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Engineering Education Reform; Thinking Globally, Acting Locally

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A B S T R A C T

Objective: With the fast growth of technology globally, the need for more talented and skilled engineers across the world have also increased. But, what makes an engineer talented and skilled? What should be the goal of engineering education? **Methodology:** As engineering educators and engineering education researchers, how can we foster those engineers? When is the best time to start educating our future engineers? In order to address the global need, we should answer the questions mentioned above. Answering these questions requires knowing how engineering education community across the world are addressing this need. **Results:** In this position paper, we seek to answer these questions by reflecting on what we know about engineering education based on our experience of working in a developed country and the knowledge we gained during this time. **Conclusion:** At this point, we would like to invite all the members of this community to start the conversation of reform in engineering education as soon as possible. We need to start identifying the needs of our industry, plan to diversify engineering education, plan to design and create engineering programs for younger students, plan to educate teachers and engineering students for teaching young children, and plan to modify engineering programs in higher education. Although these research are not enough but can be a start point for collaboration.

1. Introduction

ITH the fast growth of technology, the need for more talented and skilled engineers, have also increased. Industry should clarify what makes an engineer talented and skilled. Hence, some big companies have already identified what competencies and skills their engineers need to work in their companies. As an example, in circa 1994-1995 Boeing created a list of desired attributes of an engineer. The primary purpose of creating this list was to start a dialogue with academia and let engineering schools know what industry wants (McMasters, 2007).

We believe engineering universities should take advantages of these dialogues to address the current need of industry; having prepared engineers. This is a global need which should be addressed by considering changes made across the world.

The main goal of engineering education should be preparing future prepared engineers. The product of engineering is future engineers, and the end user is where they are sent: the world of practice. Engineering education should build a bridge between academia and the world of practice to achieve its main goal. Before building this bridge, engineering education should identify the existing concerns and overcome these using different resources. To successfully build this bridge, the reform of engineering education should be accelerated.

Moreover, engineering education reform should not be limited to university levels. The education of talented engineers should start from earlier stages as soon as kindergarten and elementary school ages. It has been proved that many of the desired competencies can be fostered in these early stages.

In this position paper, we will start by talking about the history of reform in the United States of America (USA) as an example of a developed country. We will then point to the existing industry and academic concerns. Finally, we will discuss the necessity of collaboration to draw a conclusion on where should engineering education reform be directed to and when can engineering education be started from.

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History of Reform in united states of America

In the United States, engineering education reform has started from late 1980's (Jesiek et al., 2009). One of the main purposes of this movement was to fulfill the needs of industry. The needs included whether enough engineers are being educated and prepared for the nation needs. In addition to the quantity of engineering graduates, quality of their education was in the center of attention. The reform paid a great attention to improving undergraduate engineering programs. Moreover, some focused on including historically underrepresented people in engineering. As described by Jesiek and colleagues, this reform movement has influenced engineering education and its community to some extent in this the past three decades.

Moreover, over three decades, Engineering Education Research (EER) have focused on accelerating reform of engineering education. However, not enough practical works have done to close the gap between academia and industry in engineering. In other words, not many engineering students have been fully prepared to work in the world of practice (Markes, 2006). Thus, engineering education should take more serious steps forward in the reform movement.

Over the past two decades, STEM (Science, Technology, Engineering, and Math) education and integrated STEM has grown in the United States, and many students and teachers have become interested to engage in K-12 (Kindergarten-high school) integrated STEM education. Integrated STEM refers to the efforts to combine science, mathematics, technology, and engineering in one unit or class (Moore and Smith, 2014). According to Moore and Smith (2014), integrated STEM often includes participating in engineering design to develop an understanding of technology, which requires thoughtful learning of science and mathematics. Although K-12 engineering has received less attention from educators and administrators than other STEM disciplines, the pace of integrating engineering into K-12 education is also increasing recently, and more students are experiencing engineering education (Katehi et al., 2009a).

The National Resource Council reports that integrating engineering in K-12 education has become an important phenomenon because of its potential benefits. Potential benefits include familiarizing students with introductory engineering concepts, engineering jobs, and increasing interest in engineering as a future career. On the other hand, the quality of science teaching and learning has become a concern in K-12 education (Katehi et al., 2009b). However, as a potential benefit, engineering improves learning and achievement in science and mathematics (Katehi et al., 2009b). Since, K-12 engineering integration hinges on student engagement, the successful integration of engineering design in science and math curricula seems a necessary step in improving Kindergarten-high school STEM education.

