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DEVELOPING DEEP LEARNING COMPETENCIES IN ENGINEERING EDUCATION

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In the 21st century engineering is seen both as an art and a science. The science comprises the careful and knowledgeable use of scientific principles, physical materials, and design techniques to produce devices and systems, and their operating arrangements, to perform useful functions in a reliable and affordable way. These can range from smart grids to computer networks; from mobile phone applications to intelligent meters; from motor drives to wireless credit cards. The art lies in creating new directions in human activities by perceiving non-traditional applications of scientific knowledge, combining different fields of knowledge in unique ways, introducing new technologies and managing a variety of technical resources to produce innovative outcomes.

In other words, engineering is about developing, providing and maintaining infrastructure, goods and services for industry and the community, and about helping to identify and implement directions for sustainable future. Professional engineers normally work in interdisciplinary teams and are supposed to cope with risks and take social responsibility for the results of engineering projects. New pedagogies for deep learning that are available in the 21st century are aimed at training specialists prepared to work creatively in the global economic community and respond to the unpredictable challenges of the time for the sake of the stable and sustainable development [1, 2].

Deep learning skills (also termed as 21st century skills and competencies) are composed of 4 groups of skills, which include: ways of working: communication and

collaboration; ways of thinking: critical thinking, problem solving and metacognitive skills; tools for working: information and communication literacy; and ways of living in the world: global citizenship and civil responsibility, as well as cultural awareness and competence [3]. International and Russian standards for professional engineering competence require that university graduates must demonstrate generic areas of competence, also designated as transferable skills. These include knowledge and understanding, design and development of processes, systems, and products, responsibility and management, communication and interpersonal skills, and professional commitment. They also include planning the process of self-learning and its results, improving performance, as the foundation for lifelong learning and continuous professional development [4, 5, 6].

In 2012 the Institute of Power Engineering at Tomsk National Research Polytechnic University jointly with Czech Technical University in Prague launched the double degree master programme in electric power engineering and electrical engineering. One of the compulsory courses constituting the programme is the course „Philosophical and methodological issues of science and engineering“ originally designed and realized as a multidisciplinary course that provides master students with knowledge, experience and practice in deep learning skills and competencies required for professional specialists in the area of electric power engineering. As a result of successful completion of the course the students will be prepared for understanding the role of philosophy in the development of science and engineering (Objective 1); analyzing tendencies relating to the development of science and technological progress and their societal and global impact (Objective 2); and improving intercultural skills relating to the professional area (Objective 3). Among a complex set of outcomes incorporating knowledge, abilities and experiences, the students will develop competencies in critical thinking and applying creative problem-solving techniques for the purposes of engineering, interpreting and presenting the results of multidisciplinary group projects. Mention should be also made that the course is presented in English, and master students are exposed to improving their English and communication skills alongside with developing intercultural awareness and competence.

Following the policy of the European Union that is aimed at facilitating students' autonomy and supports the strategy of life-long learning and continuous professional development, the learning process is remodeled according to the principles of learner-centered pedagogy, which is based on students' backgrounds and experiences, focusing on self-directed learning and developing metacognition, involving elements of collaborative learning (pair and group work, peer assessment and support), and others. The facility to learn autonomously is understood as interactive practice for the purposes of acquiring job-relevant skills and competencies, taking responsibility for the achievements and outcomes of the learning process [7].

The above mentioned key competencies for successful professional career can be developed and mastered through the modules of the course, among which the following topical areas: responsibility and ethical issues in engineering, risk taking and consequences of engineering solutions, entrepreneurship and project management in engineering. The agenda of themes for discussion within the mode of group projects comprises a variety of burning issues in the area of electric power engineering: smart

grid trends, eco-friendly energy generation, micro grids, electric vehicle technologies, smart metering 2.0, perspectives of alternative fuels, energy storage trends, green-powered projects and others.

Project work is seen as a universal combination of innovative pedagogies of the 21st century: learner-centered approach, autonomous learning, collaborative learning, and experiential learning. Being involved in project-based learning, students are able to use the English language to achieve a real purpose, which can make students both more independent and confident; develop a much wider knowledge of the world through content-based learning which can feedback into improving and supporting their general educational needs; develop very valuable critical thinking skills by taking information from different sources, re-evaluating and restructuring it that can then be transferred to other subjects; develop their collaborative skills, which can have great social value, work as part of a team and take responsibility for the results of their joint activity; solve problems, using techniques for generating and sorting out ideas; communicate ideas clearly and meaningfully; do self- and peer assessment.

