



## A New Vision for Engineering Education

### Dr. Hamid R. Parsaei PE, Texas A&M University at Qatar

Hamid R. Parsaei is Professor of Industrial and Systems Engineering at Texas A&M University (College Station) and also Professor of Mechanical Engineering and Associate Dean for Academic Affairs at Texas A&M University at Qatar. He is a registered professional engineer (PE) in Texas and a Fellow of the Institute of Industrial Engineers (IIE). He has published more than 200 articles in peer-refereed archival journals and conference proceedings. He also served as editor for three international academic journals and five book series. His research, in excess of \$22 million, has been funded by numerous government and private institutions.

### Dr. Nimir Elbashir, Texas A&M University at Qatar

Dr. Elbashir is an Associate Professor at Texas A&M University at Qatar (TAMUQ) and the Director of Texas A&M University Gas & Fuels Research Initiative (an initiative for a major research center involves 17 professors from Texas A&M University College Station Campus and Texas A&M Qatar Campus from both Chemical and Petroleum Engineering departments). He has over 16 years of research and teaching experience. His research activities are mainly focused on design of advanced reactors and processes for the gas to liquid (GTL) technology, and development of catalysts for the petrochemical and environmental industry besides development of engineering education models. He holds several US and European patents and tremendous publications in form of peer reviewed journal articles and conference proceedings as well as conference and industry technical reports publications. Dr. Elbashir completed research studies on design of reactor technology and applied catalysis for several world-leading companies (BASF Corporation, and SABIC R&T). He is currently leading a research team with multi million dollars fund in collaboration with researchers from nine prestigious universities around the globe and with scientists from world-leading industries. The scholarship of his research activities has been recognized by Qatar Foundation's 2012th Best Energy & Environment Research Program of the Year in addition to several awards and recognitions from the Gordon Research Conferences; BASF Corp.; the 3rd International Gas Processing Symposium; Shell; the American Institute of Chemical Engineers; and Texas A&M University.

# A New Vision for Engineering Education

## Abstract

Texas A&M University opened a branch campus in the Education City of Qatar Foundation in 2003 by offering Bachelor of Science degrees in four engineering majors: chemical, electrical, mechanical and petroleum. The main objective of the Qatar campus is to support Qatar's development by educating engineers to contribute to the Qatar National Vision 2030. This paper highlights the success stories from this program as per the experience of our students and alumni who are working in several sectors in Qatar, the region and the world, since the graduation of the inaugural class in 2008. Furthermore, this paper highlights the potentials of this new program to become a unique model for the future engineering education programs in the region and worldwide. Also, the paper briefly lists few of the challenges that face the implementation of this program. Number of activities in this vision have been implemented during the past 5-6 years and have shown significant success while others are still in their first phases of testing.

## Introduction

The State of Qatar, surrounded by Persian Gulf water and the Kingdom of Saudi Arabia by land, is one of the fastest growing nations in the world. The country's vision in transforming its carbon based economy into a knowledge based economy has made this nation an icon in the Middle East. The Qatar Foundation for Education, Science, and Community Development, a non-profit organization, which was founded in 1995, is the primary driving force behind Qatar's 2030 Vision that plans to provide the skills and education necessary to move the State of Qatar to a knowledge based economy. Since 2000, several western universities were invited to establish specialized campuses in Qatar's capital, Doha. Texas A&M University at Qatar (TAMUQ) is the third campus established in Doha in 2003 which delivers engineering education in four undergraduate disciplines including chemical, electrical, mechanical, and petroleum engineering. This campus also offers both Master of Science and Master of Engineering in chemical engineering. All undergraduate degree programs are accredited by the Accreditation Board for Engineering and Technology (ABET). Other countries in the Gulf region built similar programs such as Masdar institution in Abu Dhabi of the United Arab Emirates, King Abdullah University of Science & Technology in Saudi Arabia and others.

The curricula offered at TAMUQ are materially identical to the ones offered at the main campus in College Station, Texas and courses are taught in English in a coeducational setting. As the nation strives to develop a knowledge-based society, the University recognizes the profound need for highly skilled engineers to lead the next generation of discovery. The university developed a unique model for engineering education entitled "the Initiative in Engineering Leadership, Innovation and Teaching Excellence (ELITE)" to promote partnerships, collaboration and discourse that contribute to educating and preparing young people to address Qatar's, the region and the world grand challenges of tomorrow. The ELITE vision recognizes that post-secondary education is only one of several important phases of that development process, and the initiative will endeavor to provide support, innovation and inspiration throughout Qatar's educational enterprise to promote students to their greatest potential to become engineering leaders.

