International Partnerships for the Development of Science, Technology, Engineering, Mathematics, and Medical Education of Middle Eastern Women

Daniel R. Wang[1], David P. Hajjar[2] & Curtis L. Cole[1]

[1] Weill Cornell Medicine, Cornell University, New York, USA

[2] Weill Cornell Graduate School of Medical Sciences, Cornell University, New York, USA

Correspondence: Daniel R. Wang, Weill Cornell Medicine, Cornell University, 445 East 69th Street, Olin Hall 411 New York, USA. E-mail: drw2006@med.cornell.edu

Received: October 25, 2019 Accepted: November 20, 2019 Online Published: December 27, 2019

doi:10.5430/ijhe.v9n2p1 URL: https://doi.org/10.5430/ijhe.v9n2p1

Abstract

The development of a knowledge economy requires a nation to foster a robust foundation in science, technology, engineering, and mathematics (STEM). The countries of the Arab world, including the oil-rich nations of the Gulf, have made great strides in this regard, though much remains to be done. This article examines the cultural barriers these nations face, such as a lack of educational access and post-graduation employment opportunities for women, as well as systematic obstacles, such as poor quality of STEM education. The article also examines international partnerships with foreign institutions as viable solutions for the Arab world, with the case of Weill Cornell Medicine-Qatar presented as a case study of a sustainable, mutually beneficial endeavor. Recommendations are made for the near future, including the removal of antiquated restrictions on women and the continued development of international collaborations at all educational levels.

Keywords: STEM education, female education, Arab world, medical education, science diplomacy, international partnerships

1. Introduction

1.1 Overview

Some of the most daunting challenges governments face today include poverty, lack of access to clean food and water, and inefficient responses to disease outbreaks(Hajjar DP, Richardson J, & Coleman K, 2015). Addressing these issues is technologically demanding, requiring a robust foundation in science, technology, engineering, and mathematics (STEM) (Hajjar DP et al, 2015). For countries of the Arab Gulf – Kuwait, Oman, Qatar, Bahrain, Saudi Arabia, and the United Arab Emirates (U.A.E.), further obstacles exist in the form of social, political, economic, and security challenges(Greenbaum SG & Hajjar DP, 2017; UNDP, 2014). Declining oil and gas prices in recent years have negatively impacted their economies, with resultant decreases in investments in science and technology(Greenbaum SG & Hajjar DP, 2017).

Yet prior to the economic downturn, most Arab countries already occupied a region of the world where less than 1% of expenditures were in research and development (R&D), well below the global average of 2.13%(Greenbaum SG & Hajjar DP, 2017; UNDP, 2014; Hajjar DP, 2015). The result has been a drastic underperformance in science on the global stage. In 2005, the Arab world collectively produced 13,400 scientific publications; Harvard University alone produced 15,500(Hajjar DP, 2015). In the years since, growth has continued to be slow, even for the oil-rich Gulf nations. For instance, the United States (U.S.) published 14,949 health professions-related articles in 2018, while the Gulf collectively published 503(Country Rankings, 2019). Similarly, in 2018 only 9,044 engineering-related and 4,117 biochemistry, genetics, and molecular biology-related articles originated from the Gulf(Country Rankings, 2019). In comparison, the U.S. published 95,958 engineering and 89,805 biochemistry, genetics, and molecular biology-related documents(Country Rankings, 2019). On average, the Arab region publishes 41 research papers for every one million people, versus the global average of 147(UNDP, 2014).

1.2 Importance of STEM Education

An emphasis on STEM education, however – and in particular, STEM higher education – is one crucial facet that leads to economic growth and the development of human capital(Donn G & Al Manthri Y, 2013; Goh L, 2019; Miller-Idriss C & Hanauer E, 2019). In turn, human capital development has become, in a world dominated by globalization and technological advances, increasingly critical for a nation's economic future(Al Balushi S & Griffiths D, 2013; Nabli MK, 2007). As such, the so-called "knowledge economy" has emerged, in which knowledge-based resources are more critical than all other resources, including natural ones(Al Balushi S & Griffiths D, 2013; Varghese NV, 2013). Knowledge-based production is now accepted as the distinguishing characteristic of globalized economies, but achieving this requires special higher education programs with high science and technology teaching standards to impart scientific skill training(Al-Razouki MM, 2019).

