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Key Factors in the Tertiary Educational Trajectories of Women in Engineering: Trends and Opportunities in Saudi Arabia, the GCC, and Comparative National Settings

Jennifer DeBoer and Ashley Ater Kranov

Introduction

The participation of women in engineering undergraduate programs and in the workforce in numerous Gulf Cooperation Council (GCC) countries stands in contrast to the systematically low proportions of female engineers in the United States (US) and numerous western European countries. Across most of the GCC nation-states, women attain degrees at the tertiary level at near parity to male students, and they participate in engineering undergraduate studies at significant rates (Charles 2011). Although this varies by engineering discipline and by GCC country, and although this balance is less equal in some sectors of the workforce, the participation of women in the technical innovation enterprise has been an important component of growth in the GCC (Al Masah Capital Management Limited 2012; Shehadi et al. 2011).

This has not always been the case. Women's participation in economic, educational, and political arenas in GCC countries has been historically low, primarily due to socio-cultural factors influencing laws and policies that have hindered involvement in the public sphere. Over the last quarter century, as attitudes and policies have changed, so has women's representation in these arenas. Yet, in spite of these changes, the female participation rate in the general workforce in the GCC stands at 27%. Again, their overall participation remains at just over one-quarter of the workforce even though women graduate from college or university at higher rates than men in the GCC and also at higher rates than women outside the GCC (Shehadi et al. 2011). Women in Kuwait, Qatar, the UAE, Oman, and Saudi Arabia represented 67%, 62%, 60%, 59%, and 57%, respectively, of their nation's university graduates in 2009 (UIS 2015). As a comparison, in the same year, women comprised 58% of graduates in the US and 57% in the United Kingdom (UIS 2015). This pool of highly educated women in the GCC, including many engineers, is an underutilized resource that, if leveraged, could greatly benefit the region's economic, political, and societal spheres.

Why is the study of women's participation in engineering across countries important? Further exploration into the multi-faceted core causes of gender disparity in education and the workforce are necessary because such disparities:

1. limit the educational, career, and life opportunities of both boys and girls;
2. promote "separate but equal" distribution principles that frequently do not result in equal pay or power; and
3. prevent women from filling the growing global shortage of technical expertise (Charles and Bradley 2009).

GCC countries are in the unique position of having relatively new educational institutions in place and, therefore, may be well situated to build educational policies and structures that respond to the needs of their citizens, the region, and the global economy. Women's participation in the GCC's growth trajectory in both the economic and educational spheres is significant (Shehadi et al. 2011). Capturing a current, cross-sectional measure of women's engagement as engineers is one step in leveraging existing expertise in the GCC and MENA regions, cultivating existing success pathways, and developing new ones (Al Masah Capital Management Limited 2012).

In the next section of this chapter, we delve into trend information and current data in the GCC countries to illustrate women's educational participation during the tertiary schooling and in engineering and STEM. This includes data on educational performance and attitudes, incorporating relevant pre-university information, as well as labor force statistics. Section three of this chapter provides a succinct review of the literature on gender parity in STEM fields worldwide. In section four, we then provide "country brief" case studies of one GCC country (Saudi Arabia) and a selection of non-GCC comparison countries, including the US. Section five discusses the implications of new educational structures for women's educational and occupational opportunities in the region. We conclude with a brief discussion of implications, policy recommendations, and remaining opportunities.

Relevant Trend Information and Current Data on GCC Countries

We begin with available data that illustrate trends in women's participation in engineering studies in the GCC countries. In addition, we look at women's enrollment and attainment in the tertiary (and, for added context, pre-tertiary) education system overall. We then look more closely at women and girls at early stages of their engineering educational trajectories in terms of their STEM academic performance, their perception of the field, and their self-efficacy and confidence in the field. Next, we discuss performance during tertiary education where engineering domain learning is focused, as well as student perceptions of their motivations towards learning engineering content. Finally, we discuss available information on the labor force in the GCC in terms of STEM researchers and gender ratios in STEM field jobs.

For all of these metrics, we draw on existing international and comparative datasets. The Organisation for Economic Co-operation and Development (OECD) runs the Programme for International Student Assessment (PISA), which assesses math, science, and reading literacy for 15-year-old students (ostensibly in their last year of mandatory formal education). To complement the PISA data, we present descriptive information from United Nations Educational, Scientific, and Cultural Organization (UNESCO)'s Institute for Statistics (UIS), including women's participation in STEM research. Finally, we present corresponding data from the International Labor Organization (ILO), where available. These data not only contextualize our descriptions of participation in engineering for women in GCC countries, but they also inform the choice of countries to study in our international, cross-comparative investigation of women's engineering study and practice.

The three sections of Table 1 (a-c) provide an overview of key metrics that we have compiled from the UNESCO Institute for Statistics digest and UNESCO World Atlas of Gender Equity. Table 1.a. highlights enrollment and dropout metrics for secondary and tertiary education for both females and males (for comparison). Table 1.b. gives attainment figures for the current adult population in GCC countries, where data are available. Finally, Table 1.c. provides enrollment, attainment, and research and development (R&D) labor force participation figures specific to engineering and STEM fields in GCC countries. We follow the International Standard Classification of Education (ISCED) 2011 guidelines to categorize educational levels and to define secondary (ISCED 2, 3) and tertiary/postsecondary schooling (ISCED 6 and up; UNESCO 2015).

Table 1.a. Enrollment in General Education (Secondary/Tertiary)

Enrollment in General Education (Secondary/Tertiary)						
Country / Percentage (%)	Dropout Rate (lower secondary)		% Students in Secondary who are Female			Female Tertiary Enrollment (% of student body)
	F	M	Lower	Upper	All	All Fields
Bahrain	1.9	2.8	48.3	50.0	49.1	59.2
Kuwait	0.9	15.5	49.1	52.3	50.3	63.9
Oman	1.45	1.7	48.9	49.0	48.8	52.8
Qatar	3.7	10.9	49.3	48.7	49.0	65.1
Saudi Arabia	16.1	5.4	47.1	46.1	46.6	49.3
United Arab Emirates	4.1	6.7	48.7	49.5	49.0	55.4

Source(s): UIS Statistics, 2015.

Table 1.b. Attainment of ISCED Qualification Levels

Attainment of ISCED Qualification Levels (Population 25 and older, by ISCED 2011)						
	6 (Bachelor's or equivalent)			8 (Doctoral or equivalent)		
Country / Percentage (%)	F	M	MF	F	M	MF
Bahrain	10.0	7.7	8.5	0.1	0.2	0.2
Kuwait	11.1	6.8	8.3	0.3	0.5	0.4
Oman	11.3	15.3	14.0	-	-	-
Qatar	34.5	17.1	20.5	-	-	-
Saudi Arabia	0.6	1.3	1.0	-	-	-
United Arab Emirates	25.1	15.7	18.0	-	-	-

Source(s): UIS Statistics, 2015; ISCED 2011.

Table 1.c. Enrollment, Attainment, and Labor Force Participation in Engineering/STEM

Enrollment, Attainment, and Labor Force Participation in Engineering/STEM					
	Engineering, Manufacturing, and Construction		Engineering & Technology Researchers	Natural Sciences Researchers	Total R&D workforce
Country / Percentage (%)	Female Tertiary Attainment (% of whole graduating body)	Female Tertiary Enrollment (% of student body)	Females as % of total researchers	Females as % of total researchers	% Female
Bahrain	25.7	21.1	-	-	
Kuwait	25.0	43.4	28.4	28.3	40.7
Oman	52.7	37.1	12.1	31.5	22.4
Qatar	27.4	34.3	-	-	-
Saudi Arabia	3.4	5.9	-	-	-
United Arab Emirates	31.1	35.1	-	-	-

Source(s): UIS Statistics, 2015.

