Developing a Mutually-Recognized Cross-Domain Study Program in Cyber-Physical Systems

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***Abstract* — The primary scientific targets of the European COST Action Multi-Paradigm Modelling for Cyber-Physical Systems (MPM4CPS) are: i) the conceptualization of techniques and tools for improving interoperability; ii) the development of new ontologies and formalisms (and the links between them) to deal with the heterogeneity; and, iii) to perform the integration of the problems resulting from several application domains, under a common MPM4CPS umbrella. The action also aims at crystallizing MPM4CPS contents into a suitable format for educational purposes. This entails to create the base for a European Master and PhD program in MPM4CPS involving several European leading Universities and setting up the respective discipline roadmap facing the challenge of development mutually recognized cross-domain expertise based study program in CPS. This paper offers a methodology for the creation of CPS expert profile for educational purposes, provides an analysis of results of an initial survey of experts in the field and sets up a discussion about the next steps of the research. The paper depicts the work in a progress.**

Keywords — Multi-Paradigm Modelling, Cyber-Physical Systems, design and simulation, software engineering, electrical engineering, computer engineering, student master program development.

I. Introduction

Recent technological advances on the Internet of Things along with industry interests open new opportunities for the collaboration and development of Cyber-Physical Systems products and applications on an international level. These new market opportunities need to be covered by a new generation of engineers with a multi-disciplinary background in mechanical, electrical and computer science engineering, capable of delivering market-oriented products from the idea till the end product alone or in the researchers' groups. Another key competence of this new generation of engineers is the ability to employ multi-paradigm modeling to overcome engineering complexity. The competencies offered by standard educational approach are not flexible enough to support market-oriented developers' preparation. The new programs and tools supporting both technological and business skills educational approach should be opened to the students.

The integration of physics-based and complex digital world models based on Big Data provides learning and predictive capabilities for decision support (e.g., diagnostics, prognostics) and autonomous operation. Systems engineering-based open architectures and standards

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provide for modularity and composability for customization, systems of products, and complex or dynamic applications [1]. These trends anticipate the reality where a new breath of products is about to be developed and reach the market that is requiring a prompt response from the European academia.

The development and deployment of mutually recognized Master Programs in European universities is a basis for increasing of student exchange, using Erasmus Plus and other cooperation networks. This instrument should be leveraged to create a specialized offer in Cyber-Physical Systems. Towards this desideratum, the priorities for education settled up under the European cooperation action for science and technologies in Multi-Paradigm Modelling for Cyber-Physical Systems MPM4CPS [2] are:

- Identify the adequate profile(s) of CPS experts (i.e., the minimum required knowledge);
- Identify existing courses in the realm of CPS and MPM4CPS in Europe, and the need for new courses on topics relevant to CPS not yet covered by the European Universities;
- Lay out the basis for a European Master/Ph.D. Program in MPM4CPS involving several European-leading Universities (and companies) and set up the corresponding discipline roadmap.

The most relevant pan-European Master's Program in Pervasive Computing and Communications for Sustainable Development PERCCOM [3] is an example of good practice and highly positive evaluation template by European Erasmus Mundus framework experts. However, to achieve mutual recognition of master programs in Europe the divergence of applicants' background, as well as specific education at the national level should be taken into account.

The paper offers a methodology for the creation of MPM4CPS expert profile for educational purposes. As the first step of the research, the paper provides an analysis of results of an initial survey of experts in the field and sets up a discussion about the next steps of the research.

II. European Efforts towards Cyber-Physical Systems Education

Smart (embedded) systems are regarded as the most important business driver for European industry. They are a targeted research area for European Research Programs in Framework 7, European Technology Platforms (ARTEMIS [4], ENIAC [5], EPoSS [6]) and now for the follow-up JTI ECSEL (Electronic Components and Systems for European Leadership) in Horizon 2020 [7]. They are not only used in the traditional areas of aerospace, railways, automotive, or process industry and manufacturing, but also in robotics and services of all kind, home appliances (smart homes, ambient assisted living) and health care.

ARTEMIS has founded an Education and Training (E&T) Working Group [8] to establish a strategic agenda for E&T, taking into account the needs of the European industry. The E&T WG was vision to achieve a self-sustaining Innovation Environment for European leadership in Embedded Systems (ES) / Cyber-physical Systems (CPS). Its mission was to enable long-term sustainability of this Innovation Environment by: contributing to an infrastructure for E&T that facilitates new content and curricula; strengthening links between industry and academia; raising business awareness and facilitating short-term exchange and training in both directions (industry and academia), complementary to long-term basic research, etc.

