Priorities in Engineering Education in 1404 (2025 A.D.)

Asad Azemi
Department of Engineering
Pennsylvania State University
azemi@psu.edu

Morteza Khademi
Department of Electrical Engineering
Ferdowsi University of Mashhad
khademi@um.ac.ir

Abstract.

In this work, we will discuss priorities in engineering education in year 1404 (2025 A.D.) based on some of the attributes of an engineer in 2020 as discussed in "The Engineer of 2020," and new priorities such as environment, society, and energy by extrapolating the current socio-economic conditions. Moreover, the manner that engineering education in Iran can realize those characteristics is also discussed. Some of these characteristics, such as "strong analytical skills" are being actively promoted in Iran but others such as "practical ingenuity," and "Creativity (invention, innovation, thinking outside the box, art)," requires fundamental changes in engineering education in Iran. Given the uncertain and changing character of the world in which 1404 engineers will work, engineers will need something that cannot be described in a single word. It involves dynamism, agility, resilience, and flexibility. This requires basic changes in how engineering education is perceived and more importantly assessed so that the linkage between a quality undergraduate program and strong graduate and research programs can be established. Engineering education in 1404 also includes a solid relationship with industry and society. Requirements for such a link are also discussed. In order to deliver such attributes, the proposed structure should also include an effective program evaluation with a focused learning assessment components.

Keywords: Engineering Education, Design Methodology, Program Assessment

Introduction

Following numerous calls, in United States, from various academic and governmental reports, professional societies, and industries for the improvement of engineering education The National Academy of Engineering (NAE) Committee on Engineering Education (CEE) launched a two-phase vision-casting initiative on engineering in the future and educating engineers. The report for the first phase of the project, The Engineer of 2020: Visions of Engineering in the New Century was released on May 17, 2004 [1]. The motivation behind this project was to make engineering education more proactive and rather than following the fast paste of changes in technology and society, to anticipate needed advances and prepare for a future that it will provide more benefit to humankind. The report provides a strategic look into the future and identifies the attributes and skills that engineers will need if the U.S. is to maintain its economic leadership and sustain its share of high-technology jobs. As it has been stated in the report, since precise predictions of the future are difficult at best, the committee

approached its mission using the technique of scenario-based planning. Four scenarios that were considered were (1) The Next Scientific Context; (2) The Biotechnology Revolution in Societal Context, (3) The Natural World Interrupts the Technology Cycle, and (4) Global Conflict or Globalization. The report addresses the societal, geopolitical context within engineering and its new technologies will exist. Next, it identifies basic themes that are worth striving for if engineering is to be a positive force in the future. Finally, the report identifies attributes needed for the graduates of 2020. These include such traits as strong analytical skills, creativity, ingenuity, professionalism, and leadership. This study suggests that if the engineering profession is to take the initiative in defining its own future, it must (1) agree on an exciting vision for its future; (2) transform engineering education to help achieve the vision; (3) build a clear image of the new roles for engineers, including as broad-based technology leaders, in the mind of the public and prospective students who can replenish and improve the talent base of an aging engineering workforce; (4) accommodate innovative developments from non-engineering fields; and (5) find ways to focus the energies of the different disciplines of engineering toward common goals.

As stated in the Engineer of 2020, many of the key attributes of engineers in the future will be similar to those of today but made more complex by the impact of new technologies. The attributes mentioned in the report are: strong analytical skills; practical ingenuity; creativity; good communication; good business and management skills; good understanding of management principles; high ethical standards and a strong sense of professionalism; dynamism, agility, resilience, and flexibility; and be a lifelong learner. In our work we focus on the first three attributes and identify them as 1) strong analytical skills, 2) design and problem solving skills, and 3) interdisciplinary competence. We focus on these three attributes for several reasons. Design and problem solving is the core of most, if not all engineering work. Interdisciplinary competence is a relatively unexplored domain and it involves competencies such as synthesis and evaluation of interdisciplinary knowledge. We will also briefly mention some of the new priorities such as environment and energy and refer to this attribute as contextual competence.

Strong Analytical Skills

Engineering relies heavily on principles of science and mathematics. This will not change as we move forward. Therefore, a strong analytical skill is a requirement as it has been in the past. In this regard one can argue that Iranian universities are doing a good job of promoting such an attribute.

