A Preliminary Research to Improve the Creativity of Engineering Education

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Abstract

This paper discusses the importance of improving the creativity of engineering education. Nowadays, the engineering students are required to gather huge amount and updated information other than the available in the textbooks and lectures in order to build an adequate level of knowledge. The offered teaching methods in the engineering institutions have to reflect the emerging global needs to prepare students to be successful engineering managers in the future. Although the effort of improving the engineering education system is continuous, it is still challenging to effectively apply the creative teaching methods. The research of this paper presents the requirements of the modern global engineering education, suggests a number of creative teaching methods, and discusses barriers for implementing these creative teaching methods.

Keywords

Engineering education, creative teaching methods.

1. Introduction

The engineering education in today's global economy is keyed to the demand of creative engineers who are able to solve technical and managerial problems in creative ways suitable to the facing challenges and rapid changes in the global communities. The stakeholders who are involve in the engineering education improvement, including engineering institutions; faculty members and lecturers; and students, are collaboratively facing the pressure to improve the systems of engineering education that will produce creative engineers with the required skills to stand up to the challenges of the global economy.

Unfortunately, nowadays the engineering profession does not hold the same position it did prior to the twentieth century. The root cause of this problem of perception is the inadequate preparation of engineers for their work (Arciszewski, 2014). Lack of proper preparation for engineers adds pressure on the engineering education systems. Orhun, and Orhun (2013) emphasized that the engineering education systems must accommodate the fundamental changes necessary to produce highly skilled creative and innovative engineers who can stand up to the challenges of modern industry. Although teaching the skills of creativity and innovation has become essential to any engineering education system, engineering students typically feel they lack the element of creativity in their educational experience (Donnelly, 2004) and (Korgel, 2002). Donelly (2004) believed that the lack of creativity in engineering education is due to too little focus of the teaching methods on developing the students' ability to think in creative ways. The goal of the engineering education system is to fulfill the industrial needs of global economy and markets, and at the same time enhance the creative capabilities of engineering students.

Arciszewski (2014) identified the mission of 'successful education' which is to create an engineering education system that teaches engineers to think creatively and become leaders and successful inventors with an influence to their societies. The author discussed that the degree of this success can be measured, for example, by a particular engineer's professional and social position, political influence, and number of patents and income. The author believed that successful education has political, technical and methodological goals. Two major goals were identified by Arciszewski (2014), and if these goals are met, the engineering profession will be more impactful and will attract the most brightest and creative students. The first goal is that engineers become successful leaders that develop and initiate changes to the political and technical infrastructure of their societies. The second goal is that engineers are again perceived by society as leaders of civilization, with high social status and income.

Many efforts were carried out to improve the engineering education systems. For example the criteria for accrediting the engineering technology programs by ABET are designed to be reflective for the global requirements of having a creative engineers. The engineering education literature is also considered a good source for offering methodologies that can be applied by engineering institutions for improving their engineering education systems. In addition, the engineering institutions are considering several internal and external initiatives for improvement. Examples of internal improvement initiatives include suggesting enhanced teaching methods to foster the creativity of students, and updating the curriculum and offering new courses to reflect the new industry market needs. Examples of external improvement initiatives include partnering with industry professionals and society to provide real world experience for engineering students through projects, internship, and volunteer tasks.

Although the process of improving the engineering education system is continuous, it is still challenging to attain the required goals and plans for improvement. This paper overviews the requirements of the modern global engineering education. Then presents a preliminary research examples of creative teaching methods from the engineering education literature. The paper also discusses the barriers for implementing the creative teaching methods that cause the engineering education improvement to be delayed and challenged.

2. Requirements of the Modern Global Engineering Education

The global current and future demands shape the new paradigm for engineering education. Splitt (2003) described the new paradigm of engineering education in which the solution of problems involve human values, attitudes, and behavior, in addition to the interrelationships and dynamics of political, social , environmental, and economic systems within a global basis. The engineering education systems must not be limited to go beyond the need to keep students at the cutting edge of new technology, but also should call for a better balance in the various areas of engineering profession (American Society for Engineering Education, 1994).

With regard to the criteria for accrediting the engineering technology programs by ABET, it designs a number of requirements that must be applied by all programs accredited by ABET commission. The curriculum must effectively develop a number of subject areas in support of student outcomes and program educational objectives. An example of theses subject areas include: The Integration of Content which requires the Baccalaureate degree programs to provide a capstone or integrating experience that develops student capabilities in applying technical and non-technical skills in solving problems. Also an example of ABET learned capabilities for student outcomes is maintain a commitment to quality, and continuous improvement, also the knowledge of the impact of engineering technology solutions should be considered in a societal and global context (ABET Criteria for Accrediting Engineering Technology Programs, 2016).