Additionally, in Part D, provided by the EPoSS Industrial Association (European Technology Platform on Smart Systems Integration), education plays an important role in their ecosystem as well, as is demonstrated by the following figure taken from the ECSEL MASRIA 2014, Part D "Smart Systems" (see Fig.1) [9].

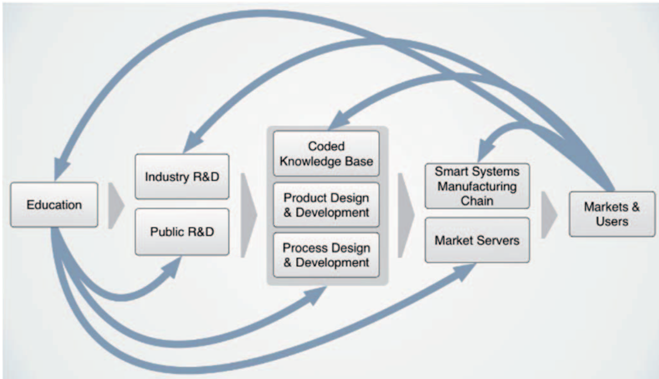

Fig. 1. A European ecosystem for Smart Systems according to [9]

Very detailed and comprehensive analysis of EU policy in Electronic Components and Systems for European Leadership and especially about Cyber-Physical Systems as well in education and training for the needs of the industry in the last decade is provided in [10, 11].

A. The response of Applied Sciences universities

In general, the knowledge that is necessary to design large-scale hardware / software systems of *today is so large and complex that it is impossible to teach it to a student in a single bachelor or master program* [12]. Hence, there is the problem of coming up with educational programs that teach at least significant parts of system design technology, which are basic, such as e.g. digital system design, software technology, or fault tolerant computing. The research [12] identifies the gaps between Bologna education system approach applied by German, Czech and Estonian universities and industry needs.

Universities of applied sciences have reacted to new trends in student interest and introduced programs that neglect basic education and introduce a high degree of specialization quite early. Of course, students from such programs are not natural candidates for post-graduate studies. For example, Brandenburg University of Technology, after having been merged with a former university of applied science in 2013, has started to introduce a one-year college program (Fig. 2). It is mainly meant to be placed between secondary school educations and starting of Bachelor programs to make up for the shortcomings in school education.

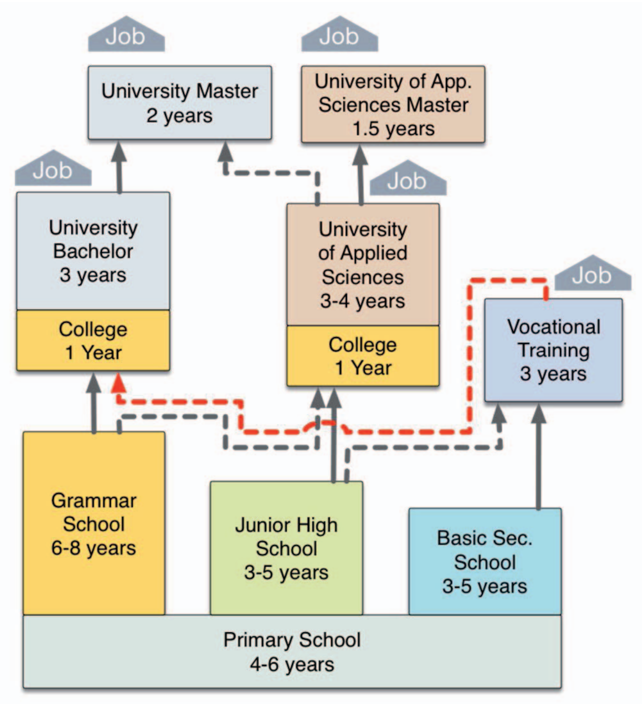

Fig. 2. Education paths with college phase (adapted from [12])

One of the conclusions is the Bologna reform, by replacing the technical diploma by bachelor and master, left little space for periods of industrial training as part of the programs. Industrial training periods were essential parts of most diploma programs, but are becoming scarce in university bachelor and master programs.

