Sociocultural competence-oriented curriculum for engineering education in Russia

Ekaterina Galanina[a], Tatyana Adamova

National Research Tomsk Polytechnic University, 634050 Lenin Ave., 30, Tomsk, Russia

Abstract. Presently engineering education standards undergo vast changes due to the need in preparing "global" engineers. In the 21st century engineering education needs to adapt to the rapidly changing technical and sociocultural context. This need requires engineering education institutions to alter curricula on a regular basis. Universities tend to change curricula to meet the requirements of employers, industry and society because today engineers need to possess knowledge and practical skills not only in technical issues, but they also need to be competent in economics, ethics and social communication etc. Incorporating the competence and module-based approach along with accrediting engineering curricula also contribute to the transformation of higher engineering education in Russia. This matter is topical because today an engineer needs to acquire certain social and humanitarian qualities and skills specified by the requirements of Russian and international certification and accreditation organizations for engineering education. We suggest incorporating modules in humanities and social sciences into the structure of engineering curricula to make the process of forming sociocultural competence in Russian higher education institutions more efficient.

1. Introduction

Today engineering education in Russia is being reformed, which is explained by social and economical changes on local and global scale. These changes are connected with the globalization processes that are also inevitable in higher education and science [1]. Interconnected, competitive, and entrepreneurial global economy makes engineers develop technical competence and a set of professional skills that differs from what used to work in the past [2]. Information becomes outdated and skills in a certain sphere might get useless in new conditions. Higher education institutions need to prepare engineers with the skills and knowhow which they will need to manage rapid changes, uncertainty and complexity [3]. While developing engineering curricula we need to consider that the scope of engineering activity is becoming more and more global and is constantly changing. Engineers should be able to continuously develop their skill and knowledge, foresee social and ecological consequences of their work.

The research conducted by Hart Research Associates shows that employers believe that, in order to increase graduates' potential to be successful and contributing, members of today's global economy colleges need to pay more attention to the learning outcomes ranging from communication skills to critical thinking, from complex problem solving, ethical decision-making, science to the real-world application of knowledge and skills [4]. According to Parashara and Parasharb (2012), "social sciences, humanities, cultural and management studies are also as important as the traditional applied sciences for the portfolio of engineering competencies" [3].

2. Engineer's Sociocultural Competence

A successful career in engineering depends on a wide range of competences including technical skills and abilities, teamwork, effective communication, understanding ethical responsibility in making engineering decisions, etc. All that "non-technical" knowledge of an engineer we join together into one major competence of the "sociocultural competence of an engineer".

In this research the sociocultural competence is composed of the following: professional and ethical responsibility, understanding of the social impact of engineering solutions, the sociocultural context of professional activity, effective communication, functionality in multidisciplinary and multicultural teams, tolerant perception of cross-cultural differences and foreign cultural awareness, teamwork and leadership

[a] Corresponding author: galanina@tpu.ru

skills. One of the efficient methods in sociocultural competence development is gaming simulation [5].

Modern international standards of certification and accreditation organizations for engineering education as well as professional associations, e.g. ABET, ECUK, APEC, JABEE, FEANI, NSPE, WFEO, pay close attention to forming of the engineers' sociocultural competence. For example, ABET criteria for accrediting engineering programs require programs to demonstrate the following student outcomes [6]:

(a) ability to apply knowledge of mathematics, science, and engineering

(b) ability to design and conduct experiments, as well as to analyze and interpret data

(c) ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

(d) ability to function in multidisciplinary teams

(e) ability to identify, formulate, and solve engineering problems

(f) understanding of professional and ethical responsibility

(g) ability to communicate effectively

(h) broad education necessary for understanding of the impact of engineering solutions in a global, economic, environmental, and societal context

(i) recognition of the need for and ability to engage in life-long learning

(j) knowledge of contemporary issues

(k) ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Outcomes d, f, g, h, i, and j are considered to be quite significant for engineering curricula. It is those «non-technical» competences that help prepare an engineer able to function successfully in changing global conditions. Shuman, Besterfield-Sacre and McGourty (2005) state that "a set of six 'professional' skills is equally important to a set of 'hard' engineering skills" [7].

Presently there are two trends in engineering education. According to Crawley, Lucas, Malmqvist and Brodeur (2011), "on the one hand, there is the ever-increasing body of technical knowledge that graduating students must have a command of. On the other hand, there is a growing recognition that young engineers must possess a wide array of personal, interpersonal, and system building knowledge and skills" [8]. The CDIO (Conceive, Design, Implement, and Operate) approach to engineering education integrates a comprehensive set of personal and interpersonal skills, and process, product, and system building skills with disciplinary knowledge [9].