Another advantage of project work is that it provides sufficient opportunities for implementing different problem-solving techniques. To become a confident problem solver the student should learn how to approach the problem correctly and go through the main steps in solving it: first, defining the problem, second, generating alternative solutions, then analyzing, evaluating and selecting alternative solutions, and, finally, implementing the selected solutions. The most effective and commonly used techniques in solving problems embrace brainstorming, affinity diagrams, mind-mapping, flow charts, lateral thinking, SWOT analysis and others. Brainstorming is an efficient tool for practicing creativity and facilitating dynamics of the project team. The facilitator (or the leader of the group) should follow the structure of the brainstorming session and obey the rules in order to lead the group through the following stages: defining and agreeing the objective; brainstorming ideas and suggestions within a limited time period; categorizing and refining the suggested ideas; assessing their effects and results; prioritizing the options; agreeing actions and time; and monitoring the follow-up.

Master students were offered the following activities for brainstorming sessions: ways of modernizing university buildings according to the norms and standards of smart houses, promotion of city gardening in the university campus, pros and cons of electric vehicles in Siberia, activities of university lab researching on the efficiency of renewable energy sources, promoting green jobs in electric power engineering, ways of generating energy in the remote locations, etc.

The SWOT analysis is an extremely useful tool for understanding and decision-making for all sorts of situations in business, industry, and organizations. SWOT is an acronym for strengths, weaknesses, opportunities, and threats. The SWOT analysis headings provide a good framework for reviewing strategy, position and direction of a company, business proposition, innovative project, or any other idea. Strengths are those positive aspects of the project, which the team can build upon, for example through doing innovative work or creating new products. Knowledge and skills of team members are valuable assets in the project. Weaknesses are those deficiencies in the present skills and resources of the team which need to be corrected and

action taken to minimize their effect on the project. Opportunities usually arise from the nature of the environmental change. The team needs to be sensitive to the problems of managing a project and responsive to change in the planned activities, products or outcomes. Threats are the converse of opportunities and refer to external developments which are likely to endanger the operations of the team, for example the drop out of the team member.

Whatever the application, students need to be sure to describe the subject (or purpose or question) for the SWOT analysis clearly so they remain focused on the central issue. This is especially crucial when others are involved in the process. People contributing to the analysis and seeing the finished SWOT analysis must be able to understand properly the purpose of the SWOT assessment and the implications arising.

One of the teams of master students was involved in a group project aimed at planning an experimental laboratory researching on the efficiency of renewable energy sources. They made the SWOT analysis in the following way. As strengths they listed several positive aspects of joint work, including teamwork, knowledge of electric power engineering, knowledge of management, knowledge of design, and openness to creativity. Weaknesses incorporated insufficient business knowledge, high cost of research and development activities, and costs for staff training. Opportunities involve creating marketable products, working with people in other teams, possibilities for diversifying the activity of the laboratory, making contacts with new people. Threats embrace communication difficulties, time management, uneven workload within the team, and difficulties relating to meeting deadlines.

The brief review of the interdisciplinary nature, technologies of learning and perspectives of interactive learner-centered pedagogy applied within the course

"Philosophical and methodological issues of science and engineering„ provided at the Institute of Power Engineering at Tomsk Polytechnic University demonstrates the potential of educational programmes to train specialists with understanding, skills and competencies they need to cooperate in managing the challenges of the 21st century.

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ФОРМИРОВАНИЕ IT-КОМПЕТЕНТНОСТИ С ПОМОЩЬЮ СОВРЕМЕННОГО ВЫСШЕГО ОБРАЗОВАНИЯ

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Задача формирования и развития IT-компетентности специалистов является очень важной для вузов, при подготовке будущих специалистов. Действующие образовательные стандарты высшего образования основываются на компетентностном подходе к подготовке специалистов. Процесс формирования и развития профессиональных компетенций рассматривается как средство достижения нового качества образования.[1]

Термин «IT-компетентность» определяется как «способность и умение самостоятельно искать, анализировать, отбирать, обрабатывать и передавать необходимую информацию при помощи устных и письменных коммуникативных информационных технологий». С этим термином тесно взаимосвязаны понятия IT-грамотность и IT-культура. IT-грамотность студентов является основой формирования IT-компетентности и включает в себя совокупность знаний, умений, навыков студента, позволяющих эффективно использовать информацию для успешного включения её в разнообразные виды деятельности. Технологическая подготовка будущих специалистов в условиях современной высокотехнологичной информационно-образовательной среды (ИОС), реализуемая путём выполнения значительной части учебных действий с использованием средств информационно-коммуникационных технологий (ИКТ), предполагает обязательность начальной IT-грамотности студентов, проявляющейся не только в овладении навыками использования в своей деятельности совокупности тех-