Preparing New Engineer for the Job Skills Demanded in the 21st Century

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Abstract

Over the past three decades, the engineering education and engineering programs in the United States and abroad have gone through several reforms. Their curricula have gone through significant revisions and refinements. Several intense reforms and activities in engineering programs have primarily concentrated in two areas. These include new and recently developed knowledge into the courses and curricula, primarily utilizing hands-on and experiential learning methods to prepare engineers' next generation. In addition, the emergence of professional/soft skills including communications-presentation and public speaking and writing, entrepreneurial and business strategies awareness, leadership, and ability to work in a team whose members represent different and diverse backgrounds concerning ethnicity, educational background, cultural diversity, etc.

These types of reforms often are originated by some pioneering programs and eventually are caught up by other institutions either due to the recommendation of alumni and former students, members of the advisory board, or other program's constituencies. Furthermore, aside from some articles that appeared in the academic journals and conference proceedings, there is not much information publicly available to serve as a guiding light to show the best and most effective methods to incorporate these skills into curricula. And also, the established milestones to measure and compare the engineering program's achievements. The efficacy of various techniques in delivering and instilling these professional/soft skills is often questioned. No factual data regarding the long-term benefits of these skills have been made public. It has also been noticed that programs' status and reputation incorporating these demanded professional skills into their curricula have positively enforced their reported achievements.

The new frontier in engineering education, engineering education for the 21st Century, required professional skills for new engineers, training a new generation of engineers for the new global market, entrepreneur

engineers, world-class engineering education, and incorporating communication skills in engineering curricula. Success is about people – leaders and lead engineers.

Keywords
Engineering Education; Leadership; Professional skills; New Engineers; Global Market; Cultural Diversity.

1. Introduction

Many academic institutions in the United States have invested a significant amount of time, effort, and funds to improve both technical and professional skills in the next generation of engineers. These efforts include introducing new computer programming languages to the undergraduate engineering curricula, enhancing laboratory equipment, and publicizing skills and mastery their graduates can exhibit upon completing their degree programs.

In addition to technical skills, many schools have further concentrated on experiential learning, which basically implies that engineering students are encouraged to do more hands-on activities during their education and academic training. More engineering schools have started emphasizing experiential or hands-on learning along with theoretical classroom instructions.

Over the past two decades, many engineering schools have started focusing on professional or soft skills as often recommended by employers, alumni, and members of their advisory boards. These soft skills or professional skills in the past primarily meant communicating effectively both in writing, presentation, or public speaking. However, many engineering schools have recently emphasized other skills that can be equally important in maximizing the engineers' career success.

2. Attaining Professional Skills to Optimize Career Success

Traditionally employers were focusing on technical abilities and the course work taken by newly graduated engineers during the course of the interview and assuming the rest could be attained by observation or managerial supervision. However, in reality, these professional skills are teachable and can easily be absorbed during the four-year undergraduate education, should engineering programs strategically emphasize these necessary attributes.

These professional skills have become essential and demanded by US employers over the past decade and equally become important to global engineering companies. Texas A&M University at Qatar is a branch campus of Texas A&M University which has been established in the State of Qatar in the Middle East in 2003. Since its inception, this branch campus has offered four engineering degree programs, including Chemical, Electrical, Mechanical, and Petroleum. Figure 1 shows the Texas A&M Engineering building in Qatar. Many multinational corporations established offices in Qatar's capital, Doha. Due to these companies' business models' significant emphasis on professional or soft skills and hands-on experience is demanded by these companies' recruiters due to these companies' business models. These expectations are often conveyed by the company's leadership serving on the program's advisory boards. They consistently provide feedback to programs via their participation in the senior capstone design projects and interviews or specialized seminar courses designed to prepare students further to meet these expectations.

Figure 1 – Texas A&M University at Qatar

2.1. Communication

Almost a hundred percent of students pursuing engineering degrees at Texas A&M University at Qatar either are bi-lingual or tri-lingual. All applications meeting the minim admission requirements are invited to campus for interview by a panel of faculty, admission staff, and senior students. The panel and rubrics ask both technical and professional questions to gauge and score applicants' responses. While in the program, the curriculum has been structured to prepare and expose students to numerous opportunities to further publish their technical skills through writing and presentations in several courses to various audiences, including peers, members of the program advisory board, potential employers, etc. (Retnanto et al. 2020; Retnanto et al. 2020). Some disciplines offered non-credit required courses in which students are provided opportunities to work on technical problems and present their findings in a public setting to a large audience. As an example, as part of the curriculum, senior petroleum engineering students are required to present the outcomes of their independent study in the annual petroleum engineering student paper contest. Industry judges assess students' ability in communication skills, such as clarity of technical content, visual aid, and speaker delivery. The rubric has been used for assessing the ability to communicate effectively orally. The student achievement is recorded on a 1-4 scale, with 1 indicating lack of ability and 4 indicating proficient or skillful ability. Rubric on clarity of technical content can be seen in Figure 2.

