

## CONTEMPORARY CONDITIONS OF ENGINEERS EDUCATION PROCESS MANAGEMENT

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**Abstract:** Engineers education is a difficult and damaging process in dynamically changing conditions in the modern labor market. Theoretical and practical knowledge, which is being provided them, must be (at every level of education) strictly compatible with labor market needs. This situation requires providing future engineers contact with real working conditions. It significantly affects better conformity of future engineer qualifications to employers' demand. This article presents initiatives selected in this area, which are being taken by Polish universities. The authors indicate a group of key competencies of future employees-engineers and characterize potential way of the development of their key skills and competencies in the context of e-learning courses.

**Keywords:** engineers education, engineer of the future, competencies, e-learning.

### Introduction

Modern universities are forced to adjust their activities to a number of changes resulting from i.a. implementation of the National Qualifications Frameworks (Kraśniewski, 2011), transformation to knowledge-based economy or commonness of information and communication technology (ICT) usage. Firstly, these changes concern a proper adjustment of graduate profile to labor market needs and paying special attention on measurable effects of the education process. Secondly, it is very important to enable students to take part in projects embedded in economic reality and to increase the number of practical classes oriented on employers' requirements (Ślusarczyk, 2014). Thirdly, skills to teach using new forms of teaching such as e.g. e-learning courses become more and more important. Briefly indicated, key factors of changes also have crucial importance in the modern engineers' educational process (Kraśniewski, 2013). Adaptations to changes force universities to take a number of actions, which aim is pro-industrial engineers' education.

The last decade has greatly favored changes of trends in the engineers education. This change is mainly associated with taking into account in the educational process not only elements of technical knowledge but modeling of competencies in non-technical knowledge, precisely in so called "soft" skills (Saad et al., 2013). In Poland, in case of engineering studies, educational process should not be less than 7 semesters and the total number of ECTS credits should not be less than 210. Before enforcement of the National Qualifications Framework (NQF) technical engineering studies must include 50% of technical classes and at least 50% of practical classes. In addition, each field of study had to be subordinated to

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educational standards specified by the Ministry of Science and Higher Education. The aim of such organization of curriculum was to provide engineers better preparation to follow a profession. These assumptions turned out to be not always sufficient, when it comes to graduates preparation for employers' expectations and labor market requirements. Currently, technical studies, according to NQF, implement the concept of teaching, which does not apply curriculum standards specified for particular field of study. Such activities' aim is to change the role of the teacher, from teaching person only to a person, who plays the role of tutor, mentor and adviser (Gajewski and Jarosińska, 2011; Tabor , 2014). An important element of educational process, in terms of technical studies (according to NQF) is to draw attention to non-technical aspects of engineers' activity and to achieve certain results in terms of social competence. The new system of education must take (except for gaining technical knowledge) procurement of necessary professional skills and forming good attitudes into consideration in a larger extent and, above all, skills associated with team works, project management, interpersonal communication and communication in foreign languages.

The main objective of this article it to indicate the importance of non-technical skills and competences of future engineers and present various actions taken by Polish universities, which lead up to shaping key skills and competencies of future engineers, putting special attention on e-learning classes.

### **Key competencies of engineers of the future**

Universities are forcing a huge challenge associated with intense adjustment of educational program to labor market requirements. It means that educational program should lay emphasis on the development of specified competencies of future employees. Lack of competencies, especially those 'soft' one, more often is a decisive factor in the recruitment process and in employee promotion. It also applies to technical positions because employers mostly take on this position engineers. Combination of interpersonal and social competencies enables effective functioning of engineers in the professional environment. Previously, engineers education was mainly focused on the acquirement of technical knowledge. Currently, engineer qualifications are as important as possessing specified skills, interpersonal and social competencies and knowing foreign languages. Engineer position does not concern positions separated from co-workers, but more often requires work in interdisciplinary teams and activities in organization key processes (*Kompetencje miękkie*, 2012).

Contemporary conditions in the labor market and development of knowledge-based economy highlighted the need to identify the competence profile of future employees, including engineers (Ali Taha et al., 2013). Table 1 presents key competencies of future employees.

