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Supporting education of engineers of 2020 through triple helix model

Nela Cvetković[1], Milovan Medojević[1] and Slobodan Morača[1]
[1] Faculty of Technical Sciences/Department of Industrial Engineering and Engineering Management, Novi Sad, Serbia
e-mail nela_cvetkovic@yahoo.com, medojevicm@uns.ac.rs, moraca@uns.ac.rs

Abstract: *This paper presents Triple Helix model and its appropriate key aspects (components, relationships and functions among helices) as the framework for collaboration among Universities-Industry-Government, with the overall objective to improve engineering education and formation of Engineers of 2020 and to overpass the most significant deficiencies of engineering education. This approach, with adequately defined roles of all parties, benefits and correlations, offers benefits for all model components and, in terms of education, facilitates overcoming deficiencies of traditional education.*

Keywords: *Engineer of 2020; Higher Education; Triple Helix model; Engineering education; Networking;*

1. INTRODUCTION

One of the main goals engineering education is striving for is to prepare students for encountering challenges in the future professional life [1] and to shape engineers fitting the industry demands [2]. Therewith, the higher education institutions are challenged to actuate students into the real-world situations and problems, enabling them to adapt and influence the fast changing future trends and needs, and to form students as future leaders and engineering professionals broadly educated, ethical and inclusive in all segments of society [3]. These future engineers, known as Engineers of 2020, can briefly be described by their main desired attributes: engineers with strong analytical skills, ingenuity, creativity, leadership skills, high ethical and professional standards and engineers who are lifelong learners [3]. The traditional learning has no capacities to fulfill these aspirations [4]. Completely opposite of the constant technology and industry changes, 'education has changed very little over the last half of this century' [5], which is testifying to the urgent need of improved and adjusted teaching methods. Thus, certain learning approaches within higher education started demonstrating effective results in preparation of Engineers of 2020. Work Based Learning (WBL), Problem Based Learning (PBL), and hands-on learning practice are few of the methods that have gained popularity within the engineering education, as significant instruments in concept: learning by doing, learning by using and learning by interaction [6].

The focus of this paper is to give an overview on engineering education challenges and to present our perspective on the adequate model of Triple Helix approach and its contribution

to the improved education of Engineers of 2020 .

2. TRIPLE HELIX APPROACH AND ENGINEERS OF 2020

2.1. Engineers of 2020 and their education

In brief, Engineers of 2020 can be described as the next generation of engineers able to adopt to the fast changing future technology trends and beyond that, to contribute and participate in its going evolution. Related to that, the adequate engineering education has to constantly implement changes that are following the changes in technology and society.

The emerging question is if universities are capable of catching up with challenges, opportunities and rapidly developing technologies that are influencing and shaping the needs for future engineers with certain attributes. Furthermore, the concerning issue is 'What will or should engineering be in 2020? How engineers can best be educated to be leaders, able to balance the gains afforded by new technologies with the vulnerabilities created by their byproducts without compromising the well-being of society? Will engineering be viewed as foundation that prepares citizens for broad range of creative career opportunities? Can the engineering profession play a role in shaping its own future?' [3] Nowadays, there are certain identified deficiencies in engineering education and consequential engineering "skill deficiencies" among which the most significant are:

- The inability to work and discuss with others [4] and inability to work in team [1];
- The inability for creative problem solving and solving complex problems that require integration of social, economic, legal and technical factors [4],[7];
- Inability to communicate [1];
- Non awareness of workplace expectations [1];
- Lack of independent and critical thinking [7].

Considering the presented needs for engineers' skills improvement, foreseen guiding principles and trends that will shape engineering activities, the main desirable attributes of Engineer of 2020 are described as following [3]:

- Strong analytical skills;
- Practical ingenuity;
- Creativity;
- Leadership;
- High ethical standards and professionalism.

Furthermore, additional significant attributes that are recognized are:

- Lifelong learners;
- Good communication skills;
- Business and management skills.

Outlined attributes describe engineers who are broadly educated, see themselves as global citizens, can lead in business and public service, as well as in research, development and design, are ethical and inclusive of all segments of society.

Engineers of 2020 must not only be technically capable, but also to be able to understand the contextual requirements and consequences of their work [3]. In their book, authors [8] define contextual competence as 'an engineer's ability to anticipate and understand the constraints and impacts of social, cultural, environmental, political and other contexts on engineering solutions'. However, despite the importance this issue has gained during the

previous years, it was found that engineering students were generally lacking in key aspects of this skill. This points to the need for improved education which emphasizes on understanding the organizational, cultural and environmental contexts and constraints of engineering practice, design and research [9].

In order to face this deficiency, certain approaches for integration of contextual competences and development of desirable engineer's attributes within higher education need to be identified.

Student's immersion in a real world community context and real-world projects [8], introduction of education system which emphasis hands-on learning, practice and risk-taking and failure culture [10] and generally, practical work and engagement on real-world cases, are approaches seen as valuable for improved education of engineers. Related to that, it is considered that the best way to learn and understand a theory is trying to see whether you can apply theory in engineering problem solving, applying so called Problem Based Learning (PLB) and furthermore, Work Based Learning (WBL) [1]. What makes PBL concept valuable for education of Engineers of 2020 is that it allows students to develop excellent analytic skills and "attack" complex engineering problems [1] which are among the key attributes of Engineer of 2020.

Considering this, co-operation between university (students, researchers) and industry is necessity to find enough relevant real life problems, practical learning context [1] and to enable development of analytic skills, problem solving capacities, creativity and team work skills. However, even though the connection with industry plays crucial role in improvement of education and its modification towards adequate engineering programs and curriculums, the government obtains an active role within the same process. Alongside of acting as policy maker, the continuing role of government rests on ensuring that education makes a contribution to the well-being of society and the economy.