As we compare overall enrollment and attainment metrics for the GCC countries, we can see notable diversity across the six countries in their outcomes for women. In Qatar, about twice the proportion of women as men have attained the ISCED equivalent of a bachelor's degree, and females have a lower dropout rate than their male counterparts. By contrast, Saudi Arabia has a higher female dropout rate and a slightly lower female proportion of secondary enrollment (about 46% in upper secondary). Although there is a great deal of variation in the proportion of the students enrolled in engineering programs who are women, many of the GCC countries show female enrollment in these programs at rates higher than in North America and Western Europe (e.g., women as 43.4% of the student body in engineering programs in Kuwait). Kuwait and Oman also provide data on engineering and STEM researchers. In both contexts, women make up a notable group of the researchers, whether in engineering and technology, natural sciences, or the broader R&D workforce.

Participation: Enrollment and Attainment

First, we present information on women's participation in secondary and tertiary education overall (all disciplines, including engineering). Statistics in the following two paragraphs are drawn from the UIS Data Centre (Data Centre 2015) and its records across countries, years, and topics, except where specified. Across many of the GCC countries, drastic increases in overall enrollment, related to the push for Education for All (UNESCO 2014), have bolstered the proportions of the school-going population of females. For example, female enrollment in Bahrain has trended upward with the dramatic overall increase in the gross enrollment ratio—up to 36 times previous levels (UNESCO 2012). For the adult population of at least 25 years of age in all GCC countries, a higher proportion of women than men have attained the highest level of tertiary education, International Standard Classification of Education (ISCED) levels 6 and up (postsecondary, tertiary) (ISCED 2015). In some cases, this difference is nearly double; for example, in Qatar, 33.9% of women in that age range have attained ISCED 6+ qualifications as opposed to 17.9% of men. Other empirical work corroborates this tendency in Qatar. Felder and Vuollo (2008) describe the beneficial prospect of the inclusion of Qatari women in the workforce. They describe women in Qatar as better educated than Qatari men, with great ambition for advancement and success in their academic and professional careers. Qatari women are increasingly joining the workforce, and, according to Felder and Vuollo, display tendencies for higher perseverance in their employment alongside windows of motherhood. Furthermore, the authors note that Qatar has enhanced opportunities for women through important changes in political, educational, and social areas. However, female economic participation is still on the low side in Qatar, even with recent increases and numerous improvements to the policy environment.

Despite drastic increases in enrollment across the GCC, there are numerous instances like Qatar where the profile of women's enrollment and attainment is still mixed. For the latest year of attainment data that is available for the adult population in each respective GCC country, the percentage of women with the highest ISCED level of qualification is only less than men in Oman, and there, only slightly so (11.3% women vs. 15.3% men). Still, on the other hand, in Oman, there are slightly more women with ISCED 4/5 (postsecondary, non-tertiary) qualifications. And, there are slightly higher proportions of women who are currently enrolled in ISCED tertiary levels 6+, which may reflect current changing trends in that country. Indeed, the rising profile of pre-tertiary enrollment and attainment may explain women's participation in tertiary education and indicate where changes are beginning to occur. Some of the remaining gender gaps in adult attainment may be attributable to persistent differences in retention and completion in lower education levels. For example, trends in Oman and in Qatar show higher numbers of female repeaters than males in secondary education (UNESCO 2012). Differential dropout rates plague female students in Saudi Arabia

(11% dropout rate for females vs. 2% for males), and, although Saudi's secondary gross enrollment rate (GER) is high for both females and males, it continues to be notably higher for males (103% vs. 90%). As a counterpoint, male dropout is much higher in Qatar (10% male vs. 3% female). Qatar has notably higher secondary GER for females than for males (107% female vs. 73% male, one of the largest female overrepresentations around the world), which then translates into higher tertiary numbers (UNESCO 2012).

Upon closer inspection of enrollment and attainment by discipline, we see that there is strong and growing representation of women in engineering and STEM study and work. In fact, higher proportions of the female tertiary student cohorts are enrolled in science in Saudi Arabia (16.3% of female vs. 12.7% of male students), in the UAE (8.2% of female vs. 7.9% of male students), and in Oman (24.7% of female vs. 18.3% of male students; UIS 2015). This may be related to the overall greater participation in tertiary education for female than male students in Oman, UAE, Qatar, and Saudi Arabia. There are still higher proportions of male students in GCC countries in engineering, manufacturing, and construction, however, it is not possible to disentangle these three complex and different fields from each other because the existing data do not differentiate between the disciplines (UIS 2015). And, although they are not the majority, females make up a significant portion of the STEM research labor force, whether in engineering and technology (Kuwait 28.4%, Oman, 8.9%); natural sciences (Kuwait 28.3%, Oman 24.8%), or total R&D (Kuwait 40.7%, Oman 25.7% [in 2002]). Throughout the engineering and STEM pipeline in the GCC, female students and practitioners participate at strong and growing rates.

Performance and Attitudes Towards STEM

Here, we summarize performance in and perceptions of STEM for nationally representative samples of 15 year olds who are poised to transition into higher education or the workforce. The PISA system also measures students' intrinsic and instrumental motivation to study mathematics. In the UAE and Qatar, boys report much higher intrinsic motivation to study math. By age 15, for many female students in GCC countries, there is an observable drop in positive attitudes towards math and science from previous high scores on earlier surveys. For example, in UAE and Qatar, there is a small but observable gender gap that favors boys in relevant attitudes towards learning such as "openness to problem solving", which PISA defines as an attitude toward general problem solving, even accounting for differences in math performance (PISA 2012). And, in the UAE, there is an increased likelihood of boys scoring among top performers in problem solving as opposed to girls (14% increase in relative likelihood). However, UAE boys are also more likely to score among the lowest performers (18% increase), which mirrors what has been observed in other national contexts for math/science performance of boys vs. girls (that is, higher variance in performance among boys, with similar mean achievement; Hyde et al. 2008). In fact, UAE girls on average outscore boys by 26 points on problem solving, by 28 points on science, and 5 points on math (PISA 2012). Similarly, in Qatar, girls on average outscore boys by 35 points on science and 16 points on math (PISA 2012). And, controlling for math performance, girls across the GCC still report higher instrumental motivation to study math (PISA 2012).

