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The integration of cross-professional skills into engineering curricula

The paper focuses on the need to produce engineers fully trained in their professional domain and equipped with skills enabling them to meet the current global challenges. An overview of successful practices of implementing those skills throughout engineering university programs is presented.

Key words: engineering education; digitalization; eco thinking; problem-solving; lean production; critical thinking.

Scientific and technological advances have given rise to radical changes in various spheres of human life. We have witnessed the increased overall literacy rate, the advent of new professional areas as well as the transformation of the current ones. However, these technological novelties are accompanied by new challenges for the engineering workforce and as a consequence for engineering education.

The essential directions of the development of engineering training have been the subject of many studies. The one conducted by the Nordic Engineering Hub involved the university academic staff from five countries. The study identified the three major challenges the future engineering education has to deal with, those being digitalization, sustainable development, and employability of engineering graduates.

Digitalization is related to the innovations of the Fourth Industrial revolution that requires specialists to have a thorough understanding of such things as artificial intelligence (AI) and the Internet of Things (IoT), which are to penetrate every sphere of life and impact the engineering disciplines.

The climate changes observed forced the United Nations to formulate the 17 Sustainability Development Goals that are vital for this planet and urge education to produce engineers capable of contributing to sustainable development.

To keep pace with changing market conditions engineering graduates have to improve their employability opportunities by acquiring knowledge and skills related to innovation, creativity and entrepreneurship.

The focus of this paper is on what actions should be taken for engineering institutions to train graduates able to address the current challenges. Over the past two decades, a number of surveys and studies have been conducted aimed at determining the proper development trajectory of universities.

The survey conducted by the Royal Institute of Technology in Sweden [3] revealed a large variation of personal perceptions of the faculty members regarding the changes of future engineering institutions. Some professors, mainly involved in more science-dominated engineering disciplines, emphasized the need for deep content-knowledge in a major subject, claiming that the trend of education being broader may result in knowledge drainage within the discipline and in society. Meanwhile others substantiated the vital importance to have basic knowledge in such areas as safety, ethics, and sustainability issues, as well.

The interviewees identified different roles for the future of education at a university. Some of the professors expected it to play a more active role, whereas others thought a university diploma would be substituted by a file with various course certificates. All the interviewees see a significant need for more digitalization and programming in the educational curriculum.

The survey aimed at identifying the most relevant soft skills for future engineers was performed at TPU. Its results, which were presented in [1], showed that the respondents considered the most valued ones the following: a foreign language command (67%); problem solving (67%); critical thinking (64%); digital literacy (54%); communication (53%); leadership (43%). The authors L. M. Bolsunovskaya and O.V. Trusova conclude that «humanitarian knowledge is not just an intermediary stage between technical knowledge and professional activity; it shapes the inner world of future specialists (their mindset, personality, responsibility)» [1].

Despite the common understanding about the importance of those soft skills there are many variations on the introduction of those into the curricula, which is an issue addressed further. An attempt was made to get a picture of how some of the above competences are reflected in the curricula of leading engineering universities. The models presented are available in the public domain.

Environmental deterioration is an increasing global problem. There is a growing understanding that sustainable development actions can be put into practice by an educated, informed public. It is crucial to raise environmental awareness among engineering students to make sure they develop technological solutions that take into account the needs of the natural environment so as

to reduce any negative impact. Seoul National University introduced a special course «Life Protection Education», which, although earning no credits, is compulsory for graduation for all engineering department students.

Lean production skills are becoming more valuable. Lean manufacturing dates back to the post-war Japanese practices of Kaizen and just-in-time, which focuses on cutting out waste, increasing speed and efficiency, whilst ensuring quality. It is also a process that, «when done correctly, humanizes the workplace, eliminates hard work (both mental and physical), and teaches people how to do rapid experiments using the scientific method» [6]. Even basic Lean thinking is useful and can be applied far beyond manufacturing. Additionally, it is a great way to teach problem-solving.

Lean production courses are compulsory for Business / Management students, but are rarely present in the curricula of engineering schools. Still, there has been a shift in this direction and more and more universities have been focusing on developing lean production competences of their engineering graduates. The two options of incorporating lean production into their curricula have been observed in some leading American universities. Some universities include lean production information into existing courses, whereas others introduce specially designed ones. For instance, at Ohio University, a laboratory course was developed to familiarize senior-level students with various lean manufacturing concepts through hands-on LEGO Model-based simulation exercises and in-class presentations. Organizers of this course received mostly positive feedback: students liked the idea of using LEGO to demonstrate lean production principles [4].