**Table 1: Key competencies on the labor market and their characteristics (Domaradzki, 2014; Naduk, 2014)**

Competences	Characteristics
<b>10 key competences on the labor market in year 2015</b>	
<b>Ability to work in a multicultural environment</b>	Globalization processes significantly influence internationalization of many professional environments and implementation of transnational projects. In such conditions, work is done in groups ethnically, age and cultural diverse. That is why, employees have to be able to adapt to the rapidly changing professional environment.
<b>Communicativeness</b>	Customizing the message to the conversation partner is necessary to reach an agreement. In many professions, employees have to deal with demanding customer groups. It is necessary to treat them in a right way to have specialized and detailed knowledge about company, products/services etc. and to use communication skills. Also ability to use different communication forms, especially remote communication, is very important.
<b>Multitasking</b>	More and more often, employees have to do several different things simultaneously, what is more, sometimes they belong to different specializations. This trend will continue, because scopes of activities of particular departments regularly combine.
<b>Analytical thinking skills</b>	Ability to analytical thinking is especially useful in case of professions, which require a lot of independence - associated with managing overall processes. People, who can comprehensively and consistently manage their tasks are especially demanded in the labor market.
<b>Knowledge of foreign languages</b>	Nowadays, knowledge of English is a basis and many positions more often also require knowledge of additional foreign language. The ability to use rare languages, like Hungarian, Czech or Scandinavian is especially appreciated.
<b>Ability to work in a group</b>	Work begins to have more distributed nature. It means that people are obliged to close professional cooperation. People, who can do this, automatically increase their position on the labor market.
<b>Goal-oriented approach</b>	Employers do not want employees to spend many hours in the office, they just want them to bring benefits to company. Therefore, goal-oriented approach, ability to focus on tasks and consistent striving to their realization are gaining importance.
<b>Understanding of the basics of business</b>	Financial positions require daily cooperation of many departments and persons at the different level of the organizational hierarchy. Good communication skills, flexibility and openness to changes are very important to make cooperation effective. Understanding and sense of company business needs are also essential.
<b>Additional qualifications</b>	Ability to acquire additional qualifications is important and appreciated by employers, because today's economic or technological changes significantly affect the structure of employment - new jobs appear, while current change or are completely abolished.
<b>Ability to work under the pressure of time</b>	People often do not talk about it openly, but every company pursuit to optimization and continuous improvement of its processes. Corporations look for employees, whose are resistant to stress and make decisions quickly - only those right of course.

5 key competencies on the labor market in year 2014	
<b>Ability of abstract thinking</b>	At a time, when the business environment changes from day to day, ability of abstract thinking is unquestionably crucial. The aim of the leader is to lead in hard times. That is, why innovation, coping with complex problems or paradoxes is inherent in his responsibilities.
<b>Ability to use technologies in business</b>	Progressive digitization of economy force to have ability to use and adjust technologies in business activity and to know limitations of information and communication technologies and observe current changes in virtual environment (e.g. importance of social media in business development).
<b>Ability of global management</b>	Globalization processes and expansions of organization activities on transnational markets force employees to have ability to manage diversity and knowledge about foreign markets.
<b>Ability of effective communication</b>	Unstable situation on the market and economic difficulties influence situation within organization and have direct impact on employees at all levels. Even if selected individuals are not affected by the changes, moods, as well as confidence in company may deteriorate. That is way transparent communication is so important. Real leader should react in difficult situations properly and base relationship on genuine dialogue.
<b>Ability to change management</b>	Currently, technological changes in global scale, resulting from market or internal conditions are permanent element of any organization. That is why, implementation of change management strategies, supported by effective communication and cooperation at all levels is essential.

Key competencies indicated in Table 1 relate primarily to non-technical skills and engineering knowledge, but they also apply to future engineers. Hence, technical universities undertake various initiatives to seek the best education systems, which will be adjusted to labor market requirements and employers needs. In addition, development of engineers' education programs, which include development of non-technical skills, will result in graduates, who are well-prepared to act on the labor market.