For nations, the options to acquire such educational structures – research universities for theory, and other institutions for vocational workers and production – lie largely between home-grown education or foreign imports(Varghese NV, 2013; Momo MSM et al, 2019). The oil-rich countries of Gulf have attempted to straddle both paths, relying heavily on imported materials, services, and expertise while promoting educational reforms(Qureshi S et al, 2016). For instance, Qatar launched the Qatar National Vision 2030 in 2008, one key goal of which was to diversify the Qatari economy away from depending wholly on oil and gas revenue to deriving sustenance from scientific knowledge and invention(Said Z, 2016; Said Z & Friesen HL, 2013). Free access to education has been promoted since the mid- 20th century, and the educational reform projects across the Arab region has led to large increases in educational attainment from 1980 to 2010(Assaad R, Hendy R, & Salehi-Isfahani D, 2019; Dagher ZR & BouJaoude S, 2011). Notwithstanding such efforts, the World Bank reported in 2008 that these investments in the Middle East – that is, the Gulf and beyond – have not been accompanied by higher economic growth nor gains in productivity(UNDP, 2014; Al Balushi S & Griffiths D, 2013).

The difficulties faced by Arab Gulf nations in achieving international-level STEM education and research have not been ignored by their scientific communities or governments. In 2014, leading figures in science, including ministers of higher education and science, from Arab countries developed strategies and issued policy statements calling for even greater investments in STEM(Dickson M, Fidalgo P, & Cairns D, 2019). This had followed on the heels of a report released in 2013 by an international consortium of scientific and educational experts, similarly calling for increased focus on STEM and R&D(Hajjar DP, 2015).

A few nations in the Gulf region, such as Qatar and the United Arab Emirates (U.A.E.), have emerged as leaders in this regard. Both strongly promote higher education through training university faculty, engineers, physicians, and physician-scientists, as well as through partnerships with international universities(Hajjar DP et al, 2014). Such has led to the birth of "Education Cities," sprawling centers in major cities that, in the instance of Qatar, includes eight campuses from top universities based in the United States (U.S.), Canada, and Europe(Qureshi S et al, 2016; Chouchane L et al, 2011). These metropolises reflect the adoption of strong educational policies in these nations, such as those reforms proposed by the RAND-Qatar Policy Institute(Hajjar DP et al, 2014). They also reflect the strong dedication by the local governments to education; for instance, in 2002 the Emir of Qatar created the Supreme Education Council – now known as the Ministry of Education – to direct and control education for all ages(Hajjar DP et al, 2014).

Nevertheless, these remain isolated examples and are not without their own growing pains. As this article will explore, many obstacles remain in the development of strong STEM education programs within the Arab Gulf nations, with both cultural and systematic roots. Solutions are urgently needed, among which ought to include science diplomacy and international institutional partnerships. In today's interconnected society, only through sustainable collaboration can the Gulf region move from the STEM educational "periphery" to its "core," and successfully lay the foundation for a strong future.

2. Cultural and National Barriers to Stem Education

2.1 National Trends

There is much difficulty in describing trends within the Gulf region, with its significant social, cultural, economic, and political variation. Nevertheless, it would appear that some uniformity exists in attitudes regarding STEM education. Despite a decade or so of national reforms, and strong governmental support from countries such as the U.A.E. and Qatar, the local populations remain slow to embrace STEM careers.

In Qatar, data from 2008 indicate that participation in post-secondary education hovered at only 16%, with low rates specifically among Qatari males(Issan SA, 2013). Much has been published on this topic, with the consensus being