The initiative's activities included several building blocks such as: (1) partnering with schools in Qatar to enhance science, technology, engineering and math (STEM) education to improve students' readiness for university studies; (2) offering enrichment programs to promote STEM studies among middle- and high-school students and to attract qualified students to the University's undergraduate engineering programs; (3) providing professional development for teachers of math, science and technology to enhance their teaching effectiveness; (4) refining the University's engineering curricula to ensure they meet Qatar's evolving needs and to advance students' knowledge in fields of common interest to industry in Qatar, the region and the world; (5) bolstering teaching, research and outreach in energy, the environment, sustainable technologies, ethics, project management and other such topics; (6) encouraging undergraduate students to participate in research in energy, petroleum, communications and other fields relevant to the Qatar National Research Strategy; (7) encourage undergraduate students to undertake internships and cooperative learning experiences that increase their soft skills and hands-on experience that would guarantee their success in the workplace; (8) contributing to Continuing Education at Texas A&M at Qatar to support professional advancement of engineers working in Qatar and the region; (9) promoting scholarship and research in engineering education, and record findings in a peer-refereed journal created under the initiative's auspices; and (10) establishing an advisory committee comprising representatives from industry and government to support the aforementioned programs and to provide continuous assessments of their effectiveness in providing Qatar, the region and the world with highly skilled engineers.

Qatar's discovery of the natural gas over the last 20 years has attracted many global corporations to establish branch offices and production facilities in this country. Considering the urgent needs by these companies to recruit qualified engineers and technical staff, the establishment of western campuses to respond to the growing needs of the country, has generously been supported by the Qatar Foundation as well as the local and global industry corporations investing in Qatar and the region. The ELITE initiative is composed of several programs that include advanced engineering education models, recruitment efforts from high school students to science and engineering in addition to community service activities. The recruitment efforts to TAMUQ started with partnering with local and international high schools to enhance science, technology, engineering and math (STEM) education and skills to prepare the students to the university studies. This activity involved as well to include special programs to provide professional development for high school teachers of math, science and technology to enhance their teaching effectiveness. Examples on our success stories in recruiting students to some of our engineering programs efforts have been included elsewhere [1].

On the other hand, the TAMUQ engineering programs start refining the University's engineering curricula to ensure they meet Qatar's evolving needs and to advance students' knowledge in fields of common interest to industry in Qatar, the region and the world. This initiative brought new elective courses to TAMUQ engineering curriculum in areas of interest to the region such as in gas processing technologies, applied catalysis, photovoltaic (PV) power generation, water treatment, hydrocarbon and synthetic fuels processing, etc. Industry experts from Qatar and the region are participating in teaching and/or support teaching of number of these initiatives. Currently, several TAMUQ engineering programs teach these courses in regular basis as part of the curriculum.

The focus in this area accompanied by bolstering teaching, research and outreach in energy, the environment, sustainable technologies, ethics, project management and other related

topics. Because of local industry and government institutions support of this program, significant number of the TAMUQ undergraduate students are able to engage in well-funded research programs in energy, petroleum, communications and other fields relevant to the Qatar National Research Strategy (QNRS). Furthermore, the University encourages undergraduate students to undertake internships and cooperative learning experiences that increase their soft skills and hands-on experience that would guarantee their success in the workplace.

Since 2008, TAMUQ has graduated over 410 engineers who are employed by Qatar's or the regional corporations or pursuing graduate degrees in some of top ranking most demanding academic institutions in the USA and Europe. The engineering programs at TAMUQ have consistently put significant emphasis in providing students the opportunities to gain skills in key areas including internships, ethics, communications, and project management in addition to acquiring hands-on knowledge in the state of the art laboratory facilities generously established by the Qatar Foundation for TAMUQ students. This paper will highlight one example of the success stories of TAMUQ's ELITE program that is related to the engagement of the students in research activities associated with their discipline before graduation. Other examples and success stories of this program will be highlighted in our presentation during the conference.