#### **Pro-industrial initiatives undertaken by polish technical universities**

The education system CDIO (Conceive - Design - Implement - Operate) is related to a new vision of education focused on three elements: knowledge, skills and attitude. CDIO was initiated by the Massachusetts Institute of Technology in the late 90s of the twentieth century and it is a consortium, which consociates 70 members from 27 countries (including i.a.: Massachusetts Institute of Technology, Gothenburg Chalmers, KTH Stockholm, Sydney University, Catalunya University, Webster's College, Universidad Santiago de Chile, Notre Dame University, the US and the only one Polish Gdansk University of Technology). The main goal of this system is the emphasis on design and ability to create this, what student wants to create. These activities aim is to reduce disparities between traditional engineering

education and labor market requirements (*Studia techniczne*, 2014). CDIO system assumes that:

- moving away from typical engineering studies as the context in exchange for putting the pressure on the development of systems and products;
- abandoning studying of separated fields for the integrated system, seeing problems requiring many areas of knowledge for their solving, including social sciences and management;
- moving away from designing as the base of educating engineers and moving towards the system thinking „imagine – design – construct – judge your solution”.

The main features of CDIO system are (*Politechnika Gdańska*, 2014):

- educational program organized around mutually supporting fields;
- substantial amount of students' projects;
- integrated approach towards gaining nontechnical abilities;
- active and experimental education realized in modern laboratories and structural halls;
- constant assessing and improving of the education process.

An important component of CDIO system is "creation of the chain project management - communication - team work" (*Politechnika Gdańska*, 2014). Next, team projects should be carried out as part of the operations of many units of a given college (e.g. a few cathedrals, departments etc.), what improves chances that persons implementing a given undertaking will gain specific competences. Actions taken as part of the project should embrace: independent creating the team by students or the choice of the leader.

"Engineer of the future" is the next essential project carried out by Polish colleges. At the Poznan Technical University this project is being currently carried out and it envisions actions orientated on practical trainings, including certificate skills trainings, three-month internships in companies and advisory-psychological help. Tasks determined in the project include also the education in English directed at the specialist language (*Inżynier przyszłości*, 2014; Ulewicz, 2013). Next, "Engineer of the future" project was carried out by employees of the Czestochowa Technical University, was directed on examinations and analyses of directions of the development of engineering staffs in the perspective of changes in the structure of the economy of the Silesian province. Examinations conducted as part of this project showed that abilities of students did not correspond to modern workstations (*Politechnika Czestochowska*, 2014). An important component of the project was an attempt to determine the best image of the engineer of the future, which also takes the group of crucial nontechnical competences into account. According to data placed in the report results that to crucial nontechnical competence polled (entrepreneurs, students and researchers of technical colleges and data received from interviews with attractive employers) ranked: the creativity and the creative thinking, the cooperation with other people, communications abilities, the extensive knowledge of norms and office provisions, planning and conducting

projects and the fluency in foreign languages. The authors of the project are sure that the parts of these competences are possible to be obtained through education and the remaining through professional experiences (*Przewodnik inżyniera*, 2010). Such a situation not supports both entrepreneurs searching for employees and job-hunting graduates of higher education institutions. Ideal situation it such, which lets for carrying out the process of the teaching of future engineer this way that he can acquire competences, which are the most are expected on the labor market. It demands that the education process will be interdisciplinary and include cooperation with companies close enough and such an organization of classes is rather requiring and difficult. This problem results above all from two substantial situations:

- making the program of studies this way that the combination between basic fields of the engineering education and general fields shaping nontechnical competences is appropriate;
- combining expectations of entrepreneurs with the program of studies (e.g., it regards above all the realization of common projects, writing the engineering or graduation work. The entrepreneur is being not satisfied mainly by the time of the realization of such tasks by students, since it is often spread divided on two or three semesters. An acting company expects significantly quicker results of realized projects).