A. A new type of researcher

The other conclusion was the industry has a focus on development rather than research. While the accomplishment of a doctoral thesis often meant that research in this area was ending, assuming a continuation in industry, universities now need to carry a specific technology for a longer time to make it more ready for final industrial applications, not necessary in a single company. Even more important, doctoral education now becomes a necessity to make students fit for real demands from potential industrial employers. As shown before, the educational system installed today leaves little room at the level of bachelor and master education for the student to get a comprehensive view about basic technologies on a wider scale.

In the area of ever-increasing system complexity, education has to react by producing scientists and engineers who at least have a chance to understand such systems. Doctoral students, who were mainly driven towards in-depth research in very narrow areas, no get this new role, since the "final" education by industrial research labs has almost vanished. Universities have to accept this new role, favorably in schemes of international collaboration and networking [12].

B. Experimentation facilities

One of the major limitations of the existing ***Internet based distance-learning courses*** is their failure to deliver experiment related courses. Currently, students from distance learning programs have to visit a campus to perform the experiment sessions within a limited period of time, which is usually insufficient to allow them to complete their learning cycle [13].

A cyber-physical experimental facility can provide cost effective and unlimited access to experiments and maximize utilization of available resources. Moreover, this type of facility will allow collaboration among universities and research centers by providing research and student groups' access to a wide collection of expensive experimental resources located in geographically distant locations. The paper [13] describes a potential structure of cyber-physical systems and their use in education and research. It illustrates the design and development of three cyber-physical systems- smart house, mobile robot, and an embedded processor.

Ongoing training to support life-long learning by practicing engineers, who will continuously face new technologies and challenges, is a crucial issue for continuing education, both inside and outside the university Researchers and educators have proposed many different empirically driven suggestions for topics, with dependability and efficiency frequently mentioned. For example, one study observed professionals who created a system for use by disabled and elderly users, and this research discovered that the engineers needed better training in the design and implementation of accessible cyber physical systems [14]. This insight about engineers' actual training needs was only obtained by paying attention to their everyday work.

To uncover additional training needs of practicing engineers who create cyber physical systems, the work [15] provided an analysis of over 150,000 questions that had been posted to an online website forum, whereby engineers asked for help with their everyday work. The forum has been operated since 1999 by National Instruments, which is the company that provides the LabVIEW development environment. The main challenge raised by the study is to help cyber physical engineers with how to find and learn from code.

One of conclusions of this study was the viability of the case-study approach for training students in how to reuse components in safety-critical cyber physical systems [16]. Case studies could similarly be used to organize and synthesize the many disparate resources available online for training engineers. According to [15] such approach could link to different resources, including reusable code, whitepapers, videos, and 3rd-party tutorials for detailed aspects of the case study. Progressing through online case studies over the years could enable engineers to accumulate proficiency usable for creating effective cyber physical systems.

III. GLOBAL VOLUNTARY STANDARDIZATION AND EXPERTISE

Although internationally accepted guidelines for education in Computer Science and Engineering, Cyber-Physical Systems is an area, which requires cross-domain competence on a spectrum that spans from traditional Mechanical and Electric Engineering to Computer-Science engineering and even Business.

The international bodies have put forward clear guidelines for global education in Computing-related programs (IEEE Common Nomenclature for Computing Related Programs in Latin America). The guidelines designed to assist educational institutions, accrediting bodies and other organizations in mapping the category of their computer programs in relation to categories recognized by international organizations are specified [17].

The development of applied cyber physical system even for standard application is a challenge for engineering domain; therefore, a trans-domain education approach should be used.

The development should be done taken into account the international voluntary standardization for final products, like IEEE 1686-2013 (IEEE Standard for Intelligent Electronic Devices Cyber Security Capabilities) IEEE C37.240-2014 (IEEE Standard Cybersecurity Requirements for Substation Automation, Protection, and Control Systems), IEEE C37.240-2014 (IEEE Standard Cybersecurity Requirements for Substation Automation, Protection, and Control Systems)

The development of Machine to machine learning in to the Embedded Systems, as well as the steps towards the Cyber-Physical Systems Approach [18] requires the future development of study programs it the area of cross integration of computer science, electronics, electrical engineering and telecommunications. The issues of Cyber-Physical Systems challenges for automation are depicted in [19] (see Fig. 3).