An interdisciplinary approach was chosen at Oakland University's engineering schools. The lean production course involves a semester-long project aimed at analyzing the performance of a local manufacturing company and developing a plan for implementing a lean program. Interdisciplinary teams of students work on the project with local companies' personnel. Thus, the highlight of that approach is close cooperation of an academic institution with local businesses. It's worth mentioning that many job interviews nowadays include questions concerning graduates' lean production awareness [7].

In order to address contemporary challenges, engineers require more than just technical knowledge. Problem solving being essentially their profession, engineers have to be equipped with critical thinking skills as a powerful tool in problem solving.

«Critical thinking is the ability to analyze carefully and logically information and ideas from multiple perspectives. This skill is demonstrated in the ability to analyze complex issues and make informed decisions; synthesize information in order to arrive at reasoned conclusions; evaluate the logic, validity, and relevance of data; solve challenging problems; and use knowledge and

understanding in order to generate and explore new questions» [2]. Thus, the three major skills critical thinking is comprised of are: analysis, synthesis, and evaluation.

The rector of Tomsk Polytechnic University stressed the necessity to train context engineers with critical thinking competences. «Critical or exploratory thinking allows, without having clearly prescribed norms and instructions, to create new complex objects and move the industry forward. I would like to emphasize that in this case, one cannot ignore the framework that society sets for us, these are ethics, the environmental and social agenda», said Dmitry Sednev [5].

It should be admitted that the critical thinking skills can be and are practiced through the subject matter of many disciplines, a foreign language included, still universities design special programs aimed at enhancing the student's ability to analyze information critically through problem based learning and reflective writing.

The Higher School of Economics offers a course aimed at introducing the principles of critical thinking. Students are given a list of books for self study, which are discussed later during seminars. Some of the topics covered are: «Critical analysis of knowledge: How our cognitive abilities deceive us»; «Critical analysis of argumentation. How erroneous conclusions are imposed on us».

Critical thinking and critical reading are closely connected with each other as the latter requires deeper examination of the gist of the text and details revealing that gist. Critical reading approach is at the basis of the Critical thinking course at Moscow Engineering Physics Institute. Students are assigned readings from contemporary scientific and journalistic articles with specially designed exercises aimed at revealing their structures and assessing the information. During practical classes students are encouraged to express their views and opinions orally, support those with arguments. Essays written on the subjects touched are thoroughly analyzed in terms of critical thinking requirements and an instructor's feedback is provided. Credits are earned for both written assignments and peer reviews of other students' research papers.

Cross professional competences are as valuable for engineering graduates as the subject matter and should be covered in all universities, TPU included, but not at the expense of technical course content. Examples of successful approaches taken in Russia and elsewhere should be studied and their applicability considered. More emphasis on the development of those skills should be given throughout technical courses. National businesses and enterprises, as key stakeholders, are required to strengthen partnerships with academic institutions and provide real-life cases for subject projects, thus encouraging students to be more engaged in the process and making them realize what problems they may

have to face. An English language course can contribute greatly to enhancing students' cross-professional skills by raising their awareness of the current challenges through reading topic-related articles, by implementing critical reading techniques.

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Video games as a method for learning English

The article evaluates the effectiveness of the method for learning English through video games of different genres. The action-adventure game «It Takes Two» is considered in detail. A survey of Russian students and schoolchildren about video games was conducted, the conclusions were made and recommendations were given on how to study English more effectively with the help of video games.

Key words: video games; language learning method; game technology; vocabulary; listening comprehension; sociological survey.

The popular portal IGN, citing a study by DFC Intelligence, reports that 3.1 billion inhabitants of the Earth are gamers. It follows that about 40% of the world population plays video games [3, p. 12].

The most popular games are considered: «Minecraft», «Grand Theft Auto V», «Tetris», «Wii Sports», «PUBG: Battlegrounds». All of them are developed in English and translated into different languages. We can consider each of them, except Tetris, as almost a full-fledged way to learn English.

The main advantages of this method are:

1. Uninhibited memorization of new words, that is, an increase in vocabulary;
2. Improved listening comprehension and easier understanding of grammar;
3. Mediated immersion into the English-speaking environment;
4. Natural human interest, motivation to achieve the goal.

This happens because high interest and an emotional background create favorable conditions for assimilation of information. Emotions spur the brain to create new associations, and when playing, there are many more of them. And memorization occurs as if by itself – without any extra effort on the part of the person [2, p. 154].

It is possible to learn English with the help of any genre of the games. Starting from single quests and ending with multiplayer games, where a player interacts with other people. Consider this method on the example of the action-adventure game «It Takes Two».