"The CDIO Syllabus v2.0" pays close attention to those professional traits that build up the sociocultural competence of an engineer: professional ethics, ability to think creatively, critically and systemically, to work in groups and communicate effectively, to understand societal and environmental context [8].

Numerous researches mark the importance of formation of the engineers' sociocultural competence. For example, this is how Chak (2011) describes important competencies in engineering: "Among the most important attributes required of an engineer graduate are the ability to think critically and creativity, flexibility, assertiveness, pro-activeness, team playing, networking skills, leadership, ambitiousness, presentation skills, professional skills, tolerance, ability to predict, reliability, risk taking attitude, openness to new technologies, competitive spirit and knowledge" [10].

The research by Lattuca, Terenzini, Wolkwein and Peterson (2006) demonstrates that employers have started to treat more seriously such competences as understanding societal and global issues, the ability to apply engineering skills, teamwork; appreciation of ethics and professional issues for those competences are essential for an engineer to compete successfully in a competitive global economy [11].

Sunthonkanokpong (2011) analyzed future global visions of engineering education. The study found that successful attributes for the engineering education are as follows: "lifelong learners, ability to frame problems and put them in a socio-technical and operational context, dynamic/agile/resilient/flexible qualities, high ethical standards and a strong sense of professionalism, good communication skills for interaction with multiple stakeholders, possession of strong analytical skills, an exhibition of practical ingenuity; possession of creativity, business and management skills; leadership abilities" [12].

Thus, accreditation boards, employers, and academic societies across the world mark some common "non-technical" competences of an engineer that we combine into one notion "sociocultural competence of an engineer". It includes efficient communication, ethical responsibility, leadership skills, teamwork, etc. We need to stress that it is rather hard to form sociocultural competence when most engineering curricula are generally focused on developing technical abilities.

According to Grose (2004), "to remain accredited, engineering schools must now ensure that their students can demonstrate a host of nontechnical skills". And the only way to meet those criteria is to more fully integrate the liberal arts – humanities and social sciences (HSS) – into the engineering curricula [13]. For many universities such interdisciplinary approach is quite difficult to apply. Firstly, "many engineering professors see HSS classes as time-wasting intrusions, when it is hard enough to fit all the technical content courses they deem necessary into the curriculum. Engineering faculty reluctance to understand and endorse the value of HSS lessons can reinforce student's negative perceptions of non-technical classes" [13]. Secondly, at the faculty of engineering teachers are generally not trained in humanities and social sciences; that is why it is difficult for them to teach and evaluate non-technical skills. Thirdly, not all teachers of humanities are ready to cooperate with their engineering colleagues nor are they able to show students the connection between their HSS courses and technical matter.

3. Changing Engineering Curriculum in Russia

Engineering curricula are being altered throughout the world to comply with the accreditation criteria. Russian universities also see the need to change the educational approaches for the same reason.

However, when it comes to the formation of the engineers' sociocultural competence, universities tend to use the traditional method. Curricula basically include specific technical disciplines and a limited range of humanities. For example, the basic list of humanities for bachelors in Tomsk Polytechnic University is the following: philosophy, economics, management, history, a foreign language.

That approach has proven its inefficiency for those disciplines, and it cannot fully form "non-technical" competences – soft skills – that are needed by graduates today. As long as the humanitarian material is not woven into the fabric of engineering education students cannot see the opportunity of applying that knowledge in their future work.

On the other hand, students feel the need in the knowledge and competences formed by social and humanitarian sciences. They realize that the demand for contextual and communicative skills comes from global economy and employers.

Here we mark the lack of correspondence between the requirements of employers and society related to sociocultural education of future engineers and little opportunities that Russian universities give today in this aspect.

4. Modules in Humanities and Social Sciences for an Engineering Curriculum

As we see it, working out an engineering curriculum based on the interdisciplinary approach and realized through the modular teaching system will be effective because we need students to perceive every discipline as an essential part of their professional development.

General subjects are mainly focused on making students understand basic principles of socio-humanitarian knowledge development. However, considering the requirements of modern production, employers, and accreditation organizations the humanitarian knowledge is inconsistent now. Soft skills training and sociocultural competence formation are needed. Interdisciplinary courses and adding HSS units to current engineering courses along with incorporating specially designed courses in humanities and social sciences for engineering students are a productive way to develop the competencies mentioned above.

As far as the development of non-technical skills is a necessary element of an engineering curriculum we suggest a series of separate modules that can be included into standard engineering courses or used as an optional course. Those modules are designed to form the students' sociocultural competence making them more marketable and competitive in an industry.