The engineering education literature has identified several attributes and requirements for the modern engineering education systems. Splitt (2003) researched the literature and summarized the scholars' work by determining the requirements of modern engineering education. The following points are examples of the requirements identified by Splitt (2003):

- Encouragement of diverse student academic backgrounds and faculty members for the objective of developing emerging professionals;
- Maintenance of regular and well-planned interaction with industry through industry-based projects;
- Emphasis on inquiry-based learning with much less dependence on lectures and class notes with a concentration on preparing the students for lifelong learning,;
- Emphasis on integrative, systems thinking, managing change, communications skills, teamwork and group problem-solving skills (staring from the identification through analysis and resolution); and
- Focus on design issues such as life-cycle economics, environmental impact, sustainable development, ethics, quality, health and safety, manufacturability as well as maintainability, social, and legal, standards.

Students are required to be prepared to solve problems of interdependence systems, including multiple components of environmental factors, quality and sustainability, economic, ethical and legal aspects. For that reason, students should have the skill to innovate when finding solutions. Arciszewski, (2014) recognized the importance of introducing a fundamental shift in how the engineers should be educated. The education focusing on analytical knowledge and skills to acquire knowledge is not sufficient nowadays, the author discussed that the education must be expanded and developed to include knowledge and skills on how to creatively innovate as well.

Arciszewski,(2014) discussed that as a result of the internet revolution, the knowledge is becoming easily available and accessible to students to use this available knowledge for creating innovative problems answers.

In order to meet the global demands of more developed engineering education systems, the decision makers in engineering education must understand the fact that the education must change to let the students learn how to be creative and prepare them to be innovative engineers. The following section represents a preliminary research about several creative teaching methods.

3. Creative Teaching Methods

Rugarcia et al. (2000) described the traditional approach to teaching, in which the professor discusses lectures, and assigns readings and "well-defined convergent single-discipline" problems. The students attend, take notes, and solve problems individually. Arciszewski (2014) concluded that traditional engineering education produces students who are local thinkers focusing on details and using only the available taught deterministic procedures. The author believed that local thinkers cannot become inventors and leaders.

Badran (2007) proposed a number of points to achieve "good education system" that would lead to engineering students to be less passive and non-creative engineers. These points include suitable curriculum design; diversified teamwork activities; strong relationships with industry; and establishing a creative and innovative environment in the engineering institution by having engineering and technology organizers who can encourage the imagination and creativity of students.

The engineering education literature contains suggested techniques for creative teaching methods. Rugarcia et al., (2000) proposed an alternative educational technique that have been shown to be more effective. Among these techniques, as described by the author, are cooperative (team-based) and discovery learning, the assignment of open-ended questions and multidisciplinary problems that require creativity and innovation in finding the answers, problem formulation exercises, brainstorming with trouble-shooting exercises, and other methods designed to address the variety of learning styles. Arciszewski (2014) encourages producing global thinkers who can look at an engineering issue within its larger context. The author also promotes creative intelligence which is the ability to solve non-routine (creative) problems that require innovative skills and the use of knowledge not only from the problem domain but also from multiple domains and aspects. In order to solve these problems the students should be taught to create unknown solutions or ideas.

Kirillov (2015) emphasized the need to generate a methodological culture that allows shaping independently the ideal model of creativity. The author believed that simple request to students to apply creative methods is not sufficient; in order to encourage creativity, the faculty members should keep an open mind to creative problem-solving approaches and search for innovative solutions together with students. The knowledge developed through project and research work should be applied and used for new exercises and problem solving (Dulzon A., 2013). Kirillov (2015) discussed that both analytical and creative thinking can be developed through the educational process by using teaching tools such as case study, debates, business and role games, and collaborative (problem oriented) lectures. These methods will enhance intellectual interest, promote students to be self-dependence of multidisciplinary approach, in other words, the problem solving process in one class requires supplementary knowledge from various subjects (Gutkevitch A., 2010).

One of the examples to enhance creativity is the Engineering Projects in Community Service (EPICS) program. EPICS was created as a result of the claim that graduating engineering students had strong technical backgrounds but few other skills needed for successful careers. EPICS aims to prepare students with the requirements for their future career including:

- Professional skills, including the ability to work in teams, communicate effectively, work with customers, and manage projects;
- Awareness of the issues affecting any project, such as the ethical, legal, and environmental issues; and
- The ability to work with people from different backgrounds within many social settings (Coyle et al., 2006).

