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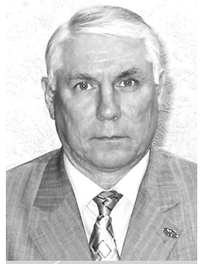

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Computer Applications in Engineering Education: New Opportunities in Training Engineers for Creative Economy

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The article addresses the issue of ensuring qualitative training of specialists for mechanical engineering and road-and-transport complex. To increase the competitiveness of the personnel, a new education pattern is proposed. It has been revealed that introduction of a system approach in engineering training makes it possible to handle the problems in training engineers able to design, manufacture, and maintain complex machines and equipment.

Key words: engineering education, computer technology, education system, engineer's competence, specialist's profile.

Introduction

The problems of the 21st century caused by depletion of natural resources and environmental hazards stipulated the changes in the existing employment structure, i.e. old and traditional jobs disappear, while new jobs emerge. On the one hand, a fast-growing economy is in a constant need for all-rounded quality personnel capable of resolving increasingly challenging tasks. In this respect, the role of an engineer who is able to design, operate and maintain complex machines, as well as create new materials and develop new technologies, is becoming more prominent. On the other hand, there is a massive inertia in the education system, which should be overcome in order to ensure qualitative training. It is one of the greatest challenges facing modern education system, and it can be addressed only by implementing systemic strategy that would make it possible to combine new opportunities offered by up-to-date technologies and positive experience gained by engineering universities all over the world. Such a strategy would ensure stability of the education system and its continuous improvement and revision to meet the needs of the real economy. Training of engineers capable of resolving modern tasks should be based on the innovative learning strategies. In addition, the programmes themselves should be designed with regard to the modern advancements in science and technology. It is important to improve the system of so-called "advanced education" aimed at training engineers of the future.

Problems and contradictions in business and education

The competences of a specialist are basically discussed in two contexts: as learning outcomes of a definite programme and as a qualification description which helps companies select the candidates for the vacancies they have. Further, they educate their own employees. In companies, the qualification of a specialist is described on the basis of the competence model. According to the education standard, competences are defined regarding the industry a graduate is going to work in. As, on the one hand, engineering activity is becoming more and more diverse and, on the other hand, the companies want to employ the specialist for definite work, the contradiction between education goals and business arises. Besides, today one should speak of so-called "global competences".

To handle these contradictions, it is essential to introduce a systemic approach in the education system. As the balance between supply and demand for engineers with a definite set of competences is defined by the labor market, it is the labor market that can make a link between education and industry. Such a mutual cooperation would contribute to the stability of both the education system and industrial sector. However, for business representatives and educators it is essential to develop a single understanding of the competence model and learning outcomes. The challenges arise when one is trying to formalize the assessment system of specialist's competences. The traditional system of education and professional standardization do not include the description of competences which directly influence the success of a company: decision making, agreement achievement, responsibility, etc. Based on the standard assessment tools, it is possible to determine the level of competence and professionalism in a definite field of study, but it is impossible to predict whether this specialist will be effective or not for the company. For this purpose, the competence model is required.

Competence-based management is a unique approach towards human resources management, with three main competences being emphasized: educational-cognitive – abilities to perceive, set goals, plan, analyze, speculate, control oneself, solve problems and address the tasks, etc.; informative – ability to search, select, process, analyze, and interpret information; communicative – ability to interact, to work in a team, and perform various social functions, etc.

The mission of an engineer of the future is to create more stable and fairer world. As engineers bear collective responsibility for improving living conditions of people worldwide, they must think and act globally. Such complicated tasks force educators to revise the current education system. According to the research literature, "global competence" of an engineer is discussed in three basic aspects. Firstly, an engineer not only has to be involved in product design and manufacture, but also he/she is responsible for market promotion, operation, maintenance, and utilization. Therefore, engineers should have interdisciplinary knowledge, especially, in the fields which are traditionally related to the engineering activity: global socio-economic and political systems, international trade and markets, ecological systems, research and technological innovations. Secondly, it is the ability to work in a team, communicate and collaborate in a global frame. Multinational team is more likely to be effective and innovative. Thirdly, for engineers it is essential to be able to live and work comfortably in multinational engineering environment. Involvement in multinational projects requires being able to demonstrate strong language and communication skills.

Another challenge to be addressed is declining interest in engineering education among young people, especially, when it entails involvement in knowledge-intensive activity. There are various ways to increase motivation: to launch career guidance programs, to define and develop potential abilities, and to enhance prestige of engineering activity. Relating to the above-mentioned tasks and challenges, one should consider computer technologies as a tool of all participants of the education process. They can be applied to design learning content and learning environment, solve the assigned problems, foster teacher-student communication, develop professional competences, and assess learning achievements and training quality.

