

Inspiring Interest in STEM Education Among Qatar's Youth

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Abstract

Countries in the Middle East and North Africa have been working to promote STEM disciplines and move rapidly toward post-hydrocarbon economies with the help of a highly skilled technical workforce. The State of Qatar has invested considerably in the education of its next generation as it seeks to reduce its reliance on oil and gas. This paper examines whether Qatari students' attitudes toward STEM disciplines and careers in engineering can be influenced through the experience of a university STEM enrichment program. This research analyzes surveys completed by students before and after a two-week summer STEM outreach program in 2015. It concludes that STEM enrichment experiences can positively impact students' perceptions of the prestige of engineering careers in a culture that places enormous personal and family pride in career success.

Introduction

Countries in the Middle East and North Africa have been investing substantially to promote STEM disciplines among young and upcoming talent. One of the long-term goals for many countries in the region is to move beyond hydrocarbons-based economies, and many nations have compiled strong credentials to support advancement toward that goal — but an indigenous technical workforce is essential for those efforts. The State of Qatar is one such country that has benefited from considerable government investment in the education of its next generation for technical careers.

Qatar is undergoing rapid transformation as it develops a knowledge-based economy to succeed the hydrocarbon resources on which its economic growth and national wealth rely. As a result of Qatar's strategic national vision beyond oil and gas, the need for a highly educated workforce, particularly in STEM disciplines, has become an urgent national priority. Accordingly, Qatar's government and its industrial sector have been working in earnest to promote STEM educational pathways and careers for young people, and there are many ongoing collaborations and partnerships to entice and recruit Qataris toward STEM-related education and careers.

The need is great: Some industry leaders estimate that Qatar's national demand for citizens in technical professions is more than double the available workforce — Qatar's national population is estimated at approximately 300,000 citizens.¹ This demand does not account for rapidly emerging needs in defense and national security as Qatar invests in high-tech defense systems and weapons; government ministries are actively recruiting Qatari engineers and scientists to support deployment, maintenance and oversight of these technologies. As a result, there has been a need to introduce Qatari youth to new notions of the diverse range of engineering disciplines and to highlight their significance for Qatar beyond oil and gas.

¹ Jure Snoj, "Population of Qatar by nationality — 2017 report," Priya Dsouza Consultancy, February 7, 2017, <http://priyadsouza.com/population-of-qatar-by-nationality-in-2017/>.

Texas A&M University at Qatar offers ABET-accredited undergraduate degrees in chemical, electrical, mechanical and petroleum engineering, and it has proven itself as one of the leading academic institutions in Qatar and the region since classes began in 2003. Since 2007, Texas A&M University at Qatar has awarded more than 750 bachelor's degrees and master's degrees in engineering in Qatar. A major engagement pursuit of the campus is to develop and implement STEM enrichment and academic outreach programs for students and teachers at elementary, middle and high school levels. Thanks to strong support from the industrial sector, Texas A&M University at Qatar has been successful in executing an array of outreach initiatives for students in grades 5–12. In particular, programs for students in grades 7–12 highlight the role of engineering toward Qatar's grand challenges, and integrated, problem-based learning is at the center of projects and activities designed to educate, enrich and stimulate young minds toward STEM studies and careers, especially in areas of Qatar's greatest need and demand.

Literature Review

Recent research indicates that an experience with STEM learning on a university campus can be a “decision point” for prospective STEM students. A study conducted in Norway found that in a STEM recruitment event, “most of the participants responded that meeting university students and experiencing the university had made them more motivated to choose a STEM programme in higher education.”² The authors build on earlier research by Jensen and Henricksen, and they conclude that the origin of students' interest was childhood experiences — and that STEM enrichment activities as a secondary school student served to confirm interest in science rather than generate it. In a similar vein, Hiller and Kitsantas found positive outcomes from grade 8 students after their participation in a citizen science project, and “path analyses indicated that students' motivational beliefs influence content knowledge and outcome expectations, which in turn affect their career goals.”³