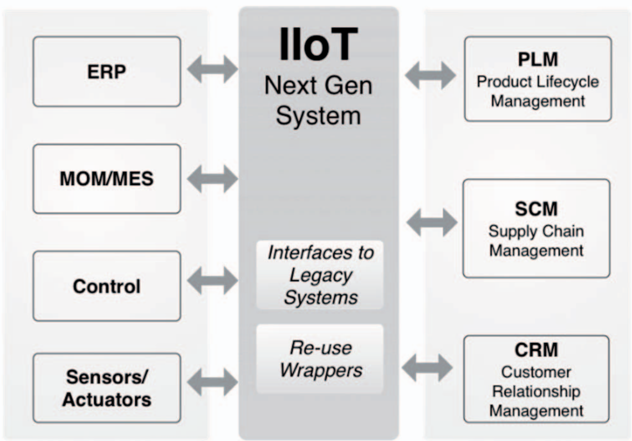

Fig. 3. CPS Challenges for automation (adapted from [6])

Development of study program can be considered from the system theory view, where the study program is a result from certain operation with several input parameters. In industrial setting, the following classification of knowledge has been introduced and is used to analyze company's competitive position [20]: core knowledge; advanced knowledge and innovative knowledge. Core knowledge is the basic scope and level of knowledge that represents a basic industrial knowledge barrier to entry. Advanced knowledge enables the company to be competitively viable. It is company's superior knowledge in certain areas. Innovative knowledge allows company to lead the entire industry. The same classification of knowledge can be applied to the contents of curricula like [21] or [22] and courses in continuously changing knowledge areas to characterize the competitiveness of a curriculum and, consequently, the competitiveness of students in the labor market [23]. Thus, from the point of view of study program development, the core knowledge is knowledge that guarantees students' ability to enter successfully the labor market, advanced knowledge provides background for advanced positions in the labor market, and innovative knowledge supports opportunities to obtain leading positions in the industrial labor market [24].

Taking into consideration knowledge partitioning given above, the input parameters for study program development can be the following:

- Theory of knowledge area / fundamental things;
- Standard of the profession / specialty;
- Network of study program courses;
- Resources for study program realization;
- Others.

In turn to prepare students to be qualified to meet the required industry competencies [25] and gain sufficient knowledge in various areas related to CPS, curricula developers must consider also (1) the complex working environments; (2) recent technologies; and (3) tools and skills, in order to prepare their students to fulfil the expectations of the industry [26].

One of the challenges in study program development is bridging the gap between industry needs and education output in terms of the prospective CPS engineers. One of the main problem to complete this challenge is outdated curricula and teaching contents. For education of software engineers SE body of knowledge [27] can help in overcoming this problem and is vital in developing state-of-the-art SE curricula in addition to the market demands to align the curricula with the SE models and standards. This includes SE body of knowledge (SWEBOK) [27] , IEEE-CS and ACM SE2004 guidelines [28], IEEE-CS and ACM SE2014 guidelines [29] and the GswE2009 guidelines (which are particularly for graduate level curricula) [30].

CPS now is one of several current drivers of change in engineering education. Some of the attributes expected of modern engineers: flexibility to manage rapidly evolving technologies; an ability to define as well as solve problems; skill and experience with creativity, entrepreneurship, and public policy implications; and facility with both theory and application [31]. Moreover, for CPS engineering there is no such or body of knowledge as we have for software engineer, where CPS engineer should be educated in. One of the ability to define taxonomy of core knowledge is to base it on CPS expert profile, which is the research object in this paper.

IV. The Challenge of Harmonization of National and International Studies in Partners Universities

The partners of the COST Action IC1404 Multi-Paradigm Modelling for Cyber-Physical Systems acquired a valuable experience in academic research and education in the areas related to CPS, furthermore, they intend to comprehend their knowledge. For example, Wallenberg Autonomous Systems Program (WASP) is Sweden's largest individual research program ever, and provides a platform for academic research and education, fostering interaction with Sweden leading technology companies. The program addresses research on autonomous systems acting in collaboration with humans, adapting to their environment through sensors, information and knowledge, and forming intelligent systems of systems.

Chalmers University of Technology and University of Gothenburg, Sweden, participated in the development of a FLYAQ platform for supporting environmental monitoring missions of swarms of autonomous quadrotors, which provides facilities for simulating, monitoring and (optionally) controlling the behavior of the quadrotors. The use of Model Driven Engineering (MDE), definition of the architecture and implementation has been investigated by both universities within the EU project titled "Achieving Complex Collaborative Missions via Decentralized Control and Coordination of Interacting Robots (Co4Robots)", Call H2020-ICT-2016-2017.