1.1 Industry and Academic Concerns

With the expand of new technologies and globalization, the need for preparing engineering students is more crucial than before (English, 2014). "Engineering UK has estimated that the UK will require 87,000 engineers a year over the next ten years" (English, 2014). We believe the need is globally and this estimation can be generalized to other countries as well. Thus, immediate action should be taken to reassure that the industrial need will be fulfilled.

Concerns about the future of engineers have been identified and discussed from late 1980's (McMasters and Komerath, 2005). However, most of the concerns have yet been solved. Below are some of the concerns mentioned in literature (McMasters, 2007):

1.2 Educating Engineering Graduates is Costly

Engineering education costs a lot, especially if industry wants to pay for this education (McMasters & Komerath, 2005). For instance, imagine engineers who have not gained the required competencies during the academic years. They need special training, and the industry has no choice rather than pay for their training. This training not only costs money but it also costs time for the company. Thus, we believe, the industry should get involved in educational process by providing special services to engineering students. These services include coops and internships that increases the cooperation between industry and academia. This cooperation not only reduces the costs for the industry but also helps engineering education to achieve their main goal in preparing future engineers.

Doing research is another type of cooperation that some big companies started with engineering schools. For instance, in 1994-1995 Boeing did a research and provided a list of desired attributes for an engineer (Figure 1). This list was suggested to engineering schools to prepare their students for the future careers. The list was also served and used in framing the Student Learning Outcomes section in ABET Engineering Criteria 2000. However, since then the list has not changed even for a single word 1. In addition, most of these attributes have not been fostered in engineering students during their academic years 6.

The authors believe engineering education research should cooperate more with industry. The findings of the research should be applied to engineering programs. Accordingly, engineering programs become stronger and more practical. Hence, students become more prepared for their careers. As a result, the costs of industry will be eliminated or reduced.