The problem of the organization of classes also turns up at the problem education system (Problem Based Learning - PBL). How M. Kaźmierkowski points, PBL allows for better training of students paying special attention to: the management, the cooperation, the design work, the problem solving, the social communication or the general technical knowledge. However the knowledge of these students in basic and specialist fields is smaller than of graduates of the traditional education (Kaźmierkowski, 2013). It causes that technical colleges, which want to educate future engineers are forced to the difficult compromise between the program of the education directed above all at the education in a technical and specialist field of knowledge and at the same time of gaining nontechnical abilities, thanks of which the graduate of the technical college will be perceived as the good candidate for work.

### **E-learning as a form of the learning crucial competences of future engineers**

ICT develop very fast. Their development concerns every part of life, as well as education area. Educations, including academies, try to suit their educational offer to the requirement of the market and the expectations of future pupils and students as quickly as possible. The significant aspect of the education is developing skills of the functioning of schools graduates in the economy based on the knowledge, in which it is important to have the existing knowledge and furthermore to build the ability of the exploitation and creation of the new knowledge (Abramowicz, 2002).

A major initiative taken by technical colleges becomes part of these expectations and needs of the economy based on the knowledge, in frames of which classes are being conducted on-line that is the e-learning system. Generally the e-learning is defined as all actions supporting the training process, using teleinformatic technologies (Hyla, 2005). An important component of the definition of the e-learning is pointing its two essential aspects among which are included: provision of information for the educational process (applying solutions of the information technology) and interactions of all kinds between the learner and the teacher (applying solutions of the communications technology) (Sørebø et al., 2009; Lee et al., 2009).

Educating in the e-learning system constitutes the important component of the teaching process, since using ICT modern technologies favors assimilating knowledge and developing determined abilities, important for every contemporary man. Completion of the teaching process in frames of e-learning training courses allows, irrespective of the classes, for the forming of specific competences among which it is possible to include: social, interpersonal, information and computer abilities, determined as digital competences. Such actions support general and current concept of studies, compatible with expectations of the labor market, in which not only the knowledge, but also abilities of different kind constitute the effect of the educational process. Moreover classes in the e-learning system let for developing abilities directed at the process of the constant education.

Teaching classes within available e-learning platforms has many advantages, to which it is certainly possible to include: the cost, the flexible access and the convenience of teaching thanks to defeating temporary and spatial barriers, fitting contents to the needs of the learners (Lee et al., 2009), the possibility of presenting information in the different form, standardization of contents, access to the information and knowledge "at the request" (Bhuasiri et al., 2012) and extended system of asynchronous and synchronous communication.

Despite many advantages significant from the academy point of view, as well as technical possibilities of ICT, e-learning as the form of remotely form of the learning still provokes many doubts, what is significantly visible in the process of the education of engineers (looking through the sites of educational institutions it is clearly visible that e-learning training courses in social and humanities are dominating). It is possible to rank among these stipulations matters connected with achieved results in remotely learning and in the traditional form whether e.g. requirements, which are being put for teachers and students being involved in classes taking place as part of e-learning training courses.

From one point of view educating engineers is particularly predestined to e-learning, but from the second point of view duties, which are mainly technical, demands from their teachers' significant requirements. These significant requirements include primarily such important issues:

- the ability of transmitting technical knowledge in different form through electronic media;

- the ability of exploiting the functionality of e-learning platform;
- the ability of suiting exploiting resources and interactions do the level of the learners, which has to ensure both the easiness of the exploitation of the training course, as well as the enjoyment coming from this form of the learning (suiting the training course according to the model of the acceptance of the technology (Technology Acceptance Model));
- the ability of motivating the learners.

Table 2 presents strengths and weaknesses of e-learning courses on technical fields of study.

**Table 2. Strengths and weaknesses of e-learning courses on technical fields of study**

<b>Strengths of e-learning</b>	<b>Weaknesses of e-learning</b>
<ul style="list-style-type: none"> <li>– reduce cost of educational process;</li> <li>– expand functionality of e-learning platforms;</li> <li>– support technical and technological processes with information systems, what can be used in the context of e-learning classes;</li> <li>– standardization of educational content;</li> <li>– attract learning process due to use of various forms of information presentation (video, audio, animation etc.);</li> <li>– develop students competences, such as time management, independence and responsibility in communication or searching and analyzing information.</li> </ul>	<ul style="list-style-type: none"> <li>– activities require use of laboratory equipment, what exclude e-learning;</li> <li>– too poor preparation and lack of ability of using functionality of e-learning platform by teachers of technical fields of study;</li> <li>– e-learning courses are highly dependent on the quality of electronic sources of knowledge, not as in case of traditional classes on teachers' teaching skills (Keramati et al., 2011);</li> <li>– proper combination of using of e-learning platform functionality available to person, who creates e-learning modules decides about courses attractiveness;</li> <li>– effectiveness of e-learning courses is strictly dependent on the existing students competences associated with information and information technology.</li> </ul>