Review of the Literature on Gender Parity in STEM Fields Around the World

How do the trends we describe for women in engineering in the GCC fit into the worldwide picture? The state of women's engineering participation in the US and in the other contexts cited in this chapter, including a number of Gulf Countries and other majority-Muslim countries, can be situated in the broader literature on women's participation in North America, Europe, and a handful of other contexts. Numerous research teams have tracked the global expansion of women's enrollment and subsequent participation in STEM fields over time. Women's enrollment in higher education appears to be growing, to greater or lesser extents, in many places. For example, Ramirez and Wotipka (2001) conducted a cross-national study that demonstrated a significant increase in the enrollment of females in the fields of science and engineering in higher education. This was apparent globally across a span of twenty years, from 1972 to 1992. They used UNESCO Statistical Yearbooks to investigate the magnitude of and change in male and female enrollments in engineering across all regions of the world—as absolute levels, as percentages of respective totals in higher education, and most importantly, as women's share of higher education enrollments in science and engineering. On average, overall, women's enrollment globally in science, technology, and engineering fields more than tripled over that 20-year period (for the sampled cases in their study). Furthermore, women's share of the enrollment in science and engineering fields increased in all countries (mean change: from14.5% to 20.7%). This change is not consistent across countries, which we discuss in more detail below. In Europe, for example, Eastern European women's participation only slightly increased, from 24.8% to 25.6%, while women's participation in Western Europe increased from 17.2% to 23.8% between 1972 and 1992. In fact, scholars investigating women's participation in the UK and Europe more broadly note that growth in tertiary engineering enrollment has not actually changed the persistent barrier in terms of retention in the field or advancement to higher-level positions in STEM organizations (academic, industry, or otherwise) (Bebbington 2002).

Considerable global scholarly and policy attention has been directed towards studying the factors that explain this underrepresentation of girls and women within STEM fields, in particular in engineering, and largely in North America and Europe (Hill, Corbett, and St. Rose 2010; Cech et al. 2011; Ceci and Williams 2009; Charles and Bradley 2002; Charles and Bradley 2009; Lagesen 2008; Luke 2002; Riegle-Crumb et al. 2012; Xie and Shauman 2005). Several factors have been identified as shaping the uneven distribution of women and men across engineering fields of study, including: women's overall status within societies, the structure of national educational systems, and international and national cultural beliefs and norms regarding women. These factors operate through a number of mechanisms to produce gender-differentiated participation. These mechanisms might be processes that affect individual decision-making such as stereotype threat, gender-based differences in cultural and social capital, and the notion of engineering as a masculine-gendered field. Even macro-level forces such as societal and global cultural norms and the logic and structure of educational systems themselves play a role (Charles and Bradley 2009; Faulkner 2000; Marchand and Taasoobshirazi 2013; Morgan 1992; Seymour and Hewitt 1997).

Sociologists Charles and Bradley are among the only researchers to have conducted a robust study of gender segregation in a variety of fields across 44 countries, using their Gender Essentialist and Self-Expressive Value Systems Framework as a method for data analysis and interpretation (Charles and Bradley 2009). The study's counter-intuitive findings suggested that gender segregation in fields traditionally regarded as "masculine," such as engineering, is much more pronounced in high GDPPC (Gross Domestic Product Per Capita) countries like the US. They found that cultural beliefs in fundamental and innate gender differences express themselves in curricular and career choice more prevalently in economically developed countries where self-expression and individualism in curricular and career choice is highly valued, in contrast to less economically developed countries, where curricular and career choice is more frequently influenced by economic and prestige factors.

In another empirical example, as part of the pan-European project "WomEng", Sagebiel and Dahmen (2006) find both explicit and "latent" discriminatory or masculinizing elements in engineering teaching environments. The elements they identify contribute to difficult organizational cultures and structures in higher engineering education and may, in part, explain lower rates of persistence for women engineers. A trend of "male dominance" was found in perceptions of engineering in society. The engineering field was classified as having a "masculine image". European female students characterized it as: "machine-oriented, with less communication, rational but not creative, not positive, but combined with high earnings" (Sagebiel and Dahmen 2006, 9). Coping strategies such as addressing feelings or attitudes towards gender discrimination, welcome events and activities, interdisciplinary tracks, and single-sex courses employing a more women-friendly inclusive culture were suggested for the field of engineering. In another example, a European project, Curriculum Women and Technology, CuWaT (1998), provided evidence for elements effective in the retention of women in engineering, through cross-disciplinary courses, group work and project work (Sagebiel and Dahmen 2006). Beraud (2003) extended this by highlighting, through his research on Engineering in Europe, that interdisciplinary degrees appear to be more attractive to female students than single-track engineering degrees and that more women could be recruited to engineering by utilizing this interdisciplinary factor. The lower participation of women in Europe persists despite these and other efforts, despite growth in general educational attainment for women, and despite reports of high value for female engineers in industry and academia presently and as integral to the future global economy (Beraud 2003; Brush 1991).

Policymakers have tried to respond by applying best practices that have been identified as important for women's participation in order to support women in engineering. Thanks to global norms and programs stressing increased educational access for all students, with particular focus on the increased educational access of girls and women, opportunity has spread through the direct influence of international and national organizations such as UNESCO and the World Bank (Bradley and Ramirez 1996). Some areas of women's participation (e.g., general higher education enrollment) have seen notable progress towards gender parity (Ramirez and Wotipka 2001). Since this growth has not universally affected engineering fields, national and international governmental organizations in North American and Europe have mobilized billions of dollars to identify and then address the underlying factors that have prevented gender progress in all areas and have implemented strategies to increase female participation as students and professionals within scientific fields. See, for example, the US National Science Foundation and the US National Academies and the Central European Centre for Women and Youth in Science. Even so, the efforts of policymakers in North American and Europe have had relatively minimal impact on overall numbers (Zoli et al. 2008).

As we note above, the characteristics of women's participation in engineering vary widely between national contexts. Although growth in women's participation has stagnated in US and the UK, it has expanded in other places. According to UNESCO data for 2012/2014, five countries accounted for the highest gender discrepancy towards male-dominated engineering, manufacturing, and construction management programs: Germany (81%), Japan (88%), Saudi Arabia (94%), Switzerland (84%), and the U.S. (83%) (UIS 2015). As we note later in this chapter in the Saudi Arabia country brief, the most probable reason for the low numbers of women enrolled in the kingdom is because the first undergraduate engineering program for women was opened in 2012 at the public King Abdulaziz University, and the graduate-level programs offered at KAUST since 2009 are for the international and national elite, and thus not representative. In contrast, in Saudi Arabia, women constituted 72% of graduates in scientific fields in 2011 (Matthews 2013). Females in science in the five GCC countries for which UNESCO published data in 2015 were strongly represented: Jordan (38%, 2012), Kuwait (43%, 2012), Oman (37%, 2013 up from 25 % in 2011), Qatar (34%, 2013), and the UAE (35%, 2013). In Jordan, in addition, 49% of computer science undergraduates in 2011 were women, according to government statistics (Matthews 2013). Mongolia, Greece, Serbia, Panama, Denmark, Bulgaria, and Malaysia constitute a diverse group of countries where women represent a third of all engineering graduates (Charles 2011). Although Charles and Bradley (2009) found that countries with high GDPPC had greater gender typing of curricular fields (e.g., engineering = male or nursing = female) than those with low GDPPC, Abu-Lail et al. (2012) and Lagesen (2008) found in their interviews of women who chose engineering as a field of study that Jordanians and Malaysians may gender-type subfields of engineering rather than engineering as a whole. In their trend research, Ramirez and Wotipka (2001) found some minor irregularities in science and engineering globally and that women more often chose science over engineering.

To further complicate the variation between countries in women's participation and the mechanisms explaining imbalances, it is important to note that the issue does not exist in a vacuum in isolation for each country. Differences in opportunities for women engineers may also translate to patterns of international skilled migration in engineering fields. Immigration and emigration statistics of foreign-born individuals with science and engineering degrees reveal high proportions of skilled workers in engineering disciplines and science/engineering overall who were born abroad and are now working in the US, as one example (Regets 2007). The share of women in the US's immigration flow was over half (55%) in both 2000 and 2010, and women make up an increasing proportion of highly skilled migrants (OECD 2012). Interestingly, international migrants in recent years are less likely to settle abroad permanently (Iredale 2005). The diverse, interwoven, and developing picture of women in engineering demands that we more deeply understand the context and trends within countries and the way in which these contexts might inform one another.