Riga Technical University contributed in the "Production and Energy System Automation Intelligent-Built environment and urban infrastructure for sustainable and friendly cities" (Arrowhead), ARTEMIS EU program. Within the Arrowhead project technologies addressing the capability of building large System of Systems based on IoT using a service-oriented approach has been in focus. The results have been tested in more than 20 real world automation and digitization use cases. Resulting in a technology framework supporting some of the most prominent requirements to automation system.

V. Approach Overview

The offered methodology pursues to develop a CPS expert profile(s) into a suitable format for educational purposes. It should be done in several steps (see Fig. 4):

- To investigate an existing literature on the topic (books, articles), while defining course material (online, etc.);
- To arrange a survey among the partners in order to identify and classify the competencies, which partners recognize as indispensable and most relevant related to particular areas of CPS.
- To identify the adequate profile(s) of CPS experts (i.e., the minimum required knowledge);
- To identify existing courses in the realm of CPS and MPM4CPS in Europe, and the need for new courses on topics relevant to CPS not yet covered by the European Universities;
- A systematic review of scientific literature and research providing by the other projects and education institution helps to be in align with the latest innovation in the field.

All this knowledge elaborated at the first stage of the project will serve as an input for creation of a CSP expert taxonomy. The final stage of the research is a validation of the CSP expert taxonomy. The validation will be done at the project final stage and beyond of the project. Furthermore, the partners will test CPS expert profiles in the students training process at their universities; even some of the partners are planning to use CPS expert profiles as an input in forthcoming ERASMUS+ projects.

At this project stages the team elaborated an existing literature on the topic and completed a survey among the partners. In parallel, the other activities of offered methodology are on the way.

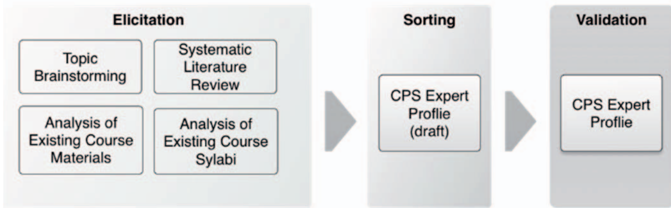

Fig. 4. The methodology used to develop a CPS expert profile(s) into a suitable format for educational purposes

VI. Survey

A. Rationale

Within the scope of the COST Action IC1404 MPM4CPS, we conducted a survey among the members in order to identify and classify the competencies, which they recognize as indispensable and most relevant related to particular areas of CPS, therefore applicable in academic education programs.

The survey was presented in the form of an online questionnaire and answered by the participants in the MPM4CPS Workshop held in Gdansk in September 2016. The participants were asked to provide some personal background information, including:

- Whether they members of the MPM4CPS network, or guests participating in the meeting
- What their professional activity is (industry, education, research, or other)
- Whether they had previous, or current experience with industrial CPS projects
- An open question on participants' background and expertise

The survey included a set of questions where participants were asked to rate, according to their perception, the relevance of each of the following topics for MPM4CPS, using a Likert scale from 1 (not relevant) to 5 (very relevant). The distance between each scale point is assumed equal, and 3 represents the neutral value in this scale. The survey items were as follows:

- Multi-Paradigm Modeling (MPM)
    - Multi-Formalism
    - Multi-Processes
    - Multi-Approximation
    - Multi-Abstraction
- Application Domains
    - Automotive Industry
    - Avionics Industry
    - Home Automation
    - Smart Cities
    - Astrophysics or High-Energy Particle Physics Detectors
- Cyber-Physical Systems (CPS)
    - Hybrid Systems
    - Combination of Domains
- Design and Simulation
    - Control Theory
        - Mechatronics
            - Fluids
            - Bio-Systems
            - Robotics
        - Tools and Languages
            - Pure Numerical
                - SPSS
                - SimaPro
                - Monte Carlo
                - Real-Time Physics Engines
            - Agents-Based
        - Industrial Design
            - Matlab
            - Modelica
            - Simulink
            - Other
- Software Engineering
    - Application Domains
    - DSL foundations
    - Verification
        - Automated test generation
        - Formal Analysis
        - Usability
    - Validation
        - Empirical Analysis

B. Results

1) Who answered this questionnaire?