1. Ideas generally not expressed logically or systematically, and statements regarding significance of the topic, problem and its solution (as applicable), or conclusions were generally absent or unclear.	2. Ideas mostly expressed logically, but presentation was somewhat disorganized or two or more statements concerning significance of topic, problem or its solution (as applicable), or conclusions lacked clarity.	3. Ideas expressed logically and in a systematic manner with mostly clear statements of the significance of topic, problem and its solution (as applicable), and conclusions, but a few minor details lacked clarity.	4. Ideas expressed logically and systematically, and clear statements of the significance of topic, problem and solution (as applicable), and conclusions were included; not more than one or two minor points lacked clarity.

Figure 2 – Rubric on the ability to communicate effectively orally—*clarity of technical content*

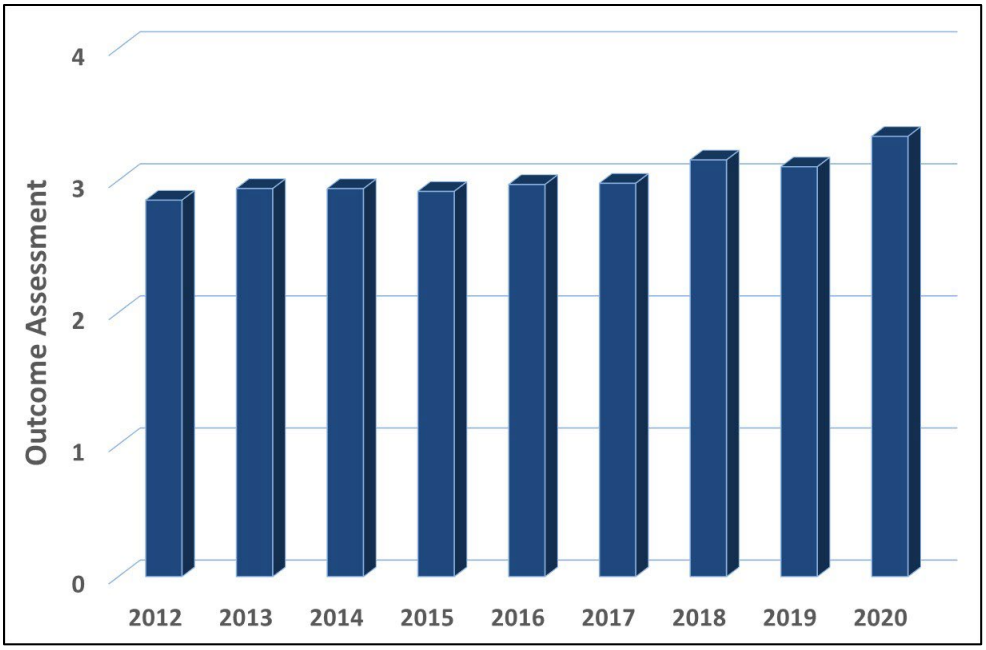

Figure 3 - Assessment outcomes - clarity of technical content

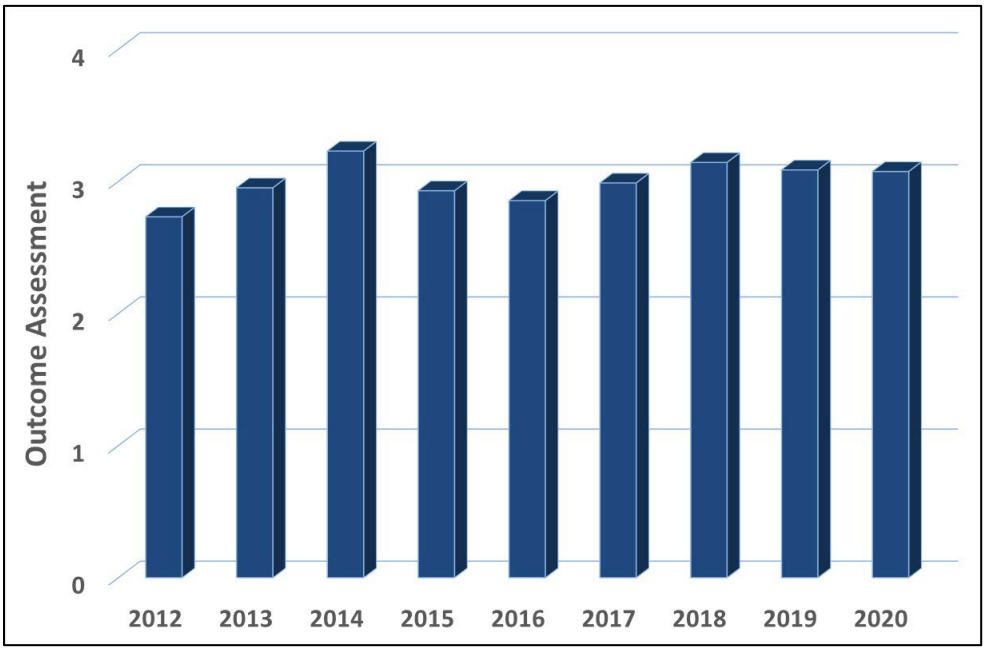

Figure 4 - Assessment outcomes – visual aid