Country Briefs

We now take a deeper look at women in engineering in one example GCC country as well as a set of comparison countries in the MENA region, Southeast Asia, and North America. These country briefs provide implications for future institutional development in the GCC and, lay the groundwork for further study of women's participation across national contexts. First we highlight Saudi Arabia, one of the GCC countries we have already discussed in detail. To complement our detailed GCC information, we include a brief on another country in the Middle East (Jordan), one in North Africa (Tunisia), another majority-Muslim country in Southeast Asia (Malaysia), and a high-GPDDC country where much research has been done with little change (US). Table 2 provides broad general summaries of the information that we detail in our country briefs below.

Table 2. Country Profile Data Descriptions

	Saudi Arabia	Jordan	Tunisia	Malaysia	US
Education	Higher female than male enrollment rate in tertiary overall; high proportion of females attaining degrees	Higher female than male enrollment rate in tertiary overall	High female secondary enrollment (89%), lower tertiary enrollment (21%)	High female literacy rate, minimal literacy gap by sex	High female enrollment, attainment overall; lower engineering and STEM
Economic	Low female employment rate (20.1%); women likely employed in administrative/ academic positions, public sector; low female STEM researcher rate	Low but growing proportion of women in engineering and computer science, higher in other sciences	Women represented in engineering, often in public or academic work	High proportion of female STEM researchers (48.7%)	High female employment; major dropoff in female engineering/ STEM participation during employment
Cultural, historical, political factors	Gender roles and gender segregated schooling adapting to new institutions and new economic demands	Gender typing of subdisciplines but not whole area of STEM	Historic support for women's equality; national union for women	Gender typing of subdisciplines but not whole area of STEM; acceptance of women in engineering industry, even in managerial roles; continued expectance of traditional family roles	High income democracy, multiple women's movements, policy focus on women's participation and women in engineering/ STEM
Available research	Some information from management and business literature, knowledge economy literature	Little available research on this question	Some literature from economics/ World Bank programs, literature from sociology	Little available research on this question	Great deal, from basic participation, documentation of women in engineering programs, to rigorous research

Source(s): UIS Statistics, 2015.

As we show in Figure 1, there is a great deal of heterogeneity in the relationship between female representation and national income level (and certainly other national characteristics). We highlight the four countries for which we provide country briefs that Charles and Bradley (2009) include in their study. We also approximate the placement of the six GCC countries on the same graph. Interestingly, five of the six GCC countries have higher representation of women in engineering than their GDP per capita would predict. The exception is Saudi Arabia, which has a much lower proportion of university graduates who are women in programs in Engineering, Manufacturing, and Construction, which is the proxy measure we have available for women's representation (3.44%; UIS 2015). However, the proportion of graduates who are women from science and technology programs (38.9%) and science programs (57.2%) is as high as or higher than other GCC countries (UIS 2015), and we delve into the Saudi case later in this section.

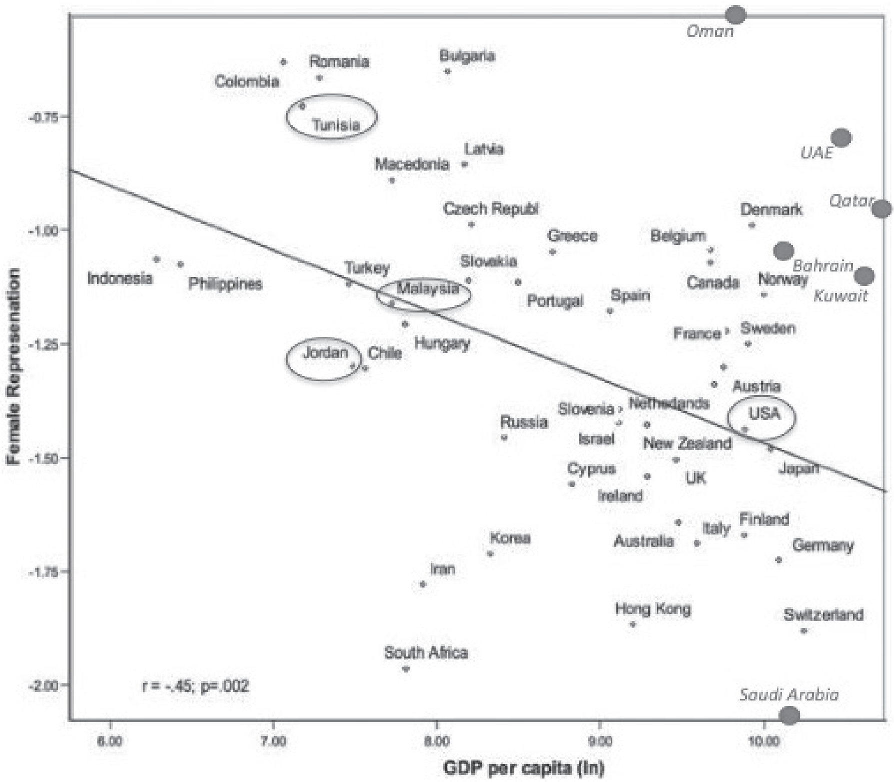

Figure 1: Country-level Female Representation in Engineering by GDP per Capita (adapted from Charles and Bradley [2009]; UIS, 2015) N.B. In our additions, the female representation of Oman is higher than the range given in Charles and Bradley [2009], and that of Saudi Arabia is lower. Also, the logged GDPPC of Qatar extends beyond their range.

Table 3 summarizes key metrics that we highlight in each of the country briefs that follow. It does not list the US metrics, as we delve into other literature beyond the UIS figures in the US section, based on the greater amount of literature available.

Table 3. Literacy Rates, Tertiary Enrollment & STEM Researchers

	Youth Literacy Rate		Tertiary Enrollment		Literacy Rate		STEM Researchers
Country / Percentage (%)	**F**	**M**	**F**	**M**	**F**	**M**	**F**
Saudi Arabia	97.0	99.0	46.0	41.0	-	-	1.4
Jordan	94-95	99.0	43.0	37.0	-	-	22.8
Tunisia	96.0	98.0	21.0	25.0	71.0	87.0	-
Malaysia	99.0	98.0	-	-	91.0	95.0	48.7

Source(s): UIS Statistics, 2015.

Saudi Arabia: High Income, High Female Attainment, High Female Unemployment, Gender-segregated Education

Saudi Arabia has shown growth over the last few decades in women's participation, but this is particular to the public sector and to jobs in education. The country's economy is healthy, with a notably higher GDP per capita than its MENA counterparts of Jordan and Tunisia. Saudi experiences near parity in the youth literacy rate (97% /99% female/ male 15-24 years of age) and higher female tertiary enrollment (46% vs. 41% female/male; UIS 2015). However, the seeming gender-parity within the educational system does not translate into equality in the labor force; in STEM, only 1.4% of researchers are women, and overall female employment hovered around 20.1 % in 2013 as compared to the GCC member average of 43%, the lowest in the region (UIS 2015; G20 Labour Markets 2014; Islam 2014). At present, only 14.4% of women are represented in the Saudi workforce, and as many as 78.3% of unemployed women are university graduates or degree-holders. The government hires women predominantly in education (85%), and, as of 2014, women cover only 5% of the jobs in the private sector. Statistics on female participation in the workforce show that only 26.0% of Saudi females are employed in a technical field, while 96.0% are in educational roles, and 90.0% are in administrative positions. Thus, administrative, academic, and medical areas dominate female employment in the public sector; whereas the technical and vocational areas house private sector female employees (Calvert and Al-Shetaiwi 2002).

