Institute of Industrial Electronics and Electrical Engineering and Department of Innovation and Business Management introduced the course, which included lectures, practical labs, creation a roadmap for development of innovative products, and presentation of these roadmaps by student teams at the final of the courses. Home tasks concerning innovative products were distributed among the students as preparation for the training course. At the end of the course we conducted a survey among the students and Belarusian teaching staff participated in the course.

*Organisation of survey*

The survey was presented in the form of an anonymous questionnaire and answered by the participants at the last day of the course in October 2017. The participants were asked to provide some personal background information, including:

- Whether are they students or professors?
- Which of the universities they represent?

Additionally, an open question to participants whether they do have any comments, suggestions about the training and what they liked and what could suggest for improvements was included at the end of each questionnaire.

The survey included a set of questions, where participants were asked to rate, according to their perception, the relevance of each of the following evaluation criteria, using a Likert scale from 1 (not relevant) to 5 (very relevant). The distance between each scale point is assumed equal, therefore, a mark 3 represents the neutral value in this scale. The survey items were as follows:

- All curriculum themes required to achieve the defined learning outcomes were covered.
- The course was well-structured and the themes were explained in a comprehensible manner.
- The logical structure of the lecture was maintained.
- Audio-visual materials were efficiently used during the lecture.
- Creative thinking and practical application of theory was efficiently promoted.
- During the class the amount of theoretical material and practical tasks was balanced.
- Recommended literature sources were accessible and helped in acquiring the course materials.
- The lecturer/professor's attitude to the students was positive and helpful.
- The time for the completing of the practical tasks was enough.
- The information about the classes organisation was clear and easy available.
- My knowledge of English language was sufficient to understand all learning materials presented by teacher.

We asked the respondents to answer to 11 questions. Ten of them were devoted to the content and quality of organization of the course. Furthermore, we included one question about English language skill, which, as we considered, could help to evaluate the ability of students to acquire learning material.

There were 21 respondents to the questionnaire. Of those, 16 were the students of four Belarusian universities, 5 respondents were the professors, who participated in training courses as teachers and as evaluators. We analysed the responses of polling participants concerning their answers on the evaluation criteria of the quality and relevance (see Fig.7). First, we presented an overview of descriptive statistics: the mean scores for the classification of relevance, for each evaluation criteria. Then, as we were interested in determining the extent to which there was a significant difference in the obtained scores, we tested whether the found differences were statistically significant. Our null hypothesis was that all criteria were similarly relevant. The alternative was that some of them were significantly more, or less, relevant for the presented course evaluation.

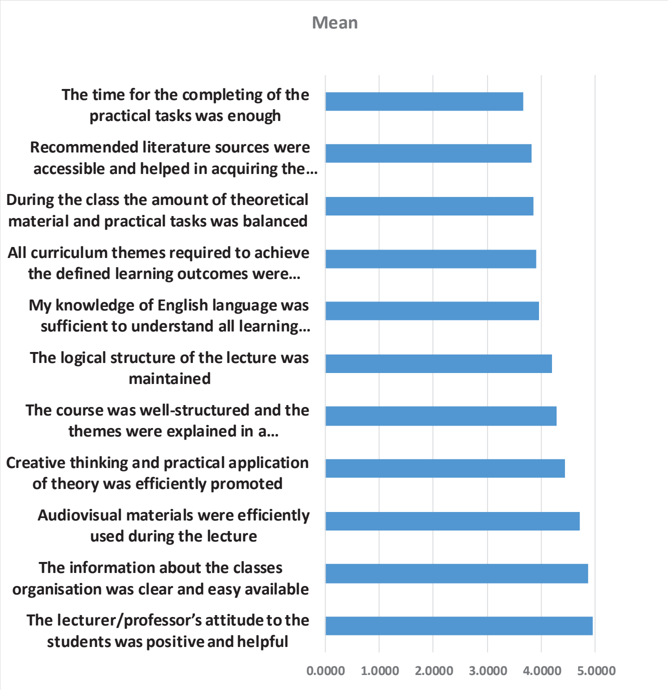


Fig. 7. Distribution of answers by evaluation criterias

The results have been analysed with two different degrees of granularity. At a finer granularity level, we observe differences in the means and the distribution of the answers provided by our participants. Fig. 7 and Table I present a broken down view of the mean scores for the scores distributions, i.e., those represented as leafs in the topics break down. Therefore, values closer to 5 represent the topics received the higher grade, while values closer to 1 would represent the least evaluation grade. The number of answers (21) is the same for all topics, reflects that all participants were ready to provide answers about each topic.