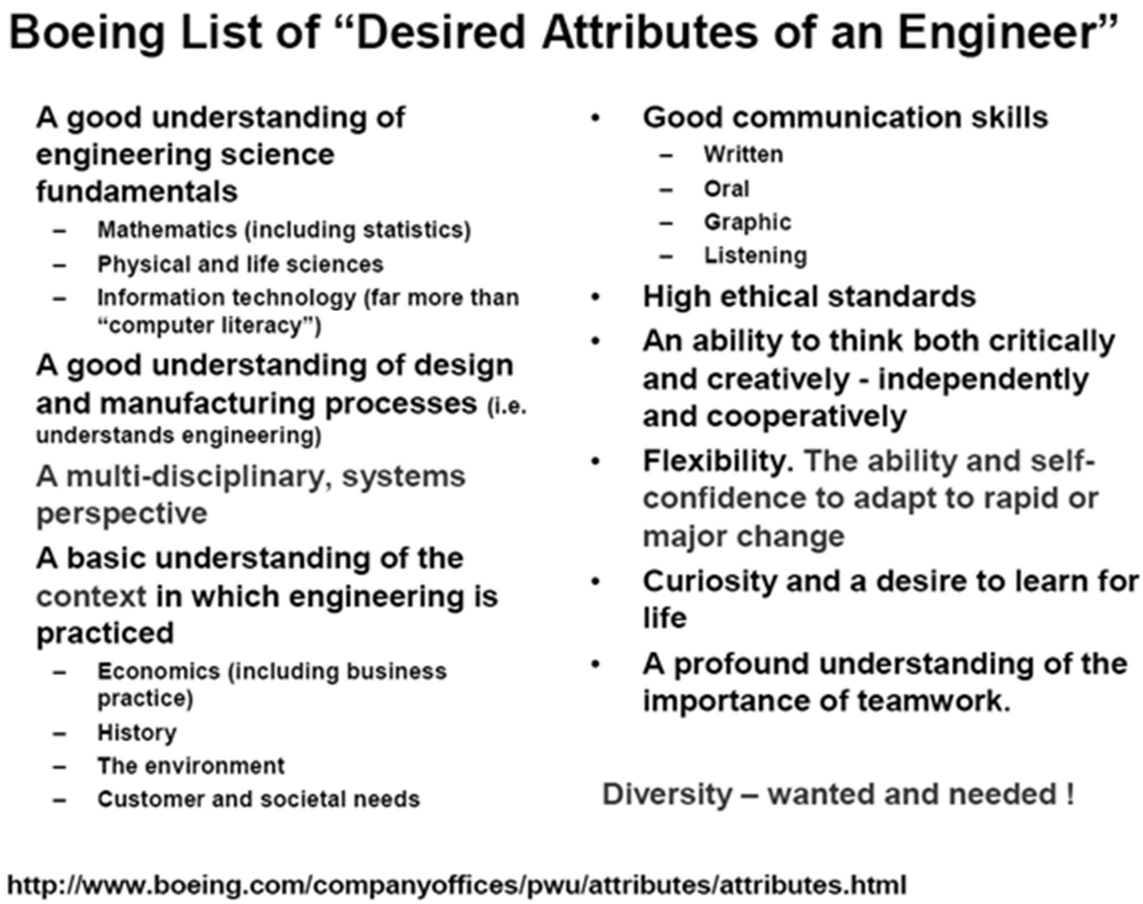

Figure 1. Desired Attributes of an Engineer

2. Materials and Methods

2.1 Current Engineering Programs are failing to Attract Underrepresented population

Engineering education is not only about teaching and training future engineers, but also it is about who becomes an engineer (Chubin et al., 2005). One of the main concerns of today's engineering programs (mainly in US and Europe) is that these programs are failing in attracting females 8 and people with disabilities. In order to have a foster talented and skilled engineers, engineering education should be inviting to all the people. Every individual comes with a valuable perspective and different point of views about engineering, which leads to a more diverse community. Therefore, having a more diverse community will help bring different ideas and different perspectives to engineering education and world of practice (Borrego and Bernhard, 2011). When a diverse group of engineers collaborate, engineering problems will be examined in a broader ways. Hence, engineering problems will be solved more carefully, and the field will improve. As mentioned in Engineer of 2020 "We aspire to an engineering profession that will effectively recruit, nurture, and welcome underrepresented groups to its ranks" (National Academy of Engineering, 2004).

Here, we should note that the first step to diversify engineering community is to identify which population are considered underrepresented in their community. Obviously, underrepresented population is a local consideration and varies in different countries. Engineering education community is responsible to identify that and consider educating them in the best way. Many countries have already identified their underrepresented population and started creating appropriate educational instructions for them.

2.2 Current Engineering programs mostly focuses on content knowledge rather than skills

Many of the current engineering programs are designed on preparing students for a Ph.D. program a research (McMasters and Komerath, 2005), regardless of where engineering students will end up working at. Both engineering academia and industry can take advantage of the research. In recent years, many studies have been conducted to identify what changes should be applied to engineering curricula. These changes can help foster student technical skills. Adams and Felder (2008) believe that shifting the focus of engineering curricula from transmission of content to development of "skills" is important. This shift supports engineering thinking and professional judgment. To drill down into the "skills," many researchers have identified necessary skills which are mainly based on industry need (Ivanova, 2012). Some of these skills are leadership (Sankar et al., 2010), globalization (Allan and Chisholm, 2008), critical thinking (Pierce et al., 2013). Other vital characteristics that a good engineer should practice includes "creativity, teamwork, and communication" (Pawley, 2009). Many researchers believe that children naturally think like engineers and are able to learn and practice engineering skills (Atman et al., 2007). Therefore, many have shifted the conversation of teaching engineering skills towards pre-college engineering education. Many engineering curricula, programs, and activities have been designed to promote engineering thinking and skills in children (e.g., Engineering is Elementary and Picture STEM).

3. Discussion and Results

3.1 Engineering Faculty don't have Enough Industrial Experience

One of the questions which is usually forgotten is who gets to teach engineering. Large majority of engineering faculties have little or no industrial experience. This fact was also mentioned by McMasters and Komerath (2005). Thus, they are not aware of industrial need. In order to prepare students for the industry, professors should at least have some minimum industrial experience to be able to understand the need and the "language" of industry. In addition, engineering education can benefit from the professors who were trained in industry. They can also transfer industry knowledge and skills to their students.

One good example was the "Boeing Welliver Faculty Fellowship Program" which is no more running. They offered this program because they believed the professors were educating future workforce, helping students develop the skills they need to be successful in engineering, business, and manufacturing and technology careers. One of the participants describes the effect of this program on his teaching: "The Welliver program has forever changed the way I look at teaching. Brought up in the classic "lecture" mode of delivering education, the program helped me realize that what we deliver through a lecture is for the most part "information." It does not become "knowledge" until the student has experienced it…" (Eberhardt and Kumar, 2002). The outcome of programs like this is to connect academia to industry. This will help engineering education to prepare better engineers which is the main goal of engineering education.

3.2 The Necessity of Research and Collaboration in Engineering Education

Engineering education reform can't be successful without collaboration between community elements. This community has four elements: researchers, policy makers, professionals in industry and educators. Researchers and policymakers should reach out to professionals to be able to find the gap between industry and academia. In that case, they will be able to draw the connection and find the solution. Industry should also feed policymakers with the needed information and its expectation of engineers. The result of these connections can then be fed into educator's curricula in order to better prepare students for future career.