Al-Mubaraki (2011) discusses how higher education in the Kingdom of Saudi Arabia (KSA) has been growing rapidly, with large-scale changes and fast-paced progress and growth. Global movements in higher education, requirements for an increasingly specialized national workforce, and the possibilities and difficulties associated with both areas (academics and employment needs), together have effectively led towards the formation of present guidelines and future strategies. This has given birth to the "Saudi model of a knowledge-based economy" (Al-Mubaraki 2011). Onsman (2011) discusses the fact that KSA's higher education development holds the primary concern of upholding and preserving its strong socio-culturally Arabian foundation, while simultaneously working hard towards gaining international significance (p. 519). Islam (2014) reports that 58% of Saudi students at the university level are women, and a scholarship program for women has been put forward by the Saudi government that is one of the largest of its kind globally.

The picture of women's participation in the Kingdom had already started to shift at the turn of the century. The number of women in Technical and Vocational Education/Training (TVET) increased sharply between 1973 and 1999 (Calvert and Al-Shetaiwi 2002). This was in major part due to the government's encouragement of and emphasis on the value of TVET for women, bringing some change in societal attitudes towards women's participation in STEM areas. Recognizing the high numbers of female university graduates and their low employment numbers as a national issue of underutilized human resources, the Saudi Ministry of Labor began to implement a series of policies and programs in 2011 that were designed to increase the number of women in the workforce, which continue today (G20 Labour Markets 2014). According to Saudi Arabia's G20 2014 Employment Plan, 8.8 million of the 12.4 million female nationals are of working age. A significant partnership between the Saudi government and Harvard's Kennedy School of Government began in 2014 in order to address the myriad technical and societal challenges that ensued after policies designed to usher women into the workplace went into effect (Searcey 2014).

Gender segregated schools are viewed as a possible vehicle for the education of the nearly "… '80% of girls in Saudi Arabia…interested in engineering' [according to a recruitment expert in the Middle East]" (Mafeo 2013). The ubiquity of gender-segregated schools is seen by some as promotion of traditional women's expectations and roles (Baki 2004). Educational institutions themselves are perceived as a mechanism of control and enforcer of the traditional and lower status of women (Doumato 2003). Secondary public school curricula for girls is cited as being up to 20 years out of date, with the topical focus being primarily on religious studies, Arabic Language, and home economics (Al-Munajjed 2009). Women continue to be under-enrolled in technical and vocational education (TVET), where jobs are reportedly undersupplied (Calvert and Al-Shetaiwi 2002). And, up until very recently, the field of engineering had excluded women from studies (Hamdan 2005).

This, too, is changing. In 2012, King Abdulaziz University in Jeddah opened the first college of engineering open to women in public universities, offering degrees in two areas: electrical and computing engineering and industrial engineering. Given the overrepresentation of women in the public sector, Calvert and Al-Shetaiwi (2002) propose a push towards increased Saudi female representation in private sector employment, and they suggest factors that would contribute to this policy goal. They suggest more cooperation between public and private sectors in the planning of TVET and establishing of direct links between women's education and the labor market. Their research implies that progress could be made by altering the structure of technical and vocational education in Saudi Arabia. Quamar (2013) states that over the past two decades there has been a rapid upward shift in quality and availability of education for Saudi women. These improvements have naturally led to increased numbers of educated women and subsequent positive growth in all related fields, such as socio-political and economic status.

Co-educational opportunities do exist, but they are rare and are not part of the Kingdom's public school system. The sole higher education example is King Abdullah University of Science and Technology (KAUST), which has offered graduate-level programs (Master's and PhD) in engineering since 2009 to both Saudi and international women and men. KAUST's enrollment of Saudis is capped at 50% in order to make the student body truly international; Saudi enrollment is currently at 35% (Havergal 2015). The university also includes "research funding for global partnerships and collaborative research with the private sector to advance economic development" (Ulaby 2010, 178). KAUST has proactively increased its female representation in both the faculty and student body, with women comprising 35% of both sectors (Havergal 2015). In the 2014-2015 academic year, the university was hosting 840 students from 69 countries, 302 of whom are women and 246 of whom are Saudi Arabian (Butler 2015). KAUST is an elite institution and, thus, does not impact a significant percentage of the Saudi female cohort in engineering programs or in the workforce. There has been a notable amount of policy literature devoted to increasing women's participation and role in the Saudi economy; yet, little is known about how the overall system impacts women's decisions to enter engineering or computing or to remain in it as a profession.

Jordan: Recent Growth in Representation, Less Research Focused on this Issue

Jordan provides an interesting complement and counterexample, another Middle Eastern country, but outside the GCC. Jordan, with a GDP per capita very similar to another MENA country we study, Tunisia, has seen a greater historical change in women's participation in engineering over its history, as the participation of women began at a much lower proportion but has increased in recent years (IGU/UNESCO 2012). In Jordan, women's and men's literacy rates are close to equal (94% /95% for women and men overall and 99% for female/male ages 15-24; UIS 2015). Additionally, the country enjoys near parity in secondary educational enrollment and notable overrepresentation of women in tertiary enrollment (43%/37% female/male enrollment; UIS 2015). This gender parity in enrollment is a recent phenomenon, and it has raised the question of a possible change in the perception of young women's roles in society (Adely 2004). Still, fewer than a quarter (22.8%) of STEM researchers are women (UIS 2015). Although the percentage of female students in specific disciplines such as computer science is lower than men (about 25% in 2009 and, as cited above, about 49% in 2011), it is rising and approaching parity (Khreisat 2009); further, the proportion of women in other STEM disciplines (e.g., chemistry, biology, physics, and math) may reach as high as 75%. Scholars have yet to identify what factors have led to such a different and rapidly changing outlook for women in engineering in Jordan.

Tunisia: Historical Female Participation, Secularism, and French Education

Tunisia provides a distinct contrasting example to the GCC and Middle East context. Historically, Tunisian national policymakers have explicitly embraced equality for women (Murphey 2003). However, recent studies found that Tunisian engineers from multiple sectors noted that traditional gender perceptions and expectations tied to familial roles did not fit with women's participation in engineering work (DeBoer 2007; Zghal 2006).

The traditional, historically French education system in Tunisia is seen as having a leveling effect on educational opportunity, and overall educational enrollment figures are approximately equal for women and men, tipping slightly towards women in the secondary (89% /93% for boys and girls, respectively) and tertiary (25% /21% for women and men) levels (UIS 2015). Researchers in STEM fields are nearly half women (47.4%; UIS 2015). The female-male literacy gap, which is notable in the overall population (71% /87% female/male), is reduced in youth (96% /98% female/male in 15-24 year olds; UIS 2015). Tunisia's marked secularism, its active civil institutions, and the longstanding involvement of groups like the National Tunisian Women's Union have improved women's engineering participation. Some sociological work has been done to understand the current experiences of female engineers and to understand the development of the Tunisian engineering education system (Zghal 2006; DeBoer 2016).