#### The Impact of the Undergraduate Students' Research Experience on the Engineering Education

TAMUQ is known to provide significant opportunities to its undergraduate students to voluntarily participate in its faculty members' research projects. The overwhelming majority of these projects are based on voluntarily participation of the students who work under the supervision of faculty members on building the proposal, conducting the research and reporting its outcome. TAMUQ developed several research programs in collaboration with the support of its faculty, Qatar Foundation and its funding agencies (Qatar National Research Fund (specifically their Undergraduate Research Experience Program or UREP) and Qatar Science & Technology Park) in addition to the support of industry and governmental agencies to this program. A good number of TAMUQ's faculty participated in the program and assisted in monitoring the students Industry Research Program. This program has been implemented in the four TAMUQ Engineering Programs and is supported by the Science and Liberal Arts Programs of the university; it has several objectives:

1. Support design courses by providing the students the opportunity to investigate real life problems with hands on experience relevant to their field of study.
2. Provide our faculty members and the industry collaborators the opportunity to work with the students outside the classroom. Also, allow TAMUQ's postdoctoral fellows, research associates and graduate students the opportunity to enhance their mentorship activities to support the institution in the undergraduate education program.
3. Develop problem solving skills and other soft skills necessary for the success of TAMUQ graduates, such as team-work activities, presentation style, proposals and technical reports writing, and presentation preparations.
4. Enhance the job hunting opportunities for our graduates and allow industry and governmental agencies to recruit and train their sponsored students and/or employees.

This study covers the assessment of the program after five years of its implementation. Significant number of our students (more than 88%) participated in the internship programs

or the research experience programs, or both. Major global and national energy companies and other industrial corporations participated in supporting these programs (e.g. Qatar Petroleum, RasGas, Qatargas, Shell, Schulmberger, Maersk Oil, Oxy and others).

Two surveys on the effectiveness of these programs have been conducted; the first one was for both current and the graduated TAMUQ students while the second one was for industry mentors for either the Research Program.

The rationale behind conducting this project is part of our evaluation of the overall effectiveness of the undergraduate students' research experience in their academic performance as well as their knowledge in the field. Both current undergraduate students and alumni of TAMUQ provided us feedback about their experience during the undergraduate research experience.

The preliminary data stems from most faculty members noticing that such experiences positively impact the students' knowledge in their field as well as improving their academic and personal performance (no data provided in this paper). Also, many students indicated that such experiences helped them to identify their future career while many alumni indicated that it provided them with a speedy start in their first jobs after graduation. Hence, this survey is aimed at compiling these findings and observations.

The purpose of this survey to look at these impacts both quantitatively and qualitatively to identify the importance of these research experiences in developing skilled engineers. The survey has been delivered on a voluntary basis by the Office of Academic Affairs to the general student body, and by the Office of Alumni Relations for the remainder; those who have not participated in any form of undergraduate research experiences have been omitted from the study. By the nature of the double blind survey the known risks are minimized, and the survey's platform (Qualtrics) does have some further advanced methods for data monitoring and filtering. This survey has been approved by the Institutional Review Board (IRB) of Texas A&M University by the Office of Research Compliance. The general theme of the survey covers:

- Quantitative and qualitative assessments of undergraduate students' research programs.
- The effectiveness of the monitoring process during this research experience and parties involved on it.
- Direct and indirect impact on the learning process, knowledge in the field and the opportunities for hand-on experience and job hunting.

Out of 53 responders, current students were 40% of the responders and alumni were 60%. Participating in this survey were 13 nationalities and more than 90% expressed either full satisfaction or satisfaction with the quantity and quality of time they spent with their research mentor (see Figure 1). Similar feedback was received for the question: "How satisfied are you with the resources, support and guidance provided as you did your research work?"

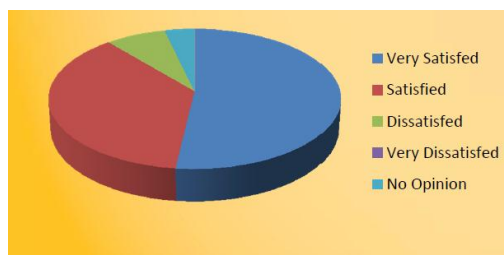


Figure 1: Feedback to the question: How satisfied are you with the quantity and quality of time you spent with your research mentor?