Results and discussion

To make vehicles more effective, cost-efficient and eco-friendly during production, operation, maintenance, and utilization stages is one of the most pressing

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problems that faces motor-vehicle industry. In addition, an engineer should have intensive knowledge in digital modeling of automobiles, vehicle maintenance, and intelligent transportation systems. Cooperating with "KAMAZ" and other companies engaged in transport, logistics, maintenance, and safety management, we have gained extensive experience in training engineers for the Research and Design Centers.

Considering the above-mentioned challenges, the first stage was dedicated to goal setting and identifying the ways to achieve them. Precisely, we systemized the tasks to be solved by engineers at their work places. In addition, to define the most important competences for graduates to make a successful career, the representatives of partner-companies were interviewed. The outputs of the survey were analyzed and categorized (Tab. 1).

To adjust professional standards to education ones, first of all, we defined the courses which are required for all engineering programmes and concern all stages of automobile lifecycle (the first module – General Sciences); secondly, we define the courses which are specific for each occupation (the second module – Professional). Then, the curricula were designed, with the key competences corresponding to the professional standards of motor-vehicle industry being specified. The courses aimed at shaping required competences were introduced in the corresponding engineering programmes with regard to future occupation in the relevant company. The peculiarity of the proposed pattern is due to the fact that students gradually become involved into the professional environment, precisely, they do internships during the first years of education, then, they have an opportunity to work as engineers and continue their education. In this case, they have access to vast information resources of the companies, learning content of the corporate university, and software support required for project execution. Thus, the courses of the first module are completed at university, while the courses of the second module are completed at the corresponding workplaces. This allows educators to solve the problem of "sharing" management functions by two LMS (learning management system) [1]. The second stage involved design of learning content, selection of appropriate teaching strategies and software to ensure qualitative education. At the third stage, the efficiency of the proposed education pattern was tested. For this purpose, experimental student groups were made up. They were taught within the proposed education pattern, with special emphasis being made on computer application.

Computer as learning environment

As the current education system should be effective in teaching creative and initiative personalities who demonstrate cognitive flexibility and complex problem solving, it is essential to turn from reproductive approach in education to creative learning and innovative teaching. In this regard, importance of computer is indisputable as it allows learners to shape the required skills and competences independently by means of the relevant learning content. Daniel Araya noted that global network capitalism is a network model that involves democratization of education, development of horizontal links on a global scale, rise of self-discipline and interaction. It is this model that would define the education system of the future (Araya D., 2010) [2]. John Seely Brown [3] stated that the obligatory content of education programme should correlate to the basic competences, while additional aspects ("open" component) to be covered over the programme completion should be defined by the learners themselves according to the opportunities provided by the learning platforms.

Application of a computer in designing learning environment allows educators to settle a number of contradictions. The first contradiction arises due to the need, on the one hand, to minimize the length

GLOBAL TRENDS IN DEVELOPMENT AND MANAGEMENT OF INTERDISCIPLINARY RESEARCH AND EDUCATIONAL PROJECTS AND TEAMS

Table 1. Results of (Partner-Companies) Engineers Survey

Group	Competences	Companies' activities		
		1*	2**	3***
Technical	Fundamental knowledge	90	60	72
	Engineering knowledge	90	56	78
	Application IT in professional problem solving	70	60	65
	Understanding of product life cycle and its stages	90	48	63
Personal	Creative and critical thinking	80	45	60
	Initiative	90	85	80
	Commitment to continuous self-development	90	90	90
	Ability to set goals and plan career	95	94	90
	Ethics and responsibility	98	95	95
Professional	Engineering thinking	98	56	68
	Ability to resolve professional tasks	95	95	92
	Systems thinking	95	48	71
	Ability to search and analyze information	95	85	80
	Knowledge of trends in engineering	98	60	70
Interpersonal and communi-cational	Ability to work in a team	80	90	90
	Business communication	90	75	85
	Foreign languages	90	70	70
	Ability to work effectively	95	95	95

Basic company's activity: 1* – Design and Manufacture of Vehicles and Automobile Intelligent Systems; 2** – Transportation and Logistics Management Systems; 3*** – Transportation Management and Safety.

of university attendance and, on the other hand, provide qualitative training in terms of acquired knowledge and competences. The second contradiction is stipulated by the need for maintaining high level of staff teaching skills and increasing faculty workload caused by constant revision of the learning content.