Malaysia: Near Parity in Academia, Perceived Need to Reconcile Gender Roles

We turn to Malaysia for the perspective of another majority Muslim nation, here located in the distinct geographic region of Southeast Asia. Malaysia's historically British education system has been combined with state efforts at modernization and support of global competitiveness. Malaysia has a high and relatively equal literacy rate (91% /95% female/male for the population, and 99% /98% for female/male ages 15-24), and over-representation of women in secondary and tertiary enrollment (UIS 2015). Indeed, nearly half (48.7%) of STEM researchers are women (UIS 2015). Despite this, executive-level female employees in a Malaysian multinational company indicated that family structure and women's commitment to family were the most significant barriers to women's career progression (Ismail and Ibrahim 2008). These findings corroborate other analyses of Malaysian women in managerial roles and of Malaysian computer scientists, wherein a specific, well-understood construct of female identity had to be reconciled with academic career aspirations (Lagesen 2008; Luke 2002; Mellström 2009).

The United States: Huge National Investment Resulting in a Plethora of Research, Yet no Real Increase in Numbers

In the US in the 1950's, women represented less than 5% of the graduating classes in schools of law, medicine, and engineering (Diekman et al. 2010). During the intervening years, despite overt and covert discrimination, US women fought in both the courts and public opinion forums to be admitted into schools of law and medicine (both human and veterinary). Women now comprise 50% or more of the graduating classes in these professions (Kam 2005) and are overrepresented in higher education in the US as a whole (Shavit, Arum, and Gamoran 2007). Many claim this majority portends a future decline in gender segregation in fields traditionally dominated by men, as well as an overall decline of gender separation in all areas of the public sphere (Charles and Bradley 2002). Yet, recent studies show that gender segregation is unrelentingly high in the US, and particularly in engineering, as it is in other high-income countries in North America and Western Europe, where legal and societal structures to encourage gender equality in educational and public spheres have been in place for a number of decades (Charles and Bradley 2002). Thus, the same progress in fields traditionally dominated by men, such as law and medicine, has not been matched in engineering, where the proportion of women in the field has remained around 11% for the last 20 years (Fouad and Singh 2011).

Studies on the underrepresentation of women in engineering in the US are abundant. Since the 1970's, the US federal government, industry and professional engineering societies have contributed billions of dollars to increase the number of women in US engineering programs with minimal impact. These funds have been used to 1) study and understand the explicit and implicit patterns of discrimination against women in engineering schools and workplaces, 2) identify and campaign against incorrect and negative stereotypes about women's cognitive abilities with respect to science and engineering, 3) attract young women to the engineering profession by convincing them that engineers make a positive impact on society, and 4) retain women once they are in engineering degree programs by providing (among others) alternative instruction, mentors, and role models (National Science Foundation 2011).

These efforts have helped to increase the women graduating from undergraduate engineering programs from 2% in the 1970s to 17% in the 1990's to 20% in 2004 and 19% in 2015 (American Society for Engineering Education 2015). According to a 2010 study, women in the US were found to be less likely to perceive that STEM (especially engineering) careers would fulfill communal goals, a belief that was related to women's lower likelihood of choosing engineering as a field of study (Diekman et al. 2010). The 2011 report, *Stemming the Tide: Why Women Leave Engineering*, highlighted challenges for female engineering graduates in the US (Fouad and Singh 2011). That report indicated that 20% of women left the field because of working conditions (lack of advancement opportunities and low salaries were among reasons cited), unwelcoming workplace climate and culture, and the desire to spend more time with family. The study also revealed that one third of women never entered the engineering workplace because they perceived engineering as an inflexible career or because the engineering workplace culture did not support women. Although the consideration of women navigating perceptions of appropriate gender roles at home and in the workplace runs across countries, more differences than similarities emerge. The notable difference in participation—stagnant growth and lower participation—in the US stands out, though. It is for this reason that our research group has embarked on an investigation of systematic differences in women engineer's experiences across countries.

Online/Digital Education as an Accessible Avenue for Education

The statistics we have discussed and the research questions our team has developed frame the current systems in place, systems that differentially facilitate women's participation in engineering in the Gulf region. In this penultimate section, we describe novel avenues for educational participation and provocative, more contemporary areas of growth. Online education has rapidly expanded, potentially fostering opportunities for women, youth, and rural citizens. Indeed, numerous GCC online learning or "e-learning" initiatives were created in order to support post-oil knowledge economies (Weber 2010). We highlight one particular recent example from Saudi Arabia. New platforms for online and blended education may indeed support the growth and variation in women's engineering study and practice. Massive Open Online Courses (MOOCs) are one such platform. Policymakers must be cautious about potential outcomes of their use of new educational structures, especially when unintended consequences are not well understood.

Online/digital education as an accessible avenue for education

Beginning at the end of the last decade (2000-2010), efforts to broadly scale online learning met with technological growth in the capacity for online platforms to connect and automate the grading of thousands of students' work. In 2011-2012, the first broadly disseminated MOOCs were presented from Stanford and MIT. Hundreds of thousands of students signed up and virtually matriculated into classes that included online lecture videos, auto-grading of homework problems, and massive discussion forums. This included notable participation from virtual "students" across Gulf Cooperation Council countries, in particular in engineering and computer science content-related courses (Breslow et al. 2013; Ho et al. 2015).

Although absolute numbers in terms of participation were high, the question of whether these courses were achieving their mission of rapidly expanding access to high-quality education where it was previously unavailable was questionable. A number of investigations of student backgrounds and performance profiles found that MOOCs might not have been truly increasing access (DeBoer and Breslow 2014a; DeBoer and Stump 2014), as many students already had university degrees, usually in the subject they were studying on the MOOC. One major barrier to differential access was likely language, as early courses were largely offered from English-language universities in Europe and North America (DeBoer and Breslow 2014a; DeBoer and Breslow 2014b)

Recognizing language as a key barrier to policy diffusion (DeBoer 2012b; DeBoer 2012a), to cross-border partnerships, and to participation in MOOCs as a global technology, edX forged a partnership with Jordan's Queen Rania Foundation to create a MOOC portal focused on the Arab world (O'Connell 2013). The platform, *Edraak*, would provide Arabic translations of existing edX courses chosen for relevance to a range of issues. In addition, plans were laid for *Edraak* to develop its own courses in Arabic in collaboration with prominent Arab faculty and professionals. (Similar collaborations had been developed, for example, with Chinese colleagues, creating "XuetangX".) The not-for-profit platform launched in 2014, featuring courses from edX founding partners Harvard and MIT as well as "the best Arab instructors [and] regional academic institutions" (Agarwal 2014). *Edraak* explicitly targeted its efforts towards the large Arabic population of youth. According to Queen Rania, as of March 2015, the platform had grown from 10 courses and 85,000 users to 20 courses and over 140,000 subscribers (Jordan News Agency 2015). The *Edraak* platform has provided access to Arabic-language courses not only for Jordanian students, but for students across the peninsula, including students in Syria, where the security situation has prevented their attendance at university; the Jordanian queen referred to the role of technology in purportedly increasing access in the Arab World as the "Startup Spring" (Gordts 2015).