As Chubin, May and Babco point out, “targeted strategies have been shown to have the potential to increase the number of underrepresented pre-college (K–12) students progressing to college STEM programs” when they promote awareness of engineering through academic enrichment by competent instructors and are supported by the student's educational system.⁴ Hernandez et al highlight the potential capacity of early access to research activities as a way to recruit larger portions of underrepresented students to STEM studies.⁵

For Texas A&M University at Qatar, the goal of STEM outreach programs is to raise awareness of engineering among schoolchildren by supplementing classroom learning of students in grades 5–12 with hands-on, problem-oriented challenges that integrate math, science and technology

² Fredrik Jenson and Maria Vetleseter Bøe, “The Influence of a Two-Day Recruitment Event on Female Upper Secondary Students' Motivation for Science and Technology Higher Education,” *International Journal of Gender, Science and Technology* 5.3 (2013): 331.

³ Suzanne E. Hiller and Anastasia Kitsantas, “The Effect of a Horseshoe Crab Citizen Science Program on Middle School Student Science Performance and STEM Career Motivation,” *School Science & Mathematics* 114.6 (2014): 302.

⁴ Daryl E. Chubin, Gary S. May and Eleanor L. Babco, “Diversifying the Engineering Workforce,” *Journal of Engineering Education* 94.1 (2005): 79.

⁵ Paul R. Hernandez et al, “Sustaining Optimal Motivation: A Longitudinal Analysis of Interventions to Broaden Participation of Underrepresented Students in STEM,” *Journal of Educational Psychology* 105.1 (2013): 102.

toward designing engineering solutions. Students in Qatar's government schools are required to select an educational track in grade 10, and the intended outcome of the STEM programs is to inspire and encourage more Qatari students to select educational pathways in intermediate and secondary school that would provide coursework to prepare them for university STEM studies. The ultimate intent is to increase matriculation of students into STEM studies at the university level, particularly at Texas A&M University at Qatar.

Methodology

This paper relies on surveys completed by students before and after two on-campus STEM outreach programs. The study was undertaken as institutional research toward developing greater understanding about educational goals and motivation for young Qataris, who are highly desired as engineering students and graduates. From this, researchers hoped to uncover findings that would inform innovation, enhancement and effectiveness of outreach and recruitment efforts to matriculate students into engineering degree programs that support the workforce needs of industry and government.

For two parallel 10-day STEM enrichment programs hosted by Texas A&M University at Qatar in June–July 2015, student participants were asked to complete surveys to measure change in attitudes toward science and engineering education and careers in Qatar. These surveys used Likert scales and asked respondents to assess the level to which they agreed or disagreed with a given statement. For each program, the first survey was administered on the first day of the program, before any presentations or activities. The second survey was administered at the end of the two-week program. The same statements were presented on the pre-program and post-program survey, with the post-program survey adding additional questions.

Over the course of the two 10-day programs, students joined morning plenary sessions in which they participated in presentations on topics such as engineering ethics, critical thinking, technical communication skills and the role of engineering in addressing Qatar's grand challenges for engineering, which include energy, environment, cybersecurity and health care. Faculty presented historical context of science and engineering in the Arab world through discussions of science and engineering achievements of the Islamic Golden Age as well as the emerging Arab scientific renaissance. Undergraduate engineering students and recent graduates hosted panel discussions on engineering studies and careers, and admissions counselors offered advice on high school coursework and preparation for university engineering studies. Students also toured state-of-the-art facilities such as a supercomputer, a 3D immersive visualization facility, and rapid prototyping and additive manufacturing facilities.

After the daily plenary session, students were separated according to the program for which they were registered. Students in the Summer Engineering Academy worked in teams with faculty in laboratories to answer age-appropriate research questions related to Qatar's grand challenges for engineering. Students participating in Future Engineers worked in teams to assemble 3D printer kits and, in parallel, to design objects to print with that technology. In both programs, students enjoyed close mentorship from faculty, laboratory instructors and undergraduate engineering students. Communication skills were woven throughout the projects as a STEAM element — students were asked to present, discuss and defend their work and research findings. Overall, the

activities were designed to illustrate the breadth of engineering disciplines and to highlight the importance of engineering, beyond oil and gas, for Qatar’s growth and economic development. The underlying message was that engineering careers could be a form of national service.