that men, in particular, have little interest in pursuing education beyond the secondary level as a result of the high status of public sector jobs, which do not require higher education(Salehi-Isfahani D, Hassine N, & Assaad R, 2014; Baki R, 2004; Benard C, 2006). Careers such as these – including the police force or military, as examples – offer security, pay, and prestige(Macleod P & Abou-El-Kheir A, 2017). Further, a heavy societal and cultural reliance on non-education-related factors, such as social connections, to secure employment has almost led to expectations of social prestige without a need for striving personally(UNDP, 2014; Dickson M, Fidalgo P, & Cairns D, 2019; Baki R, 2004; Benard C, 2006). These are phenomena replicated across almost all the oil-rich, wealthy countries of the Gulf: in Oman, for instance, all males are virtually guaranteed a form of government job(Ripley A, 2017). Despite the overall increase in educational years since the 1990s – for instance, schooling years in Qatar rose from an average of 5.4 in 1990 to 9.7 in 2007 – the growth has plateaued since(United Nations Development Programme, 2019). In Qatar, the average years of education have remained at 9.8 as recently as 2017(United Nations Development Programme, 2019). While this outstrips the 2010 global average of 7.8years, it remains below the average of 11years in high- income countries, among which Qatar certainly ranks(Barro JR & Lee J-W, 2010). Across the Arab region, the gross enrolment in secondary education was 74.2%, well below that of East Asia and the Pacific (84.5%), Central and Eastern Europe (93%), and Central Asia (98.6%)(UNDP, 2014). The same gap exists in higher education, with a gross rate of 26% in 2012 for the Arab region; in comparison, the global average was 32%, while Central and Eastern Europe boasted a rate of 70.94%, and North American and Western Europe 78.95%(UNDP, 2014).

In addition, it appears that those students who do enter higher education are drawn in large part to study education, the humanities, and the social sciences over medicine, science, engineering, and other technical subjects(Macleod P & Abou-El-Kheir A, 2017). Evidence suggests that Qatar is far from alone in this regard; in Bahrain, the imbalance of enrollment in the humanities versus the sciences may be as great as 35%, with 60% enrolled in the former versus 25% in the latter(Abou-El-Kheir A & Macleod P, 2017).

Such trends appear to be well-understood by the leadership of the Gulf nations. Hajjar *et al.* (2014) conducted interviews with key educators and administrators from the ministries of education in Qatar, Saudi Arabia, Oman, Kuwait, and the U.A.E., with the aim to identify local challenges to the promotion of science, their assessments of current science policies, and their perceptions of the roles of international collaborations(Hajjar DP et al, 2014). By and large, the interviewees reported "significant" challenges, with critical ones being unmotivated and disinterested students, poor curricula, low quality education, and little social prestige in the sciences (Figure 1)(Hajjar DP et al, 2014). They also almost universally agreed on the poor effectiveness of current science policies, with a need for increased rigor and improved articulation of national visions with regard to STEM(Hajjar DP et al, 2014). Optimism, however, exists for the possibilities offered by international partnerships, which can assist in developing curricula, creating research and training networks, as well as offering opportunities to local students and faculty(Hajjar DP et al, 2014).

It would seem, therefore, that the overall climate in the Gulf nations – as a gross generalization – towards STEM is one of inadequately-developed policies combined with national disinterest. Students lack both the fundamental skills, as a result of poor educational quality, to pursue STEM, and are further swayed away by poor exposure to the benefits of a STEM education, with the exception of limited scholarship advertisements and parent-teacher discussions(Hajjar DP et al, 2014; Macleod P & Abou-El-Kheir A, 2017).