After its 2013 announcement (O'Connell 2013) of collaboration with Jordan to create an Arabic-language specific platform, edX more recently forged a collaboration with Saudi Arabia (edX 2014). The partnership was made specifically between edX and Saudi's Ministry of Labor (specifically, the Ministry of Labor's Human Resources Development Fund), with an eye towards increasing access to job opportunities and more closely linking potential labor force participants to growing private sector needs for skilled work. Pointedly, the announcement targets bridging the gap between education and employment for women (as well as youth, the disabled, and rural citizens) (edX 2014). This platform, launched in December 2014 as *Doroob*, explicitly targets job skills and underemployment (Taibah 2015). The Saudi Advisory leading the initiative cites as justification for these efforts the fact that "50% of YouTube streamers in Saudi Arabia are women and 40% of content they view is education" (Taibah 2015).

ICT Opportunities Constructed Explicitly for Women

The Saudi platform's explicit focus on women (as well other populations that have less access to higher education) highlights the technological "fix" offered by distance education in general and the recent advent of MOOCs in particular. Women in Saudi Arabia report increasingly wanting to work, but they face barriers to participation such as transportation to the job site (Searcey 2014). Online education supports advanced learning that can happen at home, addressing both women's individual aspirations and a broader socioeconomic need without necessarily addressing prevalent social norms and practices. Indeed, online learning may address the particular work patterns of women, who, in Saudi Arabia and other emerging markets, more often participate in the informal economy (G20 Labour Markets 2015).

Some in the popular press (Gais 2014) and on the ground (Searcey 2014) perceive MOOC platforms and such alternative avenues to access as band-aid fixes for two reasons. First, the provision of increased education for women may not be as pressing a need as initially presented. There is already a notable mismatch between degree attainment and work profiles for women, who are on average better schooled than men; indeed, women make up more than half of university graduates in Saudi Arabia (Gais 2014; Searcey 2014). This means that MOOC platforms may again be delivering education to a population that already has access to higher education opportunities, whose needs are not so much for educational attainment as for labor force opportunity. Interestingly, MOOCs may unintentionally provide a more useful opportunity given the prevalence of ECS courses in their offerings. One of Saudi Arabia's major labor force needs is in the sector of information technology, where jobs may involve remote work, and women in these positions may still adhere to more conservative social norms.

However, critics see another mismatch in what MOOCs offer and what is needed in Saudi Arabia. As has happened in previous educational reforms, information and communications technology (ICT) may again serve to preserve women's distance from normative educational opportunities (e.g., such strategies were used before in schools to separate female students from male lecturers, Gais 2014). Distance education and MOOCs may again preserve sex segregation in education and the labor force. Although this segregation may reflect women's desires and the utility they perceive in e-learning initiatives (Weber 2010), this practice may create additional barriers to participation in multi-national STI partnerships and hamper the development of the Gulf's knowledge economies to their full potential.

Aswad, Vidican, and Samulewicz (2011) acknowledge, through their study, the importance of understanding how the local socio-cultural contexts affect individuals and the economy and of altering policies to better fit local constructs. They stress upon the need for rising above negative connotations of engineering and increasing awareness of content information and expectations, as well as related career opportunities that are culturally acceptable, in order to increase participation and interest in STEM fields. Syed (2011) investigated and put forward strategies for producing higher rates of success for female entrepreneurs in Islamic countries, where such activities hold great economic potential and transformative power, when utilized and channeled appropriately. Metcalfe (2008) further revealed significant progress made in female leadership and socio-political empowerment, with some ongoing institutional and cultural barriers embedded within systems and complexities local to the Middle East.

Women as an Engine of Growth

As we note, women have already played a significant role in supporting the rapid development of GCC economies. Beyond female enrollment in engineering in higher education and attending universities, there is evidence that the participation of women in the technical innovation enterprise has been an important component of growth in the GCC. Policymakers have recognized this and begun to create recruitment programs. Watson et al. (2006) have outlined various programs dedicated to recruiting and retaining females in the areas of education and employment in engineering.

Naser, Mohammed, and Nuseibeh (2009) researched the factors affecting female entrepreneurship in the region and in the UAE in particular, with a focus on what motivates women to establish their own businesses. Findings showed the importance of governmental financial support (initial capital), and links to family businesses (husband/father), along with the presence of self-sufficient feelings, knowledge, skills, and experience. However, social norms, competition, and market networks did not prove to be obstacles in the development of female entrepreneurs. Women from across the Middle East are finding the United Arab Emirates a business friendly environment for developing their own professional ventures. Many of these entrepreneurs left established positions to start their own businesses focused on effectively addressing issues affecting women in what have been predominately male-dominated sectors in the region, such as computing and IT, professional services, and news (MacKenzie 2014; Syeed and Zafar 2014).

Worldwide, only 10% of tech entrepreneurs are women; in the GCC, women have 35% of the market share (Hosea 2014). The following three examples represent some of the best-known female tech initiatives in the Gulf region. Baraka Ventures was founded in 2006 to fund regional socio-technical enterprises that benefit the community in a sustainable way; one of the 2012 investments resulted in the on-line news agency Barakabits "Good News from the Middle East" to capture and communicate the vibrant stories emerging from the region. Nabbesh, a recruitment website founded in 2012 "to address the Arab World's unemployment challenges by virtually connecting expert regional talent with flexible work, online jobs and opportunities to work from home," claims approximately 35% of their clients as women in the GCC (Hosea 2014). The Arab Women in Computing organization whose goal is "to support, inspire, retain, and encourage collaboration among, increase visibility of and help elevate the status of Arab women in computing, and allow them to achieve their career goals" was established in 2012 (ArabWIC 2014).

Some say that the internet is a more meritocratic space for women to excel than other professional environments in the region and that Arab women living in the GCC are taking advantage of that opportunity (Hosea 2014). While these are three of many success stories for women in the computing and IT fields in the UAE, little is known about the core reasons women pursue engineering and computing fields in the UAE, why the UAE is considered a female-friendly environment for entrepreneurs, and why Emirati women with tertiary degrees in engineering and computing continue to not enter the workforce at rates that mirror the degrees awarded. Another country in our study, Jordan, has similar participation by women and similarly little research on the core reasons for why women choose engineering or computing as a field of study or profession.

Lessons, Implications, and Recommendations

Our international comparative study of women's participation in engineering education and in engineering work demanded that we investigate the state of STEM and women in the Gulf overall, as well as corresponding contexts in the MENA region and globally. As we have shown in our discussion, our presentation of important background information from the GCC, and our contextualization of GCC data within a regional and global frame, the state of women in engineering and computing in the Gulf is a diverse picture, full of potential, and, in many places, trending upwards. The diversity of successes and challenges faced by the region on women's inclusion in STI make generalized policies or consequences rare, but we observe a few key emerging themes in our work. We provide here four implications that resonate with each of the complex nation states of the GCC as our concluding section.

New Policy Opportunities Must Take Into Account Potential Outcomes Both for Near-term Changes as well as for Far-term Access and Equity

Although there are early successes from some policies that have increased women's access, new avenues for education and programs to increase women's participation must be done with planning beyond temporary "quick fixes". For example, single-sex schools are common throughout the GCC, and these may be an important component of the current growth in women's degree attainment. Zeid and El-Bahey (2011) present a case study in Kuwait on the effects of introducing single-gender classrooms in a software engineering course. Findings show an upward trend in academic performance as a result of segregation, as well as a significant decrease in the performance gap between the two genders. They propose this solution as a useful strategy for improving learning in higher education and reducing problems of gender divide in the workplace. Boashash (2013) explains through a comparative analysis that engineering education in the GCC/MENA region needs to be attuned to local customs – mindful of cultural and religious norms, based on local research, with contextual adaptations – in order for engineering education to hold its own on the international platforms. Single-sex schooling may provide such a tailored response.