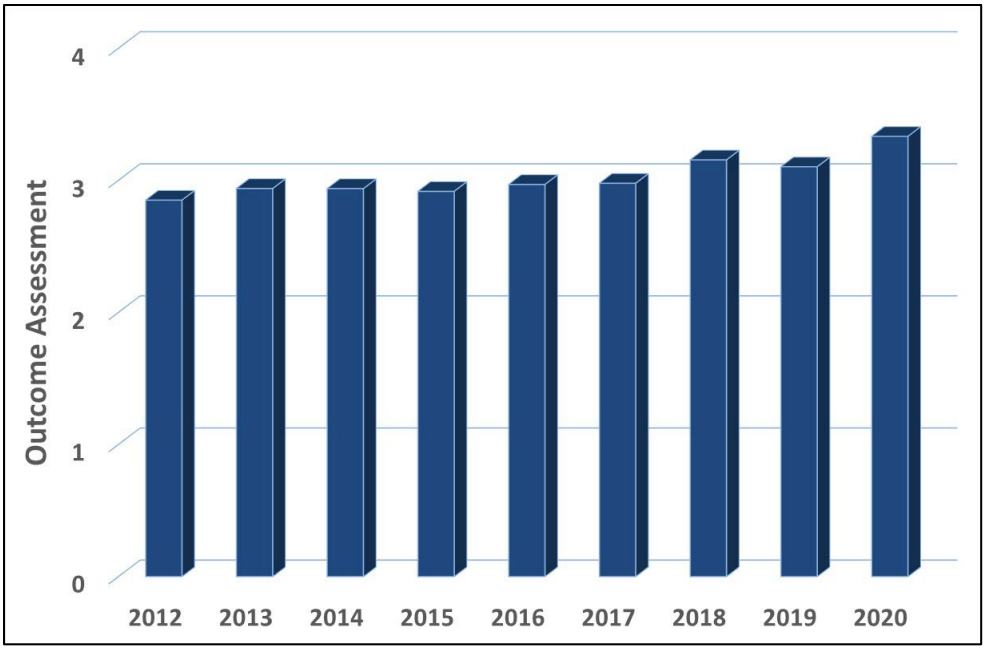

Figure 5 - Assessment outcomes - speaker delivery

Figures 3 to 5 summarize the assessment on communicating effectively orally for clarity of technical content, visual aid, and speaker delivery from 2012 to 2020. The outcome demonstrates a positive trend in student ability for oral communication.

2.2. Organization

Several introductory courses at Texas A&M University at Qatar emphasize organizational skills, including time management, task management, work quality, etc. The University honor code is a constant reminder that although work might need to be accomplished by teams, each team member must fully understand their responsibility and carry their assigned tasks to the best of their ability and with the highest integrity.

More than 20 student organizations and clubs at Texas A&M at Qatar are available to strengthen student academic performance. The student organizations represent students' diversified interests that range from academic activities to entertainment. The student's main objective is to get involved in the organization to grow academically, spiritually, socially, culturally, and personally.

