

SYSTEMATIC APPROACH TO EDUCATION OF SPECIALISTS FOR A NEW TECHNOLOGICAL PARADIGM

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Abstract The world is about to enter a new technological evolution with cyber-physical systems in its basis. One of the vital questions is exploring of new approaches to training specialists capable to develop, contribute and maintain corporate and industrial infrastructure in the new technological framework. The main goal of this research is to show approach to complex training of qualified specialists in the upcoming economic and technological paradigm in terms of three aspects: whom to teach, what to teach to, and how to teach. Interrelation and the impact of these three aspects on preparation of highly in-demand professionals in the field of cyber-physical systems and control are shown in the article. The main emphasis is made on the question "How to Teach?".

Keywords: digital education; Industry-based education; New forms of teaching; Educational platform; Knowledge management; In-demand skills; Cyber-physics systems

Introduction

The world is on the threshold of the fourth industrial revolution, Industry 4.0. Today, most people believe that digital transformation is inevitable in almost all spheres of life and economics. Fully digital industry based on modern information technology is appearing, including: digital manufacturing, virtualization of production functions, which is accompanied by the formation of a shared economy, change in the functionality of devices without making changes to them as physical objects, by changing the technologies of their control, etc [1].

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Cyberphysical systems provide a technological basis for the transition to a new economic paradigm. The essence of cyberphysical systems consists in that they connect the physical processes of production or other processes that require practical implementation of continuous control in real time with the use of software and electronic systems [2].

The search for new approaches to training of specialists able to develop and maintain corporate and industrial infrastructure in a new technological environment has already become a topical issue.

The aim of this work is to demonstrate an approach to comprehensive training of qualified specialists in the new economic paradigm in terms of three aspects: who to teach, what to teach and how to teach. The primary focus in the research is on the question of How to teach?.

Whom to teach?

It is necessary to improve the education system, as it has to provide the digital economy with competent personnel. At the same time, the transformation of the labor market, which should be based on the requirements of the digital economy, is inevitable. The key factor in the successful transition to this stage is education at all levels, from schools to universities, with the transition to continuous adult education.

In order to make effective use of human potential for the digital economy, it is necessary to provide training *for the widest possible range of citizens* who could be involved in productive activities in accordance with their skills and mobility. This is possible by providing flexible forms of employment, including full-scale distance employment. This range of full participants will include various categories of citizens, from schoolchildren and students to pensioners.

What to teach?

An important factor in the successful development of the digital economy is the contents of training. Now most educational programs are focused on training in the narrow sense of the word, which is the transfer of information, knowledge and some skills. Rather than skills, *it is necessary to develop habits for digital technology and related views*. They can be referred to as competence chains: they consist of super-professional competencies (beliefs, habits, lifestyle, general cultural competencies), professional competencies and basic competencies [7].

As it was noted at the international technology forum in April 2016, the word profession has completely lost its meaning. Profession as a concept ceased to exist long ago, but there are clusters of competence sets. Modern students need to have basic technological skills, to be able to manage a project and make their own decisions, to work in complex interdisciplinary teams.

In our opinion, the ability to perform project-oriented activities is one of these key core competencies. The trend towards the convergence of engineering and managerial education leads to a steady decline in demand for managers with traditional management education and engineers with classic engineering education [4]. The interdisciplinarity of educational courses and programmes is beginning to play a key role. Interdisciplinarity refers not only to joint consideration of problems by specialists from different branches of science and technology, who see it from different sides, but also, and above all, the synthesis of knowledge from different areas aimed at obtaining a new solution to a complex problem, at supporting the implementation of solutions from their conceptualization to implementation and commercialization [5].

How to teach?

Training for digital technologies must definitely be implemented with the use of digital technologies. Suitable digital technologies already exist: these are distance learning environments.

Continuous education should become the norm and one of the pillars of the entire education system. It can be built around continuing education networks which unite suppliers and consumers of individual courses and groups of courses (modules), certifiers (specialists and organizations conducting competence assessment), navigators (specialists and organizations providing information and career support to consumers). Traditional educational organizations should interact with these networks both as course providers and as consumers [3]. The involvement of industries in the development of educational programs content and the definition of a set of skills that professionals must have to find employment is becoming an increasingly clear requirement from the industries themselves [6].