TABLE I. FINE-GRAINED DESCRIPTIVE STATISTICS OF EVALUATION CRITERIA

| Evaluation criterion | Mean | Std. dev. |
|---|---|---|
| All curriculum themes required to achieve the defined learning outcomes were covered | 3.9048 | 0.8109 |
| The course was well-structured and the themes were explained in a comprehensible manner | 4.2857 | 1.0754 |
| The logical structure of the lecture was maintained | 4.1905 | 0.8518 |
| Audiovisual materials were efficiently used during the lecture | 4.7143 | 0.5471 |
| Creative thinking and practical application of theory was efficiently promoted | 4.4286 | 0.5832 |
| During the class the amount of theoretical material and practical tasks was balanced | 3.8571 | 0.9404 |
| Recommended literature sources were accessible and helped in acquiring the course materials | 3.8095 | 0.9571 |
| The lecturer/professor's attitude to the students was positive and helpful | 4.9524 | 0.2130 |
| The time for the completing of the practical tasks was enough | 3.6667 | 1.1684 |
| The information about the classes organisation was clear and easy available | 4.8571 | 0.3499 |
| My knowledge of English language was sufficient to understand all learning materials presented by teacher | 3.9524 | 1.1329 |

*The lecturer/professor's attitude to the students* got the highest ranked topic, while *The time for the completing of the practical tasks was enough* was the one obtaining the lowest scores. Nevertheless, we did not find topics, which obtained significantly higher (or lower) scores than all the others. *The lecturer/professor's attitude to the students* had significantly higher scores (M = 4.9524, SD = 0.2130) than *During the class the amount of theoretical material and practical tasks was balanced* (M = 3.8571, SD = 0.9404), *Recommended literature sources were accessible* (M = 3.8095, SD = 0.9571), and *The time for the completing of the practical tasks was enough* (M = 3.6667, SD = 1.1684).

More generally, the top ranked evaluation topics had a distribution of classifications with a statistically less difference when compared to *The time for the completing of the practical tasks* and *The course was well-structured and the themes were explained in a comprehensible manner*.

We also analysed the responses of participants slicing the answers by university' dimension. Additionally, one more dimension was analysed together with the universities – *Teachers* (see Table II).

TABLE II. DESCRIPTIVE STATISTICS OF EVALUATION CRITERIA BY UNIVERSITIES

| University | BSU | BSTU | GoSU | GrSU | Teach |
|---|---|---|---|---|---|
| ***Evaluation criterion*** | ***Mean*** | ***Mean*** | ***Mean*** | ***Mean*** | ***Mean*** |
| All curriculum themes required to achieve the defined learning outcomes were covered | 4.000 | 3.667 | 3.800 | 4.000 | 4.600 |
| The course was well-structured and the themes were explained in a comprehensible manner | 3.667 | 4.333 | 3.800 | 4.400 | 5.000 |
| The logical structure of the lecture was maintained | 3.333 | 3.667 | 3.800 | 4.600 | 5.000 |
| Audiovisual materials were efficiently used during the lecture | 4.333 | 4.667 | 4.800 | 4.600 | 5.000 |
| Creative thinking and practical application of theory was efficiently promoted | 4.000 | 4.000 | 4.200 | 5.000 | 4.600 |

| | | | | | |
|---|---|---|---|---|---|
| During the class the amount of theoretical material and practical tasks was balanced | 3.667 | 3.333 | 3.600 | 4.400 | 4.000 |
| Recommended literature sources were accessible and helped in acquiring the course materials | 4.000 | 2.667 | 4.000 | 3.800 | 4.200 |
| The lecturer/professor's attitude to the students was positive and helpful | 4.667 | 5.000 | 5.000 | 5.000 | 5.000 |
| The time for the completing of the practical tasks was enough | 2.000 | 3.333 | 3.800 | 4.200 | 4.200 |
| The information about the classes organisation was clear and easy available | 5.000 | 4.667 | 4.800 | 4.800 | 5.000 |
| My knowledge of English language was sufficient to understand all learning materials presented by teacher | 1.667 | 4.333 | 4.200 | 3.800 | 5.000 |
| | **3.667** | **3.970** | **4.164** | **4.418** | **4.691** |