For example, the Student Chapter of the Society of Petroleum Engineers (SPE) at Texas A&M Qatar has been one of the top student organizations in TAMUQ and has an active 300 current members. This student chapter collaborated with seven different student organizations, which helped create unity among the students in TAMUQ, making their relationships more robust and lasting longer. SPE hosted industry speakers on four different occasions in an initiative called lecture series and eight various social activities. The student chapter has an innovative initiative to start the Novel Writing Challenge in Qatar for the first time. Finally, SPE members actively participate at different SPE conferences such as student chapter officer's workshop and young members program activities. Figure 6 demonstrates a collaboration with industry on the seminar in corrosion detection thru ultrasonic.

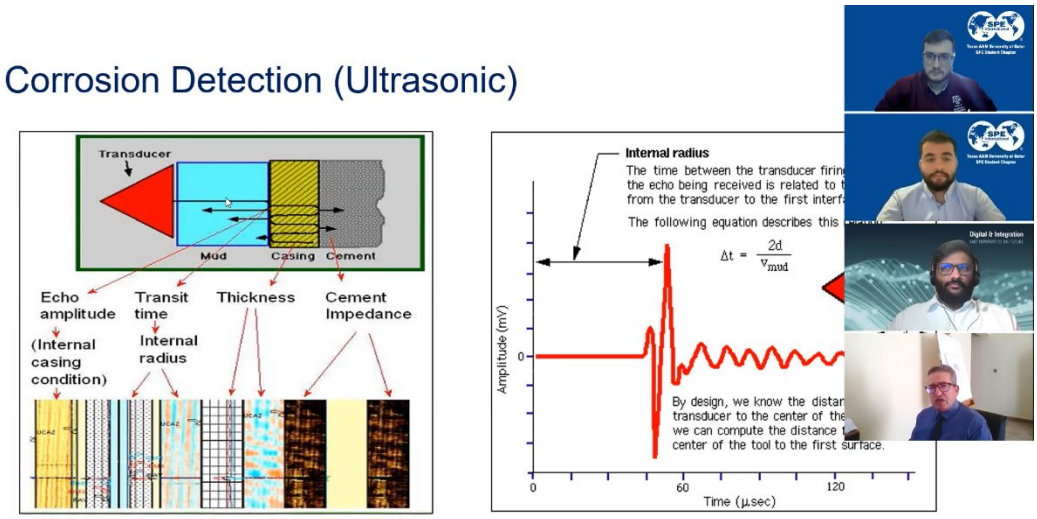

Figure 6 – Seminar on corrosion detection (ultrasonic) by SPE Student Chapter

2.3. Leadership and Teamwork

Many definitions have been documented in books and archival articles regarding leadership. In our personal opinion, a good leader is a person who can positively influence others and bring out the best in their teams. In general, leaders can see the big picture and guide and mentor their coworkers to achieve longer-term objectives. The concept of leadership and foundations of good teamwork have been embedded in several required courses. Teamwork and how to form an effective and productive team are discussed in seminar courses, and often the concept is further stressed by inviting industry leaders as invited speakers. Figure 7 shows that students work as a team and take responsibility for drilling operations.

Figure 7 – Drilling simulation workshop – work as a team and take responsibility

2.4. Creativity and Problem Solving

Engineering is generally defined as the field of applied science. And engineers have consistently been recognized for their creativity and regarded for their problem-solving skills. These problem-solving skills are frequently emphasized in hands-on learning courses, and ultimately this skill is enhanced at the senior level in the capstone design projects. Models, either physical or digital, of the real problems are built, and alternative solutions are proposed, and their economic, societal, and environmental impact are extensively studied.

For example, the key to optimum petroleum engineering education is the practical application of petroleum principles. Performing the undergraduate research experience is an efficient and effective way of enhancing creativity and problem-solving. While working on research, students apply a process to develop how knowledge evolves and the real challenge in the industry. (Alyafei et al. 2020; Retnanto et al. 2012, Retnanto et al. 2019; Retnanto et al. 2020).

Undergraduate students have the opportunity to present the outcome of the research in the regional to industry participants (Retnanto et al. 2020). Figure 8 shows an example of a student research topic investigating nanoparticles' viability in drilling fluids as an additive for fluid loss and wellbore stability. Figure 9 depicts the outcomes from undergraduate student research in the numerical investigation on the effect of wettability and heterogeneity on viscous fingering and oil recovery.