SPbPU is one of the participants of CEPHEI international project, the Cooperative E-learning Platform for Industrial Innovation (co-funded by Erasmus+ Programme), One of the goals of this project is creation of new training courses, the practical relevance of which is confirmed by the industrial sector using modern educational formats (such as digital education, blended learning, etc [9]).

As an example of such a course, The Fundamentals of Project-based Activities course is might be considered, one of the modifications of which will be presented on the CEPHEI project educational platform. The Fundamentals of Project-based Activities course is aimed at the formation of an interdisciplinary modern skill: project activity skill [8]. Currently, Open Education national platform [11] presents 12 courses, and Coursera platform [12] offers 17 courses from Russian universities related to projects implementation and project management. The main feature of The Fundamentals of Project-based Activities course is that the emphasis is not on specific

management processes, but on the step-by-step solution of complex problems from any area with the help of the project approach: what tools from project management can be used to solve the problem at all of its stages and in which ways, from the search for ideas to the implementation of solutions.

Currently, The Fundamentals of Project-based Activities course is already provided in four formats, and the work is underway on the creation of the fifth version of the course for the CEPHEI project. Table 1 shows the comparative characteristics for each version of the course, indicating the technical facilities for its implementation and the specific features of the content.

Table 1. Versions of the course on The Fundamentals of Project-based Activities

Course components	For students from SPbPU	For students and teachers from other universities	For everybody	For specific companies	For CEPHEI project
Start year	2017	2018	2019	2018	2020
Number of students	>6 000 annually	500	5500	500	To be determined
Platform	Project.Spbstu (Moodle)	Project.Spbstu (Moodle)	OpenEdu (edx)	Project.Spbstu (Moodle)	CEPHEI (edx)
Course type	Blended With instructors	Blended With instructors	Online Self-passed	Online/Blended Self-passed/ With instructors	Online/ Blended Self-passed/ With instructors
Supervising	Yes	On-demand	Yes	On-demand	On-demand

Educational course in SPbPU. The course was introduced for all areas of bachelor's degree and specialist degree training at St. Petersburg Polytechnic University and is mandatory for students of the second year (project.spbstu.ru). The course is taken annually by more than 6,000 students in all areas of training: technical, humanitarian, economic. It provides the formation of the necessary universal competencies in the development and implementation of projects

of various types, teamwork and communication, systems thinking, self-organization and self-development.

The main principle of the course is learning through practice. Accordingly, the students are given the task to study the theoretical material and to complete the project: implement the idea to get the result during the term. It is important to note that students are not limited in the choice of subjects: the project can be of any nature: research, engineering, business, social or creative. As a result, more than 500 projects are carried out simultaneously by teams consisting of students studying in any specialist areas.

The distance education platform makes it possible to organize interaction with Customers to collect and agree on the proposed subjects of projects, form teams for specific projects and appoint teachers/coaches for the teams, track the process of tasks completion in the practical part of the course (project), etc.

Thus, the control of the knowledge of the theoretical material through the passage of automated tests and monitoring the implementation of the practical part, that is, the implementation of the project.

As the crucial aspect of the practical part is teamwork, a student is awarded two grades:

- evaluation of the work of the whole team by the teacher/coach on the portal for the performance of group tasks (templates and presentations).
- individual assessment of the team members by their project manager as a personal contribution to the work on the template/presentation.

Individual assessment of each student is a product of the team points and the personal contribution. As a result, a graphical representation of the learning result of each student is automatically generated on the portal at the end of the course and can later be used as a digital representation of the student's competencies for the de-

velopment of educational and professional recommendations. The presentation includes an assessment of 12 indicators (Fig. 1).

Network program for partner universities. The next stage of the course development was a network-based program for partner universities [10]. Thanks to this initiative, not only SPbPU students, but also students from other universities can take the course. The theoretical and practical part, as well as the evaluation for this version of the course was based on the experience of its implementation in SPbPU.

Open Education a national platform. The third form of course implementation is a national platform called Open Education (openedu.ru/course/spbstu/OPD/). The main distinguishing feature of this version of the course from the previous two versions is that a student is more independent in mastering materials. Thus, students are completely independent in determining their pace of dealing with their lectures and assignments. Assessment is implemented in the form of automated testing: two intermediate tests during the course and one final test at the end. The role of the course team in this implementation is to communicate with the audience, advising on theoretical issues at the forum.