There were 20 respondents to the questionnaire. Of those, 18 are members of the MPM4CPS network, while two were guests participating in the Gdansk meeting.

Concerning the professional background, 16 of the respondents are researchers, 13 educators, and two come from industry (Fig. 5). Note that the categories are not exclusive: several of the researchers are educators, as well (i.e. they are Faculty members).

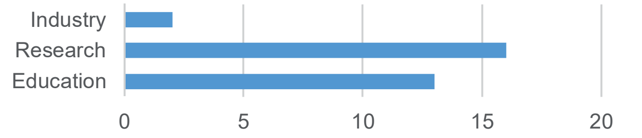

Fig. 5. What is the professional background of the respondents?

We also wanted to know the extent to which the respondents had prior experience with CPS industrial projects. 40% of our respondents participate, or have participated in industry projects on CPS.

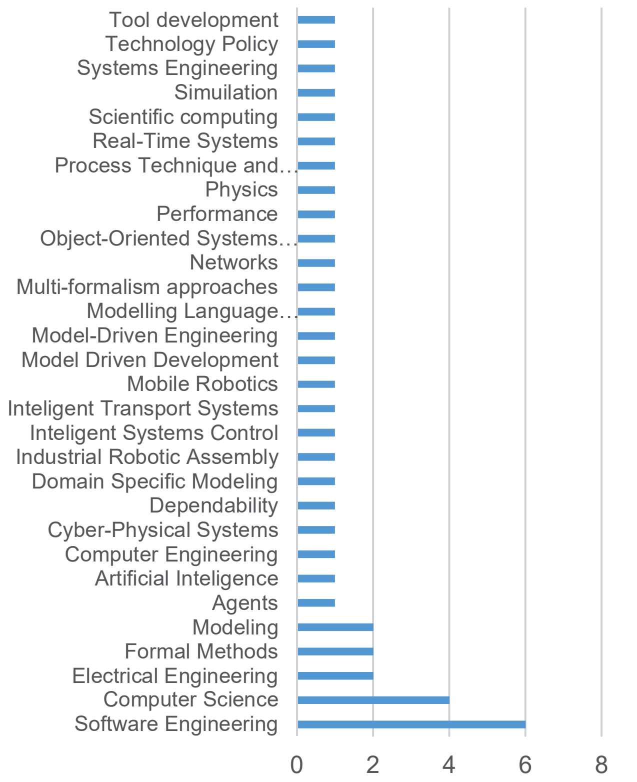

Fig. 6. Self-reported expertise

Concerning expertise, the participants in our survey identified their expertise into 30 different categories (Fig. 6). The most frequently identified expertise subject was Software Engineering (6 out of 20 respondents), followed by Computer Science (4), Electrical Engineering (2), Formal Methods (2), Modeling (2), and several other areas of expertise with only one single occurrence in our sample. Overall, we observe a predominance of respondents with a background of software systems development, as well as a diverse spectrum of expertise.

2) Which of the elicited topics are more (and which are less) adequate for a MPM4CPS curriculum?

In this section, we analyze the responses of our participants concerning their answers on the adequacy of each topic for the MPM4CPS curriculum. We first present an overview of descriptive statistics (the mean scores for the classification of relevance, for each category). 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 topics were similarly relevant. The alternative was that some of them were significantly more, or less, relevant for the MPM4CPS curriculum.

We analyze the results with two different degrees of granularity. At a higher abstraction level (first level topics, in the list of potential MPM4CPS subjects proposed in survey structure), we have an overview of the most relevant broad topics (Fig. 7, and Table 1).

The sub-topics directly concerning CPS have a mode of five (very relevant). Sub-topics concerning MPM, Application Domains and Software Engineering were considered relevant, mode of 4. Finally, design and simulation have a mode of 3 (the neutral value in the used Likert scale), with the vast majority of answers provided between either 3 (the mode) or "relevant". Among the surveyed topics, these were the ones receiving lower rankings.