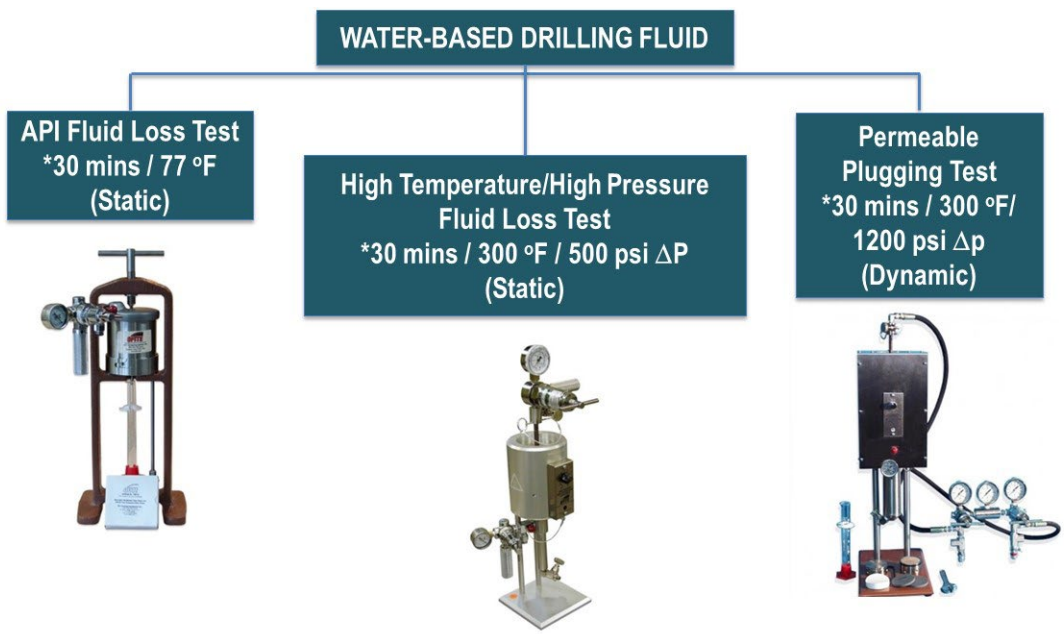

Figure 8 – Experimental apparatus for investigation of the viability of Nanoparticles in drilling fluids as an additive for fluid loss and wellbore stability

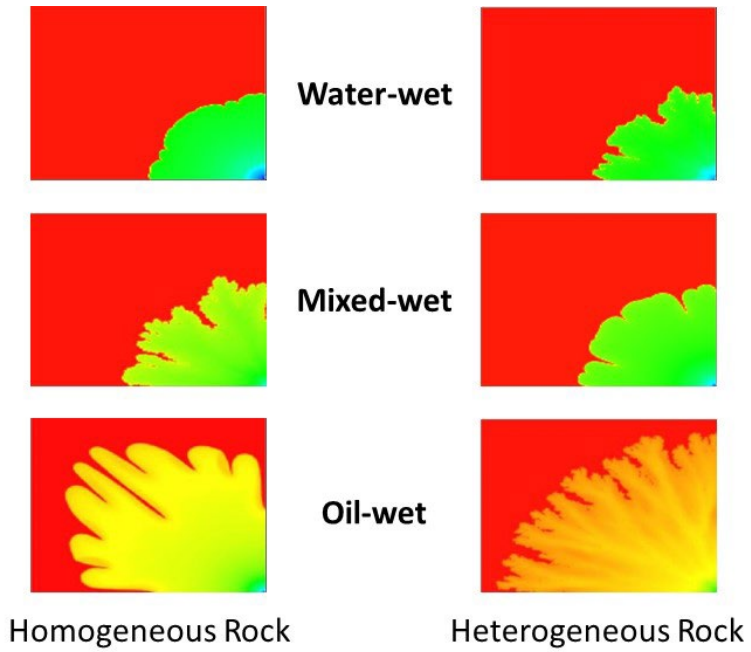

Figure 9 - Numerical investigation on the effect of wettability and heterogeneity on viscous fingering and oil recovery

Figure 10 - Virtual reality application using head-mounted devices

Figure 10 demonstrates virtual reality applications using head-mounted devices to visualize the actual operation and support students in solving the real field problem.

2.5. Interpersonal Skills and Diversity

Interpersonal skills are often synonymous with the ability to listen, encouraging coworkers to provide honest feedback, and having the ability to handle criticism. Interpersonal skills are among critical attributes that can accelerate young engineers' careers and provide them with the level of maturity expected from well-rounded leaders. The limited number of students annually admitted to Texas A&M University at Qatar on average represents over fifty different countries. This provides students unique opportunities to appreciate diversity and the multicultural environment on campus. Members of the programs advisory board and multinational companies' recruiters had openly asked Texas A&M University programs leadership to include discussions on cultural diversity in the courses. Students frequently benefit from regional companies' leaders regarding the importance of diversity and inclusion.

