Educating the Energy Engineer of 2030

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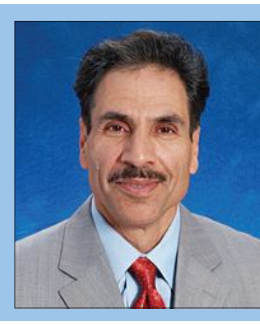

1. Introduction

Most recent research in engineering education explores the ways current engineering education practices must change to meet the needs of a twenty-first-century workforce and marketplace. Because of the complexities of current and future technologies, engineering professionals and engineering educators must increasingly adopt a systems approach. Furthermore, due to the "customerization" of engineering—the consumer-driven market for technological goods—engineers need to become accustomed to working with customers in a more public role than engineers have traditionally played. Engineers will also need to be more closely involved in public policy decisions, as technology and public policy are becoming increasingly intertwined.

Within the energy industry, demand for skillful engineers is higher than ever. Regardless of which scenario, the plenty-of-oil or the peak-oil scenario, becomes reality, it is clear that we have reached an era where the "black gold" is simply too precious to be burned. In the years to come we will see it increasingly used to produce value-added products, such as plastics and derivatives. Moreover, as "easy" oil continues to be less available, more-advanced technologies are required to find the oil and to best use it with minimal adverse impact on the environment. Twenty-first-century energy engineering education must prepare students to face these new challenges. This talk, therefore, considers possible reforms for engineering education, the unique needs of and challenges for energy engineering in general, and in the Middle East in particular.

2. Key Features

This talk considers the recommendations of the Committee on Engineering Education to "reengineer" engineering education—to enact systemic reform. It focuses on desired goals, objectives and outcomes, and aims to design a system that will provide a quality product (well-trained graduates) through a simple, integrated, and efficient process. The engineering education system involves such elements as the teaching, learning, and assessment processes; the faculty and students; curricula, laboratories, and informational technologies; and the external environment that shapes marketplace demands for engineers.

In pursuing a more student-oriented system, most recent research findings focus on two major tasks: "better alignment of engineering curricula and the nature of academic experiences with the challenges and opportunities graduates will face in the workplace;" and "better alignment of faculty skill sets with those needed to deliver the desired curriculum in light of the different learning styles of students." Some of the main recommendations to accomplish these tasks are documented in a recent report [1] and include the following:

- The B.S. degree should be considered a pre-engineering or "engineer in training" degree.
- Engineering programs should be accredited at both the B.S. and M.S. levels, so that the M.S. degree can be recognized as the engineering "professional" degree.
- Colleges and universities should endorse research in engineering education as a valued and rewarded activity for engineering faculty and should develop new standards for faculty qualifications.
- In addition to producing students who have been taught the advances in core knowledge and are capable of defining and solving problems in the short term, institutions must teach students how to be lifelong learners.
- Engineering educators should introduce interdisciplinary learning in the undergraduate curriculum and explore the use of case studies of engineering successes and failures as a learning tool.
- Institutions should encourage domestic students to obtain M.S. and/or Ph.D. degrees.

Some engineering programs in the U.S. have already successfully implemented some of these recommendations. These programs include:

- Drexel University's program, whose college of engineering curriculum was "organized into four interwoven sequences replacing and/or integrating material from 37 existing courses in the university's traditional lower division curriculum." These sequences included substantial engineering laboratory experience early-on and resulted in improved retention and on-time graduation.
- Olin College of Engineering, which developed a program comprised of about 20 percent design activities in the first year. By the final year, design activities comprise about 80 percent of the curriculum, and "greater content knowledge is expected." The design projects are both individual and team projects.
- The Engineering Projects in Community Service (EPICS) program at Purdue University, in effect for ten years. Students are involved in community-based organizations and "design, build, deploy, and maintain engineered solutions in response to customer needs." The connection between the engineer and the community quickly becomes apparent to students in this program. This service-learning program is a nationally recognized program that the NSF is helping to spread.
- The NSF Women's Experiences in College Engineering Project, which found that "early exposure to the design, build, and test process that marks the practice of engineering" is important in retaining women in undergraduate engineering programs. Also important are women-only courses in tool use and computer graphics, and advisors who provide "information, encouragement, and a welcoming environment."

Like their American counterparts, Middle Eastern energy-engineering institutions also strive to produce graduates with a strong background in fundamentals and applied engineering, strong communication skills, computing skills, and analytical thinking skills. These institutions, however, face a unique set of cultural challenges in addition to those faced by American schools. For example, Middle Eastern students mostly come from high schools that focus on math and sciences with minimal hands-on and laboratory skills. Often there is a lack of true engineering enthusiasm in the students, partly because the role of engineering in modern society is far from fully understood. In particular, students may have negative perceptions of a petroleum engineering career and the job opportunities it offers, as they are often unaware of the fact that the oil and gas industry is utilizing highly advanced technologies in exploration, production, transport, and distribution of oil and gas and their derivative products. Other educational challenges might include developing strong English language skills, independent learning habits, computer skills and three-dimensional visualization skills, as well as critical thinking skills with a global perspective for engineering as a profession, and motivation to excel at the profession. Possible solutions to these challenges are discussed in this keynote.

3. Conclusions

Modern society and technology have changed the way engineers are prepared for and are expected to perform their jobs in the twenty-first century. It is becoming increasingly difficult to prepare a well-rounded, broad-based engineer within the context of the traditional four-year baccalaureate degree. While technical excellence remains the key factor in an engineering education, graduates should also "possess team, communication, ethical reasoning, and societal and global contextual analysis skills as well as understand work strategies." These areas are necessary for a university to produce engineers who can communicate with the public and "engage in a global engineering marketplace," and who will become lifelong learners. Educating the Energy Engineer of 2030 introduces additional challenges that must be addressed and are briefly discussed in this Keynote address. Latest findings and future trends are reviewed and discussed. Specific challenges to creating a world-class engineering institution in the Middle East with a focus on oil and gas and the broader energy industry are also reviewed, and possible strategies are discussed.

4. References for Additional Related Information

1. National Academy of Engineering, 2005, "Educating the Engineer of 2020: Adapting Engineering Education to the New Century." Washington, D.C.: National Academies Press, www.nap.edu/catalog/11338.html
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4. Aggour, T., 2005, "A New Breed of Petroleum Engineering Education," 2005 SPE Technical Conference and Exhibition, Dallas, TX, USA, October 9-12.

Speaker's Biography

Prof. Michael M. Ohadi is a Professor of Mechanical Engineering and the Acting Executive Director and Chief Academic Officer at The Petroleum Institute in Abu Dhabi, UAE. Previously he served at the University of Maryland as a Professor of Mechanical Engineering and Co-director of the Center for Environmental Energy Engineering. His field of expertise is thermal and fluid systems with applications to design and optimization of advanced heat exchangers and energy systems. An internationally recognized authority in his field, he has conducted many research projects for both industry and the government agencies, which have included sponsors in the U.S., Japan, Germany, Denmark, South Korea, and Taiwan. He has published over 140 refereed technical papers, and currently serves as Associate Editor for two journals in his field of expertise. He is the past chairman of ASME Process Industry Division, as well as past chairman of ASME Potter Medal Awards committee. He is a fellow member of both ASME and ASHRAE, and has won numerous awards from both societies.