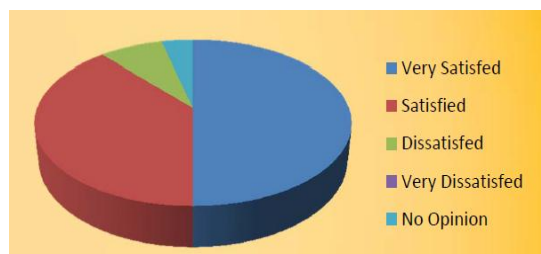


Figure 2: Feedback to the question: How satisfied are you with the resources, support and guidance provided as you did your research work?

The overwhelming majority of the participants responded positively to the impact of the program on their technical and hands on skill knowledge as shown in Figure 3. Even though the general impression of the student/alumni (both male and female) to the impact of the program on their soft skill is positive side it is less than for the technical skills (see Figure 4). Nevertheless, 85% of total respondents were 'satisfied' or 'very satisfied' with the resources/support/guidance received during their projects, and 97% of these satisfied respondents were also 'satisfied' or 'very satisfied' with the hands-on and technical skills they gained during their projects.

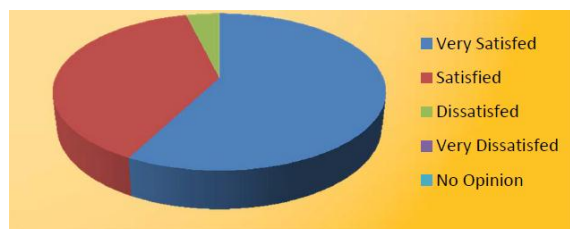


Figure 3: Feedback to the question: How satisfied are you with the technical and hands on experience you gained during research program?

The participation in this research program offered unique opportunities for the students to participate in both local and international conferences as 62% of total respondents attended at least one local conference while 65% of the local conference attendees attended at least one international conference. The research accomplishments of these students has been recognized by several awards nationally and internationally by the American Chemical Society, Qatar Foundation, American Institute of Chemicals Engineers, Texas A&M University main campus, International Gas Processing Symposium, Shell, ExxonMobil and many others. In a separate study we provided typical success story of this program for 15 undergraduate students involved in research activities related to Gas-to-Liquid (GTL)

technology and synthetic fuels characterization and formulation, which is the focus of Qatar economy [2].

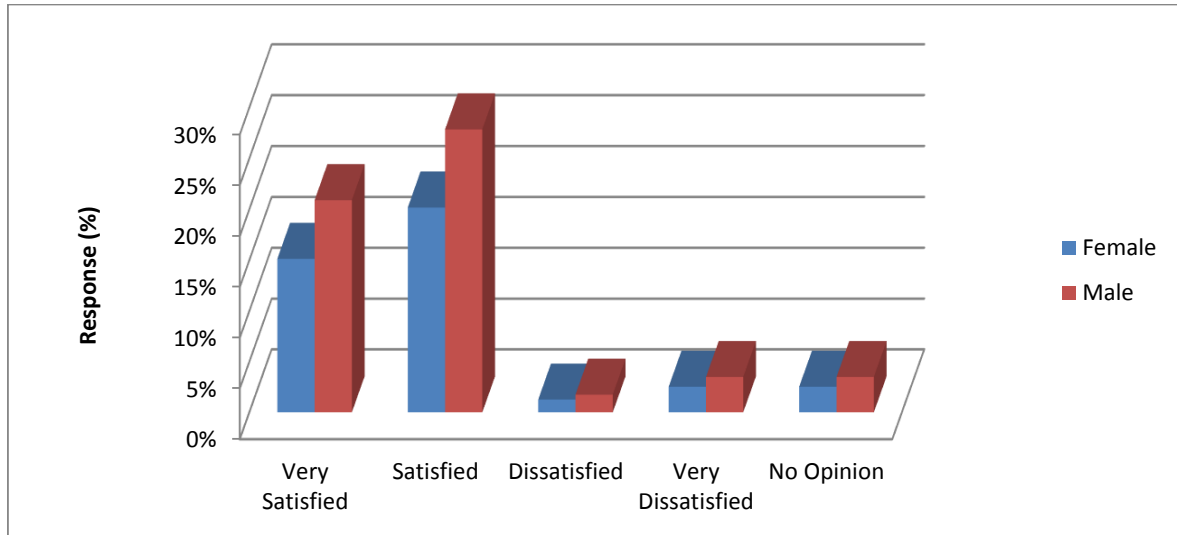


Figure 4: Feedback to the question: How satisfied are you with other personal skills (e.g. communication, teamwork, leadership, etc.) you gained during your research experience?