Survey questions were written according to historical observations by administrators and faculty at Texas A&M University at Qatar, and they were based upon anecdotal evidence from university-level engineering students and their parents. These observations suggest that engineering is perceived as a prestigious career in Qatari society, and matriculation into an engineering degree program is a point of family pride for many Qataris. Further, anecdotal evidence suggests a strong sense of patriotic pride among Qatari nationals, and from this pride stems a desire to support the nation’s growth and development. STEM outreach programs strategically highlight and demonstrate the ways that Qataris can serve their nation through STEM careers, and the surveys attempted to determine whether increased awareness of the role of engineering for Qatar’s development served as a motivation for Qataris to undertake STEM studies and careers. The 7-level Likert scale levels ranged from 1 (strongly disagree) to 7 (strongly agree), with 4 (neutral) at the midpoint.

Survey questions of interest for this study are as follows.

Q1: *I am interested in pursuing university studies in engineering, science or math.*

Q4: *Engineering is a prestigious or elite career in Qatari society.*

Q8: *Engineers are important for Qatar’s growth, development and prosperity.*

Q9: *I can serve my country by becoming an engineer or a scientist.*

Data and Results

Table 1 shows the means and standard deviations for survey responses. The higher the mean, the higher participants scored their positive beliefs about the statements.

Table 1. Means and Standard Deviations for Survey

Question	Pretest Mean (SD)	<i>N</i>	Posttest Mean (SD)	<i>N</i>
1	5.79 (1.05)	66	6.07 (1.03)	61
4	5.79 (1.05)	66	6.30 (0.90)	61
8	6.42 (0.95)	59	6.62 (0.66)	61
9	6.45 (0.75)	60	6.57 (0.67)	61

Participant perceptions about the role of engineering in their society increased after their experiences. In addition, the standard deviation decreased, showing that the responses were less varied across the continuum of responses on a 7-point scale. The standard deviation on the question about their interest in STEM fields was the only one that showed very little difference in standard deviation. The STEM interest and belief in service to their country showed the smallest increase from pre to post. The participants’ sense of service to the country was already quite high, so this would explain the small increase. Figure 1 illustrates the confidence intervals for the pretest and posttest means, indicating a statistically significant difference in means.