Analysis of the answers revealed significant differences in the answers among the universities. For example, *The time for the completing of the practical tasks was enough* is evaluated by BSU students as M = 2.000, BSTU students: M = 3.333, GoSU students: M = 3.800, GrSU students: M = 4.200, and by the teachers: M = 4.200. The other topic, which showed rather different perception related the training course evaluation was *My knowledge of English language was sufficient to understand all learning materials*: (BSU: M =1.667, BSTU: M = 4.333, GoSU: M = 4.200, GrSU: M = 3.800, and the teachers: M = 5.000). The students of BSU accepted their weaker English language skill in comparison with the other participants.

Similar to the previous two topics the participants put diverging evaluation marks to *The logical structure of the lecture was maintained* (BSU: M =3.333, BSTU: M = 3.667, GoSU: M = 3.800, GrSU: M = 4.600, and the teachers: M = 5.000).

We noticed that evaluation marks given by GrSU students are closer to these ones provided by the teachers. It turned out that GrSU administration arranged selection of candidates for training courses according criterions such as English language skill, academic progress and motivation of candidates.

*Discussions*

In the first day of the training course students of for universities were mixed and the divided to four teams using a method of Belbin Team Roles [12]. The method helped to find out strengths and weaknesses taking into account students strengths: talents, knowledge and skills, which can be used to advantage at teamwork. Each group had a task to develop an idea of new product and to present at the end of the course.

Evaluation criteria did not include any direct question about self-evaluation of personal contribution to deliverables of the team a student participated in [13]. However, we admit that students expressed indirectly answering to the topic. *The time for the completing of the practical tasks was enough* or *Creative thinking and practical application of theory was efficiently promoted*. We believe this issue to be resolved in future student training courses.

Taking into account divergent opinions expressed by different groups of respondents we need to look for appropriate balance between theoretical and practical parts of curricular developed in the project. This task is not trivial, since higher education in Belarus now is on a transition track from the old education to Bologna one. Due to the Ministry of Education set a target to reduce education time of specialists from 5 to 4 years, in reality the students with 4 years' and 5 years' education programs often will be educated simultaneously. In the presented training course, the mix of 4 and 5 years' education program' students was presented. That is why we presume our evaluation study as a preliminary one. We believe that that two years testing (the first one during the Physics and the second one beyond the project) together with the corrective actions on a feedback will be a good method for evaluation the quality of the courses against the targets set by the project.

## CONCLUSIONS

The implementation and continuous development of industry – academia cooperation provides the support for creative thinking skills strengthening of undergraduates' students in electrical engineering. This approach comprises a module of professional business-competence creation: innovations management, business organization and establishment, management methods, business economics, project development and management, record-keeping and financial accounting system, knowledge of the regulations concerning employment, social dialogue among the public, as well as knowledge of other innovations in the business or institutions management. The module is implemented primarily through competence training, business games and similar practical methods. The training of idea evaluation, concept development, market analysis, pitch presentation, prototype development, electromagnetic parameters testing as well as discussion with potential cooperation partners where done.

The application of PBL is focused on the questions that drive students to encounter the central concepts and principles of a subject hands-on. The PBL approach in RTU is extremely important, for developing innovations and technical progress in Latvia. PBL in general provides complex tasks derived from challenging questions or problems that involve the students in problem solving, decision making, investigative activities, and reflection that includes teacher' facilitation, but not direction. Application of PBL in RTU encouraged creation positive communication and collaborative relationships among diverse groups of students, because it met the needs of learners with varying skill levels and learning styles. The usage of joined e-learning platform allows standardizing 'de facto' lecturers, practical training, testing and other virtual laboratory based study activities. The joined e-learning platform opens huge perspectives in the voluntary curricula standardization and co – working in international groups.

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