Table 1. HSS modules for an engineering curriculum.

Sociocultural competence of an engineer	Modules
-Professional and ethical responsibility -Understanding of the social impact of engineering solutions, the sociocultural context of professional activity	-Engineering Ethics -Corporate Culture and Corporate Social Responsibility
-Effective communication	-Technical Presentation -Business Communication and Etiquette
-Functionality in multidisciplinary and multicultural teams -Tolerant perception of cross-cultural differences and foreign cultures awareness -Teamwork and leadership skills	-Intercultural Communication -Engineering Leadership

4.1. HSS modules description

The module "Engineering Ethics" deals with moral requirements and key values of engineering. Throughout the course we analyze ethical codes of professional associations and societies. In the framework of the module students study cases related to professional and ethical responsibility of an engineer. This module forms the readiness to operate sticking to ethical norms.

The module "Corporate Culture and Corporate Social Responsibility" includes basic principles of corporate culture, the structure and functions of corporate ethics code, goals of corporate events, methods of forming a personal and corporate image. Here we analyze the aspects of the interaction between business, society and authorities in social sphere. This module develops the skill of creating and realizing technical projects taking corporate environment and social context into consideration.

The module "Technical Presentation" offers techniques of effective verbal communication, main requirements and stages of preparing a presentation, presenter's speech culture, argumentation techniques, audience interaction techniques. This module forms the ability to discuss professional issues, make a presentation of a technical project, give well-founded answers and explain the gist of phenomena, events and processes.

"Business Communication and Etiquette" covers the rules and norms of business partners' interaction in business environment, business etiquette. This module helps to learn effective techniques of verbal and nonverbal communication with coworkers.

"Intercultural communication" deals with national and cultural differences in the context of globalization and international business. This module forms intercultural communication competence needed by engineers of today on the international labor market in the conditions of professional mobility.

"Engineering Leadership" considers developing leadership skills: ability to lead a group of engineers and

technical personnel, ability to solve problems, teamwork abilities. This module is designed to prepare an engineer able to take on managerial positions.

5. Conclusion

Thus, today engineers have to be more widely educated because current problems solved by them are becoming more and more of a multi-disciplinary nature. According to Grasso and Martinelli (2007), "the ability to model and incorporate elements of economics, sociology, psychology, and business to identify possible solutions to pressing problems will be a major part of the future of engineering" [14]. Modules in humanities and social sciences for an engineering curriculum will help students see the opportunities of applying the acquired knowledge and skills in their professional practice.

References

1. P.G. Altbach, Tertiary Education and Management, **10,** 3-25 (2004)
2. G. Tryggvason, D. Apelian, *Shaping Our World: Engineering Education for the 21st Century.* (Hoboken, NJ, USA: John Wiley & Sons, 2011)
3. A.K. Parashara, R. Parasharb, Procedia - Social and Behavioral Sciences, **56**, 685-690 (2012)
4. Hart Research Associates. Raising The Bar: Employers' Views On College Learning In The Wake Of The Economic Downturn. Retrieved from http://www.aacu.org/sites/default/files/files/LEAP/2009_EmployerSurvey.pdf (2010)
5. E. Galanina, A. Bikineeva, K. Gulyaeva, Sociocultural, Procedia – Social and Behavioral Sciences,**166**, 339-343(2015)
6. Criteria for Accrediting Engineering Programs, 2015-2016 Accreditation Cycle. Retrieved from http://www.abet.org/wp-content/uploads/2015/05/E001-15-16-EAC-Criteria-03-10-15.pdf
7. L.J. Shuman, M. Besterfield-Sacre, J. McGourtry , Journal of Engineering Education, **94**(1), 41-55 (2005)
8. E.F. Crawley, W.A. Lucas, J. Malmqvist D.R. Brodeur, *Proceedings of the 7th International CDIO Conference.* Retrieved from http://www.cdio.org/files/project/file/cdio_syllabus_v2.pdf (2011)
9. E. Crawley, J. Malmqvist, S. Ostlund, D.R. Brodeur, *Rethinking engineering education: The CDIO approach.* (Springer US, USA, 2007)
10. C. Chak, New Horizons in Education, **59**(3), 59-70 (2011)
11. L.R. Lattuca, P.T Terenzini, F. Volkwein, G.D. Peterson, The Bridge, **36**(2), 1-6 (2006)
12. W. Sunthonkanokpong, Procedia Engineering, **8**, 160-164 (2011)
13. T.K. Grose, ASEE PRISM online,**13**(6), 1-6 (2004)
14. D. Grasso, D. Martinelli, The Chronicle of Higher Education, **53**(28), B8 (2007)