Engineering education is not a quarantined community. People in this community have connection with others within the community and also over the globe (Jesiek et al., 2009). This is the nature of engineering. Also, the National Academy of Engineering (NAE) defines engineering as the production of various products through its relationship with other fields (Pawley, 2009). With all that said, we believe it is time for all community to come together and help each other to come with a feasible solution to help the reform to accelerate.

4. Conclusion

The main goal of engineering education is preparing future engineers. Although engineering education community has been talking about reform for more than two decades, still not all students are gaining proper skills. The described concerns are resulting in gaps between industry and academy. Some of these concerns were mentioned in this position paper: High cost of training the unskilled engineers in the industry, failing to attract underrepresented populations in engineering programs, lack of industrial experience among engineering faculty, focusing on the content knowledge rather than skill, and finally underestimating the power of teaching engineering to younger students (Kindergarten to high school).

The success of industry as the main consumer of engineering education relies on future engineers. Today's students will be tomorrow's engineers who will be working in the world of practice. The engineers' skills and knowledge will influence industry success. We believe industry should reform its dialogue with academia, both higher education and pre-college education. Engineering education research should help both industry and academia to better understand their common and different needs. This will help in reforming their dialogue. At this point, we would like to invite all the members of this community to start the conversation of reform in engineering education as soon as possible. We need to start identifying the needs of our industry, plan to diversify engineering education, plan to design and create engineering programs for younger students, plan to educate teachers and engineering students for teaching young children, and plan to modify engineering programs in higher education. Although these research are not enough but can be a start point for collaboration.

REFERENCES

Adams, R. S., & Felder, R. M. 2008. Reframing professional development: A systems approach to preparing engineering educators to educate tomorrow's engineers. Journal of Engineering Education, 97(3), 239-240.
Allan, M., & Chisholm, C. U. 2008. Achieving engineering competencies in the global information society through the integration of on-campus and workplace environments. Industry and Higher Education, 22(3), 145-152.
Atman, C. J., Adams, R. S., Cardella, M. E., Turns, J., Mosborg, S., & Saleem, J. 2007. Engineering design processes: A comparison of students and

expert practitioners. Journal of engineering education, 96(4), 359-379.
Borrego, M., & Bernhard, J. 2011. The emergence of engineering education research as an internationally connected field of inquiry. Journal of Engineering Education, 100(1), 14-47.
Chubin, D. E., May, G. S., & Babco, E. L. 2005. Diversifying the engineering workforce. Journal of Engineering Education, 94(1), 73-86.
Eberhardt, S., & Kumar, V. 2002. Long-term Impact of the Boeing Welliver Faculty Fellowship Program. age, 7, 1.
English, V. 2014. Helping Students Build Their Future in Engineering. Education in Science, 257, 18.
Ivanova, M. 2012. Social competencies identification for realization of successful engineering practice. Interactive Technology and Smart Education, 9(4), 217-229.
Jesiek, B. K., Newswander, L. K., & Borrego, M. 2009. Engineering education research: Discipline, community, or field?. Journal of Engineering Education, 98(1), 39-52.
Katehi, L., Pearson, G., & Feder, M. 2009a. The status and nature of K-12 engineering education in the United States. The Bridge, 39(3), 5-10.
Katehi, L., Pearson, G., & Feder, M. 2009b. Engineering in K-12 education: Understanding the status and improving the prospects. National Research Council: Washington, DC..
Markes, I. 2006. A review of literature on employability skill needs in engineering. European Journal of Engineering Education, 31(6), 637-650.
McMasters, J. H., & Komerath, N. 2005. Boeing-University relations–a review and prospects for the future. In Proc. ASEE Annual Conf. & Expo.
McMasters, J. H. 2007. Influencing student learning: An industry perspective. International Journal of Engineering Education, 22(3), 447.
Moore, T. J., & Smith, K. A. 2014. Advancing the State of the Art of STEM Integration. Journal of STEM Education: Innovations and Research, 15(1), 5.
National Academy of Engineering, U. S. 2004. The engineer of 2020: Visions of engineering in the new century. Washington, DC: National Academies Press.
Pawley, A. L. 2009. Universalized narratives: Patterns in how faculty members define "engineering". Journal of Engineering Education, 98(4), 309-319.
Pierce, C. E., Gassman, S. L., & Huffman, J. T. 2013. Environments for fostering effective critical thinking in geotechnical engineering education (Geo-EFFECTs). European Journal of Engineering Education, 38(3), 281-299.
Sankar, C. S., Kawulich, B., Clayton, H., & Raju, P. K. 2010. Developing Leadership Skills in Introduction to Engineering Courses through Multi-Media Case Studies. Journal of STEM Education: Innovations & Research, 11.

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