To settle the above-mentioned contradictions, the single unified learning environment, preferably supported by business, is required. This allows all programme stakeholders to combine their efforts in designing curricula and ensuring qualitative training. In this case, the concept of E-Learning 2.0 itself changes: «Motivation – purpose – tools – implementation».

In our opinion, engineering education should teach students how to define a problem and find the most appropriate way to solve it. That is what such courses as "Introduction to Engineering Activity", "Fundamentals of Product Design", and "Methods of Engineering Problem-Solving" are devoted to, as they familiarize students

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with the real-world examples of engineering problem-solving.

Computer as means of communication

Being able to communicate and work with people is still one of the most important competence, especially in engineering. Most skills and competences that are essential for sustainable development of the society can be developed only in a teamwork pattern. In addition, a deep insight into the media tools and technologies is also essential, since, in this case, engineering graduates are no longer just consumers of media products but producers who are able to think critically and help people raise their awareness about manipulation techniques (especially in advertising and PR) and make their own opinions about the reality.

The management of the global companies believes that competitiveness in the labor market is determined not only by proficiency level, but also by the ability to solve problems in a bilingual environment that stipulates human interaction by means of information technologies. Therefore, knowledge of foreign language is an essential component of successful professional career as it has already become a valuable tool for communication within the current information space. This fact urges educators to revise foreign language training of engineering graduates. Teaching foreign languages by means of computer software significantly improves the training process itself, as, unlike traditional teaching technologies, the use of computer ensures high information capacity and student independent work, stimulates students' cognitive activity and motivation, and provides them with valuable communication experience.

Thus, engineering programmes include such courses as "Intercultural Communication", "Translator in the Field of Professional Communication". Students are taught in the special language labs where they can practise and hone their communication skills. Participation in various international education projects (CDIO, Formula-student) provides students with an ideal opportunity to communicate with their counterparts all over the world.

Computer – virtual and augmented reality

Adequate information perception is a basis for its further analysis and decision making. As an engineer has to deal with complex systems, the systems of virtual (VR) and augmented reality (AR) are of great importance during the training process and further professional career. As stated [4], the advantages of AR use in education has become a point of attention of many specialists. However, there is an opinion [5] that educators should work together with researchers in order to design AR interfaces. According to [6, 7], one of the main advantages of AR is significant savings in time required for material revision, since students have an opportunity to learn independently. In addition, these technologies have a double effect: they allow teachers to increase efficiency of lab assignments and stimulate students' motivation. Students who participate in such projects as "virtual automobile", "virtual manufacture" have an opportunity not only to get insight into the complex engineering systems and logics of real technological processes, but also to acquire knowledge in system design and optimization.

Computer – tool for professional task solving

Being a part of professional competence, informative competence covers a number of specific issues related to the level of computerization within the definite professional domain. Besides, a specialist should have commitment to continuous development both in the professional sphere and related fields. Informative component of the professional competence should be developed upon the completion of a number of courses, internships and by participation in designed and real work-related activities that imitate real professional tasks. As employers want new hires to have knowledge in IT, the courses should be designed so that students have an opportunity to work with the software packages and mathematical models used for problem solving within the chosen professional domain.

Thus, students in various Design and Technology programmes (automobile manufacturing, engine technology) focus on the design of automobile systems. Therefore, students gain a deeper insight into 3D-modeling, simulation, and engineering analysis by means of Siemens PLM. The students who deal with design of smart control electronic systems enrich their experience of using Siemens NX, e-Series. The students in Automobile Manufacture Technology programme who are planning to work in the technological center study Plant Simulation and Tecnomatix (with modules Jack and Human Performance), which allows resolving ergonomic issues and enhancing technological processes by means of virtual models. Students employed in the field of Logistics and Operations Management study the theory of vehicle and transportation systems management, optimization methods in logistics and telematics, GIS via MiniTab, PTV Vision (VISSIM, VISUM), ArcGIS, MapInfo.

Computer – tool for assessing quality of engineering training

The shift to the test-based knowledge assessment system, increasing number of universities that are not able to ensure qualitative education are the basic challenges that are common to many countries. The formal indicators do not present fairly the condition of education system. However, the discussed learning environment and control systems allow students to assess their knowledge by themselves. The teaching staff can easily use computer tests for interim assessment, students' knowledge estimation, and grade-rating system. In addition, it is possible to calculate the time that a student spent on completing each module and revise the courses based on the obtained data.

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