With regard to the mentor-student relationship, 88% of total respondents were ‘satisfied’ or ‘very satisfied’ with the time they spent with their research mentor and about 67% of these satisfied respondents felt that their relationship with their mentor would go beyond their research project. More than 98% of our graduates are either employed or enrolled in a graduate program.

The provided assessment of this survey is a sample of a detailed one that is currently conducted to make both internal and external recommendations that identify the strengths and the weaknesses of the different programs under the umbrella of the ELITE engineering education model. A full assessment of the different programs will be provided in our presentation at the conference.

## Conclusion

This paper presented a brief highlight of a new engineering education model that has been developed and supported by Texas A&M University, Qatar Foundation with the involvement of several industry and government institutions in Qatar. The ultimate goal of this program is to prepare highly skilled engineers that are currently needed in Qatar, the region and the world. The paper provided preliminary assessment to the successful ELITE programs and a representative number of the participants in this program have been surveyed. The outcome of this initial phase of assessment can be summarized as follows:

- Texas A&M Qatar undergraduate students research program proved to be very effective in improving students’ knowledge in their field of studies and enhancing their personal and professional skills.
- A number of elective courses need to be developed in collaboration with the industry to support the effectiveness of this program.

- The program is currently under evaluation in our institution to identify the needed resources to support it and improve its quality.
- Some of our engineering programs are currently investigating their plan of study to incorporate changes to reward the students who enroll in this program.
- Industry in Qatar is very supportive to this program as it provides them with the needed skilled manpower.

Several building blocks of the ELITE vision have recently been implemented and it is still early for us to conduct detailed assessment on these programs. One of the major challenges facing this program is to sustain the fund required to several of its main building blocks. Currently the university is receiving major fund from global energy corporate such as Maresk Oil for the STEM program. Also, recruiting national students (Qatari) to the engineering discipline and specifically to Texas A&M University represent another challenge for the success and the sustainability of the fund for the ELITE program by major companies in Qatar such as Qatar Petroleum. These pursuits, and countless other endeavors, rely heavily on strong skills in the STEM disciplines (i.e. science, technology, engineering and mathematics) and for engineering students to succeed, they must begin developing those skills at an early age. Successful university engineering students are, first, successful math and science students in middle school and high school, which is an area we have limited control on it. Nevertheless, with the ELITE program we are providing several support models to school teachers and educators in the region including special workshops and courses besides establishing a recent award for the for Qatar's STEM Educator of the Year.

#### Acknowledgement

The authors would like to acknowledge Texas A&M University at Qatar for supporting this study and for providing the funds for several of the programs included in the study. Also, our acknowledgment is extended to Qatar Foundation for its vision and the leadership role in establishing unique education models of which our institution is part. Several industry sectors provided funds for different engineering students training programs at Texas A&M Qatar, and Maersk Oil Qatar is playing a major role in funding STEM development and their related activities

#### References:

- [1] Minerick, A.R., D.P. Visco, S.M. Montgomery, D. Briedis, J. Sticklen, C.A. McDonough, S.P. Walton, A.M. Portis, E.H. Chimowitz, W.E. Rochefort, K.L. Levien, Elbashir N. O., J. Condit, and S. Lindeman, (2011) "Special Session: What Works to Retain Students in Chemical Engineering Programs," The Chemical Engineering Division Publication- American Society of Engineering Education Proceedings, June 2011, Vancouver, Canada (pages 1-13).
- [2] Elbashir N. O.; Parsaei H.; Elmalik E. (2013) "A New Educational Approach towards Preparing Skilled Chemical Engineers for Special Assignments in the Energy Field" American Society for Engineering Education International Forum, special issue 2013 ASEE International Forum, V13, pages 1-4.