An important criterion for assessing the effectiveness of e-learning classes should not only be students' grade after completing the course/subject, but their position on the labor market after graduating from university (Furgoł and Hojnacki, 2005). Therefore, education of engineers of the future should include technical knowledge, as well as development of 'soft' and digital competencies. This combination is a basic professional preparation of technical graduates to work in a knowledge-based economy.

### Summary

Profile of key competencies of future employees-engineers presented in article completely changed view about education process, especially in the context of technical studies. Increasing importance of nontechnical competencies and skills of future engineers must find its reflection in developed educational programs. In addition, well-established and clearly defined expectations referring to tasks and



functions of engineers give place to image, which is constantly changing, becoming outdated and requires constant attention and modification of education programs, to meet conditions to an adequately preparation of engineers to work in a knowledge-based economy. Therefore, technical universities undertake various actions to adjust educational offers to the labor market requirements. Key activity is e-learning, as a modern form of teaching. E-learning gives future engineers an opportunity to acquire competencies, which play a key role in the current economic conditions. Combining synchronic solutions (chat, video conferencing, online games etc.) with asynchronic solutions (forums, e-books, websites, e-mail) is also very important. Due to it, e-learning classes will bring specified effects and develop competencies essential for engineers. Analysis of undertaken actions, which aim is to adjust educational offer of technical studies, should be continued. In a further study, identification of factors that conduce realization of pro-industrial activities and shape key competencies of graduates, taking into account certain perspectives, i.e. national policy, national development, development of academic staff members, students and labor market requirements and employees/employers needs is essential.

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## WSPÓŁCZESNE UWARUNKOWANIA PROCESU KSZTAŁCENIA INŻYNIERÓW

**Streszczenie:** Kształcenie inżynierów we współczesnych dynamicznie zmieniających się warunkach na rynku pracy jest procesem trudnym i wymagającym. Dostarczenie przyszłym inżynierom wiedzy teoretycznej i praktycznej musi być, na każdym poziomie nauki, ściśle kompatybilne z potrzebami rynku pracy. Taka sytuacja wymaga odpowiedniego zapewnienia kontaktu przyszłych inżynierów z realnymi warunkami pracy, co znacząco wpływa na lepsze dostosowanie kwalifikacji przyszłego inżyniera do zapotrzebowania jakie zgłaszają pracodawcy. W niniejszym referacie przedstawiono wybrane w tym obszarze inicjatywy podejmowane przez polskie uczelnie, wskazano na grupę kluczowych kompetencji przyszłych pracowników-inżynierów oraz scharakteryzowano potencjalne możliwości kształtowania ich kluczowych umiejętności i kompetencji w ramach zajęć e-learningowych.

**Key words:** kształcenie inżynierów, inżynier przyszłości, kompetencje, e-learning.

### 工程師教育過程管理條件當代

**摘要：**工程師教育是一個困難和破壞性的過程中動態地在現代勞動力市場的變化情況。理論和實踐知識，目前正在為他們提供，必須（在教育各個層面）與勞動力市場的需求嚴格兼容。這種情況要求提供的未來工程師提供真實的工作環境聯繫。它顯著影響更符合未來的工程師資質雇主的的需求。本文介紹了在此區域中選擇的舉措，目前正在採取的波蘭大學。作者指出了一批未來的員工，工程師的關鍵能力和表徵他們的關鍵技能和能力，在電子學習課程背景下的發展潛力的方式

**關鍵詞：**工程師教育，未來的工程師，能力，電子學習