EPICS offers the opportunity to form long-term partnerships between the university and the community. The way that EPICS is implemented is through a track of courses, each team is between 10 to 20 students-and of students of freshmen, sophomores, juniors, and seniors. A student may be a member of a team for up to four years (Coyle et al., 2006). The advantage of EPICS from an educational point of view is that the long-term involvement of this program allows the students to experience the whole engineering design cycle, starting with problem definition through the

application of real projects. The EPICS program at Purdue University offers in a semester more than 20 disciplines. The EPICS creates new opportunities to integrate the different components of the curriculum. The EPICS can provide the following benefits for the students: motivating learning of fundamentals through compelling applications; providing a setting where students can apply both analysis and design; extending students' craving to learn on their own to meet the requirements of their project; realizing efficiencies in the curriculum by continually building on they have learnt before; and providing a time scale that connects semesters of learning (Coyle et al., 2006).

The preliminary research of this paper shows the importance to shift from the traditional methods of teaching into more creative teaching methods that foster the innovative thinking for engineering students. Given the available technology and exposure of knowledge through internet, students are required to solve more complex problems by using the available information that can be easily accessed from the internet. Although the creative teaching methods will produce more successful engineers, these methods are still facing some barriers against effective implementation. The following section summarizes the barriers for implementing creative teaching methods.

4. Barriers for Implementing Creative Teaching Methods

Kazerounian and Foley (2007) studied the status of creativity in engineering education through examining the perceptions of students and the instructors, their study showed that the engineering students feel they lack the creativity element in their educational experience. According to the same study, students perceive a weakness in thinking creatively in open mind because they have not learned to think of problems in a new and unusual way. In addition, the fear of wrong answers while solving the problems creatively will negatively affect their grades.

The engineering education system should encourage the creativity, and that requires changing the ways in which the lectures are operating. However, an obstacle to change is the fear of loss of control. In general, traditional lecture classes in which student involvement is essentially limited, the lecture is broken by occasional questioning, the lecturer or faculty member is in a complete control of what happens in the classroom (Rugarcia et al., 2000). On the other hand, it is not easy to expect what might happen in a student-centered class. The author clarified that delays and deviations in the course structure may occur, making it difficult to stay with the syllabus requirements, also the discussion may alternate into areas unnecessary for the subject of the study. In worst cases, Rugarcia et al., (2000) discussed that students may simply not buy into the student-centered class, making the class uncooperative, with a refusal and less motivated to get involved in the planned activities. The author concluded that the skill to direct student-centered classes can be learned and be improved with practice. The lecturers and faculty members should have enough courage to try new teaching methods.

Orhun and Orhun (2013) summarized a number of obstacles facing the effective implementation of creativity in engineering education such as: rewards in educational institutions, such as appointment, promotion and tenure requirements, do not emphasize on teaching of creativity and that may even does not encourage these activities. Also, insufficient mechanisms and systems to help instructors develop their capability to raise interactive, and creative learning.

Changing engineering education is not easy. It requires significant resources, time and continuous efforts, and changing human attitudes (Arciszewski, 2014). Several steps are required to assist on proper implementation of creative teaching methods. First, the University administration must establish a suitable environment for creativity before any effort for significant change (Rugarcia et al., 2000). Second, engineering lecturers and faculty members must revise their course design putting more emphasis on activities such as group project and verbal presentation skills (Chen et al., 2005). Third, with regard to assessment methods for students, the tests and assignments should be used as a method to improve the learning experience for students. Smith (2000) recommended providing feedback to students and believed that feedback is more important than assigning grades. He suggested using a non-graded evaluation (for feedback) as well as evaluation for assigning grades.

5. Conclusion and Recommendations

Improving the engineering education system and encouraging the creativity in teaching methods are essential needs for preparing a successful engineers in today's global societies. This paper presented an introductory research to discuss the requirements of the modern global engineering education, the suggested creative teaching methods from the literature, and the barriers for implementing creative teaching methods. It is important to mention that the development of the capability to foster creativity in engineering education is the prime responsibility of all stakeholders involved in the engineering education system. The university administrators and leaders must provide

an adequate environment for creativity that include but not limited to encouraging creative teaching methods as part of the promotion and tenure requirements. The society represented by industry leaders and professionals must offer collaborative partnership opportunities through university-industry projects and internships for students. The lecturers and faculty members must have the courage and enthusiasm to introduce creative ways of teaching. The syllabus, grading systems and lecture design should reflect and control the creativity process. The students must also collaborate, and have the responsibility to understand that creative teaching methods are important for succeeding in their career.

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Biography

Rufaidah Y. AlMaian is an Assitant Professor in Industrial and Management Systems Engineering at Kuwait University. She received her Ph.D. degree in Industrial Engineering from the University of Arkansas. Her M.S. is in Industrial Engineering from the University of Pittsburgh in 2011 and B.S. in Industrial and Mangement Systems Engineering from Kuwait Univeristy in 2005. Prior to pursuing her graduate studies, AlMaian joined a specialized training program for engineers and spent four years in industry working for a financial institution. Her research interests are in engineering management, engineering education, and decisoin making analysis.