As the fitting approach for proper involvement of all three mentioned instances in education of engineers of 2020 and improvement of their desirable attributes, we have recognized Triple Helix Model.

2.2. Triple Helix model in education of Engineers of 2020

Triple Helix approach is understood as interaction of University, Industry and Government which 'generates 'innovation system' format that highlights the key new sources of novelty and the dynamics of their interaction' [11]. However, Triple Helix model has proven its value for advancement of education as well; integrated work of higher education institutions and industrial enterprises turned out to be not only meaningful for raised professional level of scientists, developers, pedagogues, postgraduate student of the university but also for promotion of higher quality and demand for professionals graduated by the universities who are ready for efficient work in high-tech organizations of the real sector of the economy [12].

As already emphasized, today's rapid technology advances require universities to be more innovative to meet industry demands. In promotion of engineering education universities will not be successful alone, due to lack of resources; however, the Triple Helix approach brings collaborative opportunities [2]. Triple Helix model transfers theory to practice enabling innovative trainings [2], facilitates successful collaboration between industry sector, universities and government institutions, provides optimal incentives for students, empowers new technological developments and enhance the reputation of universities [13].

Furthermore, Triple Helix theory supports concept that learning by doing, learning by using and learning by interaction could not only increase efficiency of production [6], but also the quality of education of high-tech engineers [2]. According to [13] this kind of collaboration creates challenges for universities: instead of focusing on traditional manners of teaching and research activities, they start to concentrate on business. Consequently, the favorable environment for Problem Based Learning in engineering education is set up. One of the most successful examples of such a collaboration where one of the outputs are improved skills of graduated engineers is cooperation between IBM and universities, supported by government institutions. Within this collaboration, interdisciplinary Research Center is established, in order to gather students to address broad and real-world needs [14].

According to [11] so far there has not been provided explicit analytical framework for conceptualizing the systematic nature of Triple Helix approach. The authors define and extensively describe Triple Helix model as 'a set of:

- *Components*: the institutional spheres of University, Industry and Government, with a wide array of actors;
- *Relationship between components*: collaboration and conflict moderation, collaborative leadership, substitution and networking;
- *Functions*: processes specific for Triple Helix spaces: Knowledge, Innovation and Consensus'.

Considering the focus on improvement and promotion of education of Engineers of 2020, the main current deficiencies in relevant education, and required attributes of Engineers, we propose following Triple Helix model, based on systemized key features of Triple Helix interaction presented by [11]:

1) Components

Universities involved in engineering and technological education, industry and government institutions.

- *University role*: collaboration with industries in order to provide students with real-life cases and problems, to enable Problem Based Learning and Work Based Learning; education of students according to the needs specified by the partners from industry; constant promotion of academic stuff; cooperation with industry sector and Government institutions in creation of education strategies.
- *Industry sector role*: cooperation with universities in order to increase its innovative and R&D capacities and incorporate in process of shaping the future engineers; including students in their real-life projects and problems.
- *Government institutions role*: facilitation of university-industry relation by adequate policies and regulations; involvement in education strategy development; support by government funding agencies.

2) Relationship among components

As interaction between components can take different forms, depending on economic, social and technology needs, we find Networking as the most suitable one in terms of education of Engineers of 2020 within Triple Helix model.

- *Networking*: networking into formal or informal structures on different levels (regional, national, etc.) is seen as effective structure in responding to changing conditions. Research networks have been found to be of critical importance

socially, politically and economically in order to generate labor among participants in the network [15], in this case, to generate engineering experts.

3) Functions

- *Knowledge space:* represents the mix of knowledge generation, transfer, diffusion and other activities among components of Triple Helix model. The construction of this space is essential for definition of involved knowledge resources and to reduce duplication of efforts within the Triple helix [11].
- *Innovation space:* implies activities planned and undertaken by components according to the goals and purpose of collaboration establishment.
- *Consensus space:* "set of activities that bring together Triple Helix components to brainstorm, discuss and evaluate proposals for advancement" and its transformation towards collaboration.

These represent the most important and essential aspects and key features of Triple Helix model described in concerning the improvement of engineering education, with focus on Work Based and Problem Based Learning, student's engagement of real-life cases and real teams and life-long learning.

3. CONCLUSION

Education of Engineers of 2020, although having a great potential and even greater importance for industry, technology and generally, society development, demonstrates significant deficiencies. Consequently, these deficiencies in engineering education have been reflected on graduated engineering students' skills. The inability to work and discuss with others [4], inability for creative problem solving and solving complex problems that require integration of social, economic, legal and technical factors [4],[7], inability to communicate [16] and independently and critically think [7] are few of the most concerning shortages of engineering skills.

With respect to these ascertainments, foreseen future trends and guiding principles that will shape engineering activities, the attributes of engineers ready to adapt to ever changing environment and needs are identified and defined as 'attributes of Engineer of 2020' [3].

With aim to accomplish and prepare Engineers of 2020, universities have started improving and modifying approaches in engineering teaching and learning. Thus, work based and problem based learning have gain the importance and the significance of engagement on real-world projects and complex problems solving have proved to be valuable for transition of students into engineering professionals.

What we have seen as approach for integration of above mentioned solutions and vital framework is Triple Helix model, with the presented defined role of all the components (Universities, Industry and Government), their relationship (Networking) and functions inside the model. With Triple Helix components, relationships among helices, and functions adjusted and defined in accordance to the goals and needs of collaboration partners, this model represents valuable support for education of Engineers of 2020 and its constant melioration.

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