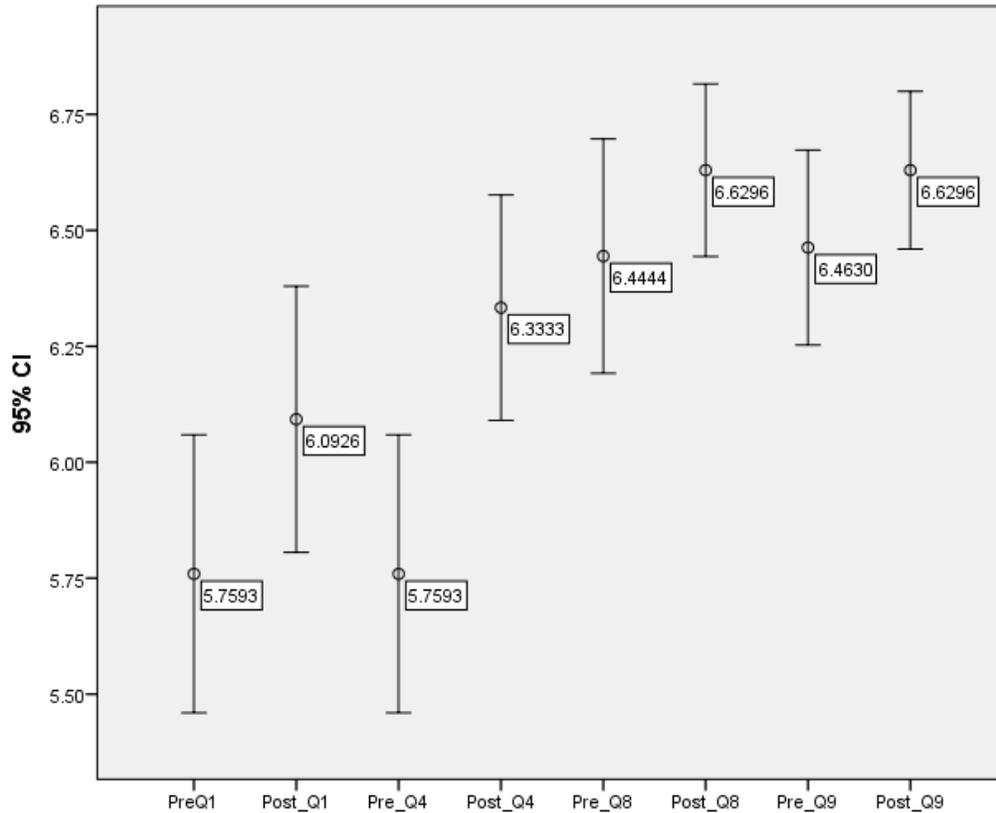


Figure 1. Confidence Intervals for Pretest and Posttest

Cohen's d effect size was calculated for the mean differences, and results are shown in Table 2, along with p values and 95-percent confidence intervals.

Table 2. Cohen's d effect sizes

Question	Cohen's d	p -value	95-percent CI
1	0.270	< .001	[-0.082, 0.618]
4	0.518	0.13	[0.161, 0.869]
8	0.245	0.18	[-0.116, 0.602]
9	0.169	0.35	[-0.189, 0.525]

The largest effect size was on the positive response to question 4, "Engineering is a prestigious or elite career in Qatari society." Cohen's d effect size was $d = .518$ ($p < .001$), indicating a difference of approximately one-half standard deviation, a statistically significant difference. This is a good effect size to show the STEM program's impact on students' perceptions of engineering prestige in Qatari society. Although the other effects were positive, none of them were statistically significantly different on the posttest in comparison to the pretest.

Discussion

The data gleaned from surveys of student participants in STEM outreach programs has informed overall strategy for connecting with the Qatar community and raising the university's profile among potential students and their parents. Overall, the data for the summer 2015 programs suggests that it is possible to influence students' attitudes toward engineering careers in Qatar through university experiences in STEM outreach programs. Additionally, the data presents evidence that students perceive opportunities to serve their nation and support its growth and development through STEM careers; this affirms their underlying sense of national pride and desire to be part of their nation's transformation.

This evidence is particularly compelling when considered with the overall gender makeup of these STEM programs — student participants in both summer 2015 programs assessed here were more than 60 percent female. Given that students self-selected for participation in the program, the high rate of female participation, along with the data reflecting attitudes and attendant shift through program participation, indicates that participation in STEM outreach programs can help female students who already are oriented toward STEM studies and careers identify ways to achieve personal and family pride through education and careers in technical professions. This finding is meaningful in an environment in which high-paying police and military careers for males compete directly with recruitment of males for university STEM studies.

This data also presents new questions about how males could be enticed to take up STEM studies and careers, especially considering the requirements for offshore or industrial work that female engineers historically are less likely to undertake. It should be noted that among Qatari nationals at Texas A&M University at Qatar, there are more female Qatari undergraduate engineering students than male Qatari undergraduate engineering students. The question of strategies for motivating and recruiting male students toward STEM studies, especially engineering, has become a refrain from government stakeholders and industry partners who are seeking to satisfy unmet demand for indigenous talent in the nation's burgeoning technical workforce.

Conclusions

The survey data analyzed from student participants in STEM outreach programs at Texas A&M University at Qatar indicates that it likely is possible to influence students' attitudes toward STEM careers through on-campus academic enrichment programs. By highlighting the importance of engineering and science for finding solutions for Qatar's grand challenges, Qatari students have greater appreciation for the role that engineering plays in Qatar's growth and development. Accordingly, students report that their civic duty and patriotic pride can be fulfilled through STEM-oriented careers that contribute to Qatar's prosperity. In essence, as students are told through their participation in campus STEM programs, Qataris can serve their country even if they do not wear a uniform.

More such studies should be undertaken to identify the contrast, if any, between perceptions of engineering careers versus science careers, particularly medicine, among Qatari youth. Additionally, special attention should be paid to any gender differential in those attitudes. Finally, future studies should examine the role of family in educational decision-making and

consider the influence of parents versus siblings, especially among families in which older siblings already have undertaken university STEM studies.

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