3. Conclusion

The professional skills can undoubtedly be immersed during the four-year undergraduate education. The engineering program should strategically emphasize these requirements. Attaining professional skills is the key to achieving success in their career. Engineering curricula and co-curricular activities can strengthen student performance in maximizing the engineer career success. The assessment indicates how the quality of professional skills is maintained.

References

Alyafei, N., Bautista, J., Mari, S., Khan, T., & Seers, T. 2020. Multi-Dimensional Project-Based Learning on Understanding Petrophysical Properties by Utilizing Image Processing and 3D Printing. Presented at the SPE Europec featured at 82nd EAGE Conference and Exhibition. Society of Petroleum Engineers. SPE-200549-MS.

Retnanto, A., Alyafei, N., Fadlelmula, M., and Sheharyar, A. 2020. The Impact of Practical Experiences on The Development of Petroleum Engineering Education. Presented at the SPE Annual Technical Conference and Exhibition, Virtual, 26 – 29 October. SPE-201449-MS.

Retnanto, A., Fadlelmula, M., Alyafei, N. and Sheharyar, A. 2019. Active Student Engagement in Learning - Using Virtual Reality Technology to Develop Professional Skills for Petroleum Engineering Education. Presented at the SPE Annual Technical Conference and Exhibition, Calgary, Canada, 30 September – 2 October. SPE-195922-MS.

Retnanto, A., Lynn, C., and Orellana, E. 2012. Managing Uncertainty of Reservoir Heterogeneity and Optimizing Acid Placement in Thick Carbonate Reservoirs. Paper presented at the SPE International Production and Operations Conference & Exhibition, Doha, Qatar, 14-16 May 2012. SPE-155079-MS.

Retnanto, A., Parsaei, H. R. and Parsaei B., Building Communication Strengths and Skills for Non-native English-Speaking Engineering Students, Proceedings of the Industrial Engineering and Operations Management, Dubai, UAE, March 10-12, 2020.

Retnanto A., Parsaei H.R., Parsaei B. Preparing Students for the Challenging Job Markets over the Next Decade. In: Nazir S., Ahram T., Karwowski W. (eds) Advances in Human Factors in Training, Education, and Learning Sciences. AHFE 2020. Advances in Intelligent Systems and Computing, vol 1211. Springer, Cham. https://doi.org/10.1007/978-3-030-50896-8_45

Biography

Dr. Albertus Retnanto is a Professor of Petroleum Engineering at Texas A&M University at Qatar and has been in the Petroleum Engineering program since 2009. He received his Ph.D. degree in Petroleum Engineering from Texas A&M University. He teaches undergraduate courses in well testing, petroleum production systems, production engineering, petroleum technical presentation, natural gas engineering, and integrated asset development and makes significant curriculum enhancements to several courses. He held a Principal position with Schlumberger and has more than 18 years of experience worldwide in technical and management positions in well testing, field development, and production enhancement. Dr. Retnanto is an active Program Evaluator (PEV) with the Engineering Accreditation Commission (EAC) of ABET.

Dr. Hamid R. Parsaei is an internationally recognized leader in the field of engineering education, manufacturing automation, economic and financial decision making, leadership, and additive manufacturing with more than three decades of experience in academia. He is a fellow of the Institute of Industrial and Systems Engineers (IISE), American Society for Engineering Education (ASEE), Society of Manufacturing Engineers (SME), and Industrial Engineering and Operations Management Society International (IEOM). Dr. Parsaei is an effective educator and an innovative researcher who draws on considerable expertise to lead colleagues toward visionary goals and exceptional results. He served as the Chair of the Department of industrial Engineering at the University of Houston and Associate Dean of Academic Affairs at Texas A&M University at Qatar. He is a registered professional engineer in the State of Texas and an ABET Engineering Accreditation Commissioner and Program Evaluator.

Boback Parsaei is the Vice President of Operations with Integrated Technology Systems, Inc. an Engineering Consulting, in Houston, Texas. Mr. Parsaei received his undergraduate degree and M.Eng. in Civil and Environmental Engineering from Texas Tech University and Texas A&M University, respectively. He is currently pursuing Ph.D. degree in Civil and Environmental Engineering at Texas A&M University. He has extensive experience in the field of project management.