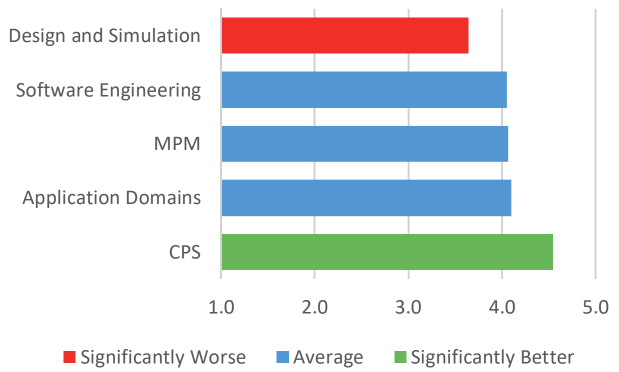

Fig. 7. Distribution of answers by High level MPM4CPS topic perception

TABLE 1 - HIGH-LEVEL TOPICS DESCRIPTIVE STATISTICS

Topic	N	Mean	Std. Deviation
MPM	79	4.0633	1.02959
Application Domains	91	4.0989	1.17431
CPS	39	4.5385	0.71987
Design and Simulation	218	3.6376	1.09117
Software Engineering	109	4.0459	1.03981
Total:	536	3.9272	1.09388

For testing our hypothesis, we used the Welch t test, instead of the t test, as it is robust to deviations from the normal distribution, different sample sizes and different variance in the samples.

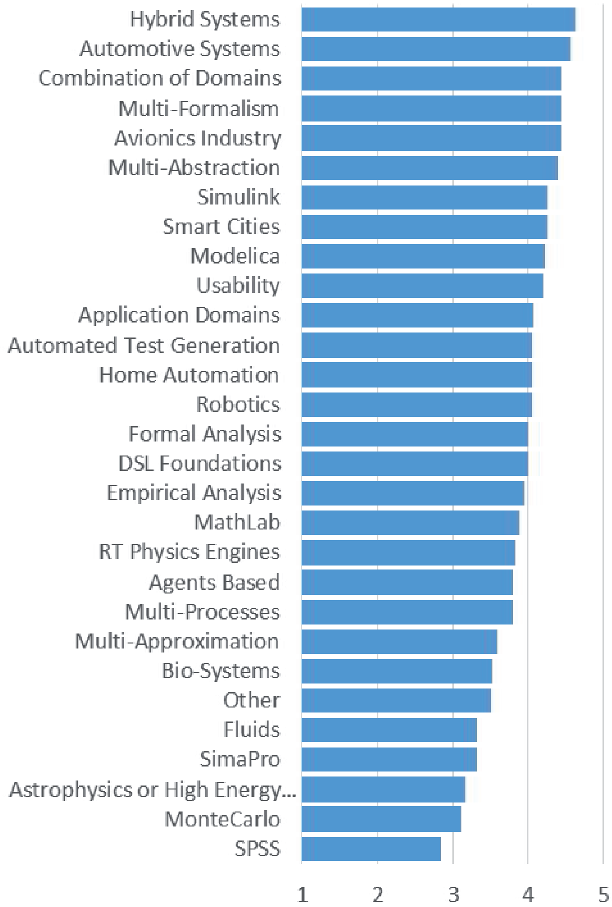

Fig. 8. Distribution of answers by leaf topic

There was a statistically significant difference (see Table 1) between the mean score obtained in the different topics, $t(4) = 11.577$, $p = 0.000$. Post-hoc Games-Howell tests allowed further identifying those differences. The most differentiated topics were CPS and *Design and Simulation*. The CPS topic ($M = 4.5385$, $SD = 0.71987$) had statistically significantly higher scores, when contrasted with each of the remaining high-level topics. In contrast, there was a statistically significant difference between the mean score obtained by the *Design and Simulation* topic ($M = 3.6376$, $SD = 1.09117$) and all the remaining topics.

At a finer granularity level, we also observe differences in the distribution of the classifications provided by our participants to the finer-grained topics. Fig. 8 and Table 2 present a broken down view of the mean scores for the scores distributions, with the more detailed topics, i.e., those represented as leafs in the topics break down. Again, values closer to 5 represent the topics regarded as the best candidates, while values closer to 1 would represent the least relevant candidate topics to include. The different numbers of answers for some of the topics reflect that the answers were not mandatory, as not all participants were familiar enough with all the topics to feel comfortable in answering about each topic's adequacy.