However, continued educational segregation may also delay the inevitable, as women entering the workforce will need to work alongside men, whether in the GCC or in multinational institutions. MOOCs and the application of online learning pose challenges for long term success in the same way as single-sex schools—women will, at some point in their trajectories, be part of an integrated labor force. And, their increased participation throughout their educational trajectories and into the labor force will buttress GCC goals for active knowledge economies. This means integration into collaborative classroom environments and preparation for global opportunities. One concrete policy recommendation is to support increased numbers of female teachers in STI content areas. This follows on extensive research supporting role models and mentors as key to long-term retention for both women and other under-represented groups in STEM fields (Carrington, Tymms, and Merrell 2008). In Kuwait, for example, high proportions of female teachers in primary education (over 90%) are strongly related to a high female gross enrollment ratio in secondary education (approximately 90%) (UNESCO 2012). Building sustainable solutions into educational structures will foster long-term women's participation in the Gulf and better serve institutional and cross-institutional goals.

As another example, GCC states have rapidly increased the number of higher education institutions locally, often by incorporating foreign branches of Western universities and/or recruiting international faculty. As the call for the 2015 Gulf Research Meeting states,

> The GCC states have made major advances over the last half century in widening access to post-secondary education. For example, eight universities were operating in Saudi Arabia in 2003. Since then at least 100 additional universities and colleges have opened, and the country's annual budget for higher education has reached $15 billion, for 23 million inhabitants. In addition, the United Arab Emirates (UAE) and Qatar have authorized 40 foreign branches of Western universities, most of which date only from the last decade. (Abusharaf and Eickelman 2015)

Although this strategy has dramatically expanded the state of higher education in the GCC, it has not kept in mind the long-term local capacity development of local faculty and institutions. Many of these universities currently have very few native students and even fewer native faculty. For example, at NYU Abu Dhabi, about 10% of the student body is Emirati of the 140 students in their first graduating class in 2014 (Al Bustani, 2015). By contrast, at Carnegie Mellon University (CMU) Qatar, about 40% of the student body is Qatari, but overall numbers are still low (about 400 matriculated in 2014; CMU Qatar, 2014). Although these prestigious collaborations may enrich the host country in a variety of ways, the number of native students impacted is relatively low. Even the benefits for the host country have been called into question, and the universities are difficult to gain admission to and considered elite by local students. They are, therefore, not currently sustainable pathways by which to substantially increase the number of women in engineering and STEM in the GCC.

Building a Competitive Knowledge Economy is a Major Goal of the GCC as a Region and as Individual Nation States

GCC countries are reshaping their tertiary education and STI workforce profiles in order to create regionally and globally competitive knowledge economies. In order to fully realize their potential, however, the *knowledge economy* literature stresses the importance of women's involvement. For example, a report from the Gender and Development Group of the World Bank begins:

> Gender equality is a legitimate policy goal in and of itself…The evidence presented in this paper, however, suggests gender equality is also desirable from an efficiency perspective: increases in opportunities for women lead to improvements in human development outcomes, poverty reduction, and—although evidence on this last point is relatively weak—potentially accelerated rates of economic growth. (Morrison et al. 2007, 1)

Each of the six GCC countries is committed to building a knowledge economy. Many of the existing universities have partnered substantially with universities beyond the GCC, ranging from Carnegie-Mellon University in Qatar to NYU Abu Dhabi, to others we have not mentioned in our chapter. The cross-continent partnerships have actively engaged institutional partners in Western Universities. As we describe above, though, many of these partnerships have not yet yielded major impacts on enrolling local students. One potential avenue for these cross-continent collaborations to influence women's participation and the growth of local knowledge economies is through their support for local women students and faculty. The advent of CMU Qatar, NYU Abu Dhabi, and such institutions has required consideration of new policies for female students and faculty, and such policy levers could concretely impact policy changes at other local universities and provide notable opportunities for local women engineers.

Further, in order to build a knowledge economy that capitalizes on universities and effectively leverages their connections, GCC institutions need to explore partnerships within the GCC and the MENA to build regional capacity by leveraging expertise and to identify common challenges and join forces to address them. These partnerships can and should involve leading female students and faculty from the region, as growing global economies must take into account shifting gender identities and roles (Gillard et al. 2008). Where institutions and societal gender norms previously created systematic barriers to women's inclusion, shifting demands for knowledge economies and even specifically engineering, computing, and information systems require re-scoping avenues for women in education and STI practice. Policy levers, such as those used in Qatar to expand opportunities for women, must be transformative and targeted; indeed, in Qatar, the changes in policies, education, and the social sphere have encouraged women to tend to persist in their professions even through child-bearing years (Felder and Vuollo 2008).

Researchers and Policymakers Must Recognize and Understand the Diversity of Contexts Within the GCC, Which Demands Tailored Policies and Even Tailored Research Questions

Our ongoing empirical research intends to unearth the "relevant" questions to ask in each national study site regarding women's education and work in engineering. Each GCC context (as well as the other non-GCC countries in our study) have different histories, economies, social and cultural norms, and current profiles of women in STI. The situations vary between countries for a variety of reasons. The GCC's national histories lead to different explanations for women's participation and necessitate relevant research questions; although we do observe some common GCC trends, both study questions and policy solutions must be tailored to the local context. We have found that only through an iterative process of research question generation and refinement, alongside a local interdisciplinary team, can relevant research strategies be created. Even then, we find that these research questions may actually apply to different contexts as well, albeit in different ways.

More Data are Needed as Women's Participation in STI Expands and Diversifies

Data quality, availability, and relevance remain an issue, especially as policymakers try to understand potential effects of novel reforms and decide on best next steps. More detailed information on women's STI participation would add necessary nuance: for example, by specific engineering discipline (mechanical engineering, electrical engineering, etc.), by institution, by subnational division (e.g., local region, city, urbanicity), or other key demographic factors. Efforts by the UNESCO Institute for Statistics and the International Labour Organization provide meaningful aggregate numbers, but even these national statistics have sporadic years of data missing, may not reflect a fully representative sampling frame, or combine engineering with fields such as construction, which may greatly obscure trends of interest.

Conclusion

More information utilized to inform the "right" relevant questions will foster productive long-term-oriented policies supporting women's full participation and contribute to integrated knowledge economies across the GCC. Increased regional and international collaborations between higher education institutions are certainly important to nurturing the growth of women's achievements in STI, and may actually help to drive broader women's access. Women in the GCC are already participating in engineering and computing in a variety of ways, in some areas, at greater rates than in the United States. Women's networks within GCC countries and throughout the region may have policy and programmatic lessons learned that could nurture women's access in other areas of the globe. Historically, changes in the labor force drive changes in societal norms. The considerable and growing presence of women in the GCC's IT and broader engineering labor force may, in turn, serve to change broader and ingrained perceptions and practices of gender roles and identities. Women are already participating in engineering and computing in GCC countries in a variety of ways, and they should be empowered to support each other, to support the next generation of female engineers, and to accelerate the growth of the burgeoning and diversifying STI enterprise in the GCC.

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