Design and Problem Solving Skills

The role of engineering design in the education of engineers has changed a lot in the last two decades. The development of a systematic approach to engineering design, including its role in the global economy, has influenced the way design is implemented in the industry and taught in the classroom [2]. The importance of engineering design education as a general subject rather than just a discipline based subject is also recognized by many educators and researchers [3]. Different approaches for teaching engineering design have been introduced by educators. Some of the examples are as follows. Anwar, and Stetler [4-5] discuss the integration of project based learning in a freshman design course with emphasis on team-based projects. Matsuishi [6] proposes the use of face-to-face instruction with e-Learning collaboration in a project-based learning approach to teach engineering design. Muslu [7] talks about a distributed design approach, where design concepts are introduced early in the curriculum, via simple design projects, and then gradually increase the complexity of the projects in advanced courses. Dutson [8] introduces an active learning approach in engineering design courses based on several well established learning models. They argue that the active methods are critical in the development of cognitive skills used in synthesizing solutions to open-ended design problems. Uddin [9] suggests the incorporation of quality management using Six Sigma into the engineering design courses. Hochstein [10] introduces a new capstone design format by adding collaboration between freshman and senior students. Zoltowski [11] discusses how to structure and manage multi-disciplinary teams of vertically integrated students to work on multi-semester projects, in order to bring “real” design experience into the curriculum. Yoder [12] discusses the benefits of cross-course design projects. Archibald [13] talks about the benefits of teaching entrepreneurship concepts in a capstone design course. Azemi and Esparragoza [14-15] present a multi-year, cross courses approach to expose students to a design experience that includes early exposure to fundamental concepts of design methodology and hands-on experience. We believe the creativity (invention, innovation, thinking outside the box, art) is an essential quality for engineering and it can be fostered through incorporating design methodology in engineering education from the first year.

Iranian higher education, with respect to the creativity attribute and promotion of design methodology is not doing an adequate job. This is evident by looking at the out dated curriculums and quality of the graduates. The emphasis on “simulations” rather than building prototypes, although has some financial and academic merits, has negatively influenced the ability of students to acquire an understanding of practical issues in engineering design. As it has been stated in Engineer 2020, the creativity requisite for engineering will change only in the sense that the problems to be solved may require synthesis of a broader range of interdisciplinary knowledge and a greater focus on systemic constructs and outcomes. Once again there is no indication that engineering education in Iran is embracing an interdisciplinary approach. By 1404 the need for practical solutions will be at or near critical stage, and engineers, and their ingenuity, will become ever more important. Unfortunately, unless there is drastic change in engineering education in Iran, we do not believe that Iranian graduates would be capable of managing the challenges ahead. We should emphasize that we are not advocating and engineering technology approach, rather we are indicating that the balance between hands-on experiments and simulation has been ignored and as a result, engineering students do not posses adequate understanding of how to deal with real world engineering problems. It is our hope that one day engineering educators and practicing engineers together undertake a proactive effort to remake the engineering education in Iran, through strategic planning tools, to address the societal challenges and opportunities for the future. This can only happen when there is an independent accreditation system is in place and universities are expected to follow its recommendations. This requires basic changes in how engineering education is perceived and more importantly assessed. Moreover, the linkage between a quality undergraduate program and strong graduate and research programs should be recognized and proper changes should be implemented. Finally, we recognize the importance of an independent establishment that would be responsible for guiding, promoting, and funding of various engineering and science projects that are identified to be vital to the present and future needs of the country. Operational models for such an organization exist in United States, China and other developed or developing countries.

Interdisciplinary Competence

As technology continues to increase in complexity and the world becomes ever more dependent on technology, the magnitude, scope, and impact of the challenges society will face in the future are likely to change in the sense that the problems to be solved may require synthesis of a broader range of interdisciplinary knowledge and a greater focus on systemic constructs and outcomes. This issue can be addressed by creation of interdisciplinary research groups and subject specific research laboratories. These issue and similar matters are usually addressed in universities strategic planning goals. Lack of such a practice and long term planning, which can be contributed to instability of top administrative personnel in Iran's educational institutions can be identified as one of the underlying reasons that such efforts are not recognized, encouraged and funded.

Contextual Competence

We define contextual competence as the students' abilities to understand the constraints and impacts of social, cultural, environmental, political, and other contexts on engineering solutions. Despite its importance in the field of engineering, employers and students agree that new graduates are not well prepared to address contextual issues (Lattuca, Terenzini & Volkwein [16]). Therefore, another attribute of an engineer in 1404 is the ability to understand the impacts of social systems and their associated constraints in engineering design, as much as resource management, standards, and accountability requirements.

Program Evaluation

In order to deliver and assess the aforementioned attributes, the engineering educational structure should include an effective program evaluation with a focused learning assessment components. The purpose of assessment is to systematically improve the quality of student learning through improved programs, curricula, and teaching. Assessment informs planning, decision making, and provides a gauge for the quality of courses, programs, and institutions. This topic requires substantial discussions and is beyond the scope of this paper; it was only mentioned due to its importance for instituting the talked about attributes.

Conclusion

In this paper we briefly discussed some of the priorities in engineering education in year 1404 (2025 A.D.), based on the attributes covered in The Engineer of 2020, and recommendations that can offer such a realization were provided. We believe, incorporating the design methodology in engineering education and program evaluation will have significant impact in Iran's engineering education and would improve its ability to serve the society's needs. Finally, achieving the attributes that has been mentioned in this paper requires basic changes in how engineering education is perceived and more importantly assessed in Iran.

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