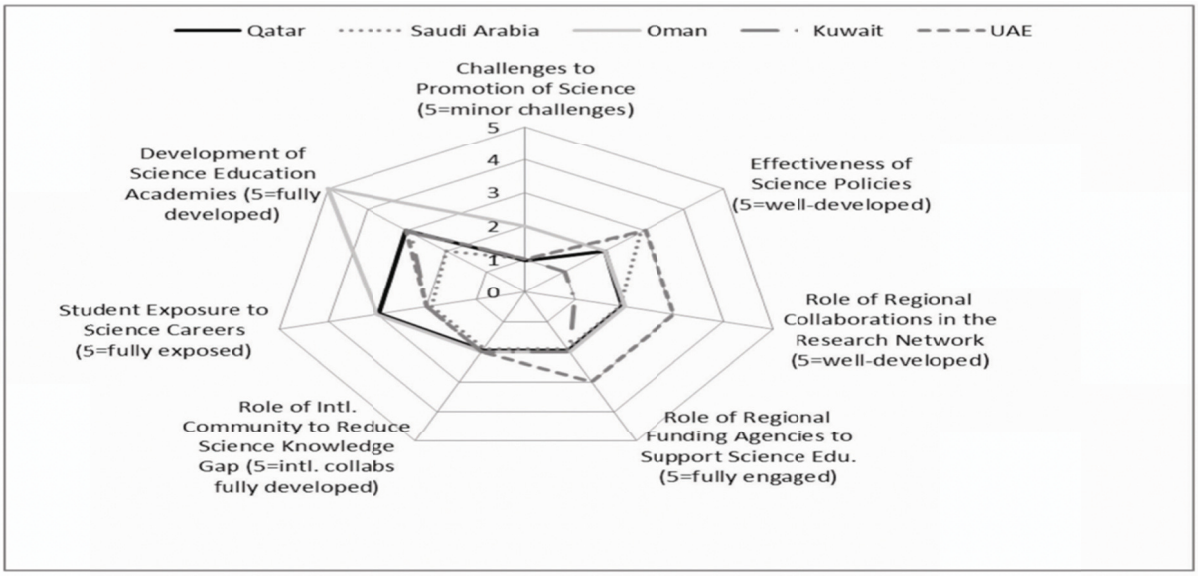

Figure 1. Scoring diagram of Arab Gulf minister/educators' responses to interview questions(Hajjar DP et al, 2014)

2.2 Barriers Against Female STEM Education and Employment

The attainment of education is, without doubt, the most fundamental pre-requisite for empowering women in all spheres of society(Issan SA, 2013; McClendon D et al, 2018). Accessing education that is equal in caliber to that of men in quality and content, and relevant to existing societal needs, remains the sole pathway for women to enter formal-sector jobs with adequate pay(Issan SA, 2013). As such, education has social and economic consequences unparalleled by any other interventions on female self- determination(Assaad R, Hendy R, & Salehi-Isfahani D, 2019).

Within the larger Middle East region, however, gender equality has never been fully established nor accepted(Issan SA, 2013). The reasons are many, and debates continue on the myriad of theories proposed. Some have argued that the difficulties for women in attaining education and social equality in Muslim-majority countries relate more to economic concerns, with women in poorer societies facing greater obstacles(McClendon D et al, 2018). Other theories include the idea of a "holdover" effect, in that current trends of low female education are not reflective of current attitudes but are, rather, a holdover from a previous era. Couched within this hypothesis is also the idea of an "origin effect," or that the educational achievements of children are influenced by those of their parents(Momo MSM et al, 2019). Yet another theory relates to the impacts of the legacies of Christian missionaries during the colonial era, with decreased access to schools in Muslim-majority areas and suspicion among populations that formal schooling was a Western tool for Christian conversion(McClendon D et al, 2018). Finally, scholars have also cautioned that Islam itself, like every other religious tradition, possesses myriad interpretations, many of which are compatible with gender equality and women's rights; as such, religiosity rather than religious affiliation per se may create an educational environment disadvantageous to women(McClendon D et al, 2018; Metcalfe BD, 2008; Al-Asfour A, 2017; Vidyasagar G & Rea DM, 2004). With all of the above in consideration, it is therefore immediately clear that within the Middle East, a region so vastly diverse in economic, political, and social realities depending on the nation or even sub-groups within a nation, all or none of the above theories could be valid depending on the population involved.

It is also important to state in the context of this discussion that not all women in the Gulf region or larger Middle East face insurmountable difficulties in entering higher education(McClendon D et al, 2018). For instance, females in the U.A.E. make up 70% of the higher education population; females similarly outstrip males in the other Gulf states(Donn G & Al Manthri Y, 2013; Issan SA, 2013; Pasha-Zaidi N & Afari E, 2016; Dalacoura K, 2019). Female participation in STEM in Bahrain at the tertiary level is also among the highest in the region(Donn G & Al Manthri Y, 2013; Issan SA, 2013; Dalacoura K, 2019). In recent years, the percentage of women in engineering and the sciences in MENA countries, as an aggregate, is comparable to or higher than in more economically developed countries(Dalacoura K, 2019). In fact, women across the Arab world earn more science degrees on a percentage basis than women in the United States(Ripley A, 2017).

Great concerns, though, still remain on ensuring that girls are provided schooling opportunities across the region, owing to sub-regional variations in female education(Donn G & Al Manthri Y, 2013; Dalacoura K, 2019). Although

women earn half of all science degrees in Saudi Arabia, their aggregate high school graduation rate of 61% still lags behind that of men (71%)(Ripley A, 2017; Al-Asfour A, 2017). Further, women may not access the same education as males, as is evidenced by differing curricula for the genders and the exclusion of women from engineering, journalism, pharmacy, and architecture in Saudi Arabia, as well as the