TABLE 2 – FINE-GRAINED TOPICS DESCRIPTIVE STATISTICS

Topics	N	Mean	Std. Deviation
SPSS	20	2.85	1.03999
MonteCarlo	18	3.1111	0.96338
Astrophysics or High Energy Systems Particle Physics Detectors	18	3.1667	1.38267
SimaPro	16	3.3125	1.01448
Fluids	19	3.3158	1.15723
Other	16	3.5	1.26491
Bio-Systems	19	3.5263	1.07333
Multi-Approximation	20	3.6	1.14248
Multi-Processes	19	3.7895	1.08418
Agents Based	19	3.7895	0.85498
RT Physics Engines	17	3.8235	0.80896
MathLab	17	3.8824	1.31731
Empirical Analysis	18	3.9444	0.9376
DSL Foundations	19	4	1.20185
Formal Analysis	19	4	1.1547
Robotics	20	4.05	0.88704
Home Automation	18	4.0556	1.34917
Automated Test Generation	17	4.0588	0.96635
Application Domains	16	4.0625	1.06262
Usability	20	4.2	1.00525
Modelica	18	4.2222	0.94281
Smart Cities	19	4.2632	0.93346
Simulink	19	4.2632	0.93346
Multi-Abstraction	20	4.4	0.75394
Avionics Industry	18	4.4444	0.85559
Multi-Formalism	20	4.45	0.88704
Combination of Domains	20	4.45	0.75915
Automotive Systems	18	4.5556	0.78382
Hybrid Systems	19	4.6316	0.68399
Total:	536	3.9272	1.09388

Hybrid Systems was the highest ranked topic, while *SPSS* was the one obtaining the lowest scores. A Welch t test was performed on this finer-grained topics rankings, following the same rationale as for the coarse-grained topics. Unlike what happened for the coarse-grained topics, here there were no topics which obtained significantly higher (or lower) scores than all the others. Nevertheless, there were differences that were considered statistically significant t (28) = 4.036, p = 0.000. Post-hoc Games-Howell tests allowed further identifying those differences. *Hybrid Systems* had significantly better scores (M = 4.6316, SD = 0.68399) than *Fluids* (M = 3.3158, SD = 1.15723), *SimaPro* (M = 3.3125, SD = 1.01448), *Monte Carlo* (M=3.1111, SD = 0.96338), and SPSS (M = 2.85, SD = 1.03999), but not for *Astrophysics or High Energy Systems Particle Physics Detectors* (M = 3.1667, SD = 1.38267), although this particular topic had a mean classification lower than that of *Fluids* and *SimaPro* (in this particular case, the due to the higher value of the standard deviation). More generally, the top ranked topics had a distribution of classifications with a statistically significant difference when compared to *Monte Carlo* and *SPSS*.

Overall, both for the coarse-grained and for the fine-grained topics, the vast majority of opinions ranged from very positive to neutral, with few exceptions. This should not be surprising, as the list of potential topics was created by identifying potential candidate topics. Even those topics receiving lower scores are often used in the context of projects involving CPS, although they were not perceived by our survey participants as core elements of the CPS expertise. This kind of ranking should be regarded as a relevant element when discussing a CPS curriculum, but not, at least in isolation, as a defining metric for including or excluding a particular topic from the CPS curriculum just because it happens to be above or below some given threshold.

VII. DISCUSSION AND NEXT STEPS

Every profession bases on a body of theoretical knowledge and recommended practices. They are formally defined in a particular form applicable for the development of education and training programs, certification of specialists, or professional licensing. Rapid changes in IT industry and computer science require regular review and analysis of the content and form of existing study programs. Engineering of Cyber-Physical Systems is relatively new and heterogonous engineering field, where the specific technologies are replaced much more rapidly than the engineering work force, and traditions for education and graduation of engineers of CPS are not yet established. Moreover, the development of new study programs should be based on current or future societal needs, i.e. on the labor market, in public or private research and development. When new study programs are developed, potential employers are included early in the process, for example through employer panels and employer surveys.

The results of such survey have been processed and analyzed in this paper in turn to develop a new study program for Cyber-Physical Systems. The conclusions and recommendations for a mapping between the competences and the curricular of the academy process now are underway. However, the working group members recognize the challenge to harmonize the views and perceptions of its members focusing on heterogeneous aspects of CPS: robotics, industrial automation or utilities network control. To address this challenge, several multidisciplinary teams of members are planning to build a collection of educational case studies in both academic and industrial setting to converge on a common vision.

In addition to the previously mentioned efforts, the network is creating a series of books on the topics of foundations, techniques, and tools, to be used in the future as reference books for the courses. Particular care is being taken to invite prominent experts in the area, and a great articulation effort is being made to avoid that the product is a collection of dispersing views.

Ultimately, the synergetic effort of the three above-mentioned approaches will materialize in a robust educational program.

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