As the survey shows, the main audience of this version of the course is students *aged 30 and over*, and the vast majority of students have a job (66.7%), including 22.6% working in the field of science/education, 15.1% in IT, 12.1% in construction, 10.4% in industry, and 9% in marketing.

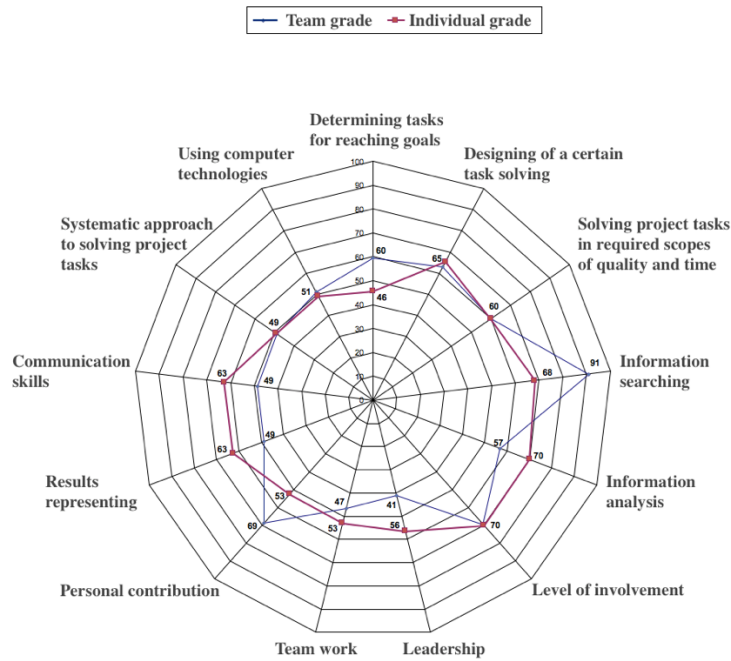


Fig.1. Team grade and individual grade diagram

The main expectations in respect of the course are distributed as follows:

- gaining knowledge about the approaches used in project activities - 74.2%
- applying knowledge in practice - 48.9%
- systematization of existing knowledge - 41.6%
- checking their existing knowledge - 21.8%

A course for enterprises. The course for enterprises is deployed on Moodle platform. The course is developed both for a specific company and for a group of companies (for example, those united by industry), which makes it possible:

- 1) To adapt the materials: the course may include company materials related to project activity. Such materials can include standards, procedures, templates, and cases.

- 2) To update the control of the development of the course not only by adding new questions on advanced materials, but also by the ability to check the open type tasks.
- 3) For a company's management, to monitor the progress on the course, collect analytics on the competencies of their employees.

CEPHEI Platform. It is planned to create a new format of the course within CEPHEI project, and the course will be based on existing materials modified in accordance with the needs of the enterprises. The main participants of the course will be representatives of industries interested in the development of project management skills of their employees. At the same time, all the existing content of the course will be adapted to the actual needs of the enterprises (based on the surveys and interviews with the company representatives), and individual and group project work of the students will be based on real cases from companies, with feedback from the curators of the course from SPbPU.

Conclusion

The course The Fundamentals of Project-based Activities in different forms of its implementation provides an opportunity to develop an interdisciplinary skill which is in great demand for all possible categories of students: starting from the open version of the course on the national platform, and ending with the version which has highly specialized content for the needs of enterprises and is presented on the CEPHEI platform. All this is becoming possible due to the use of modern means of distance education.

An important aspect of the presented course implementations is the possibility not only to identify leaders among all the students, i. e., people who are able to lead the team and to ensure the implementation of the idea with a specific result, but also to obtain, in a digital form, the indicators for evaluating the work of each student in

terms of different indicators, which can later be used to form a portfolio for potential employers, as well as to identify individual characteristics and needs for the development of a more personalized educational and professional trajectory.

An important advantage of the use of the online learning tools under consideration is the broad scale of student coverage. Actually, almost 20,000 students have taken the course over the time of its existence. The analysis of the statistics of the course makes it possible to flexibly implement changes in the script and the contents of the course, to optimize, for example, such parameters as the duration of the video, the format of quizzes for different target audiences, and quickly receive feedback on the changes introduced. That, in turn, makes it possible to significantly improve the educational process efficiency.

The presented approach is promising for comprehensive training of the widest possible range of specialists in accordance with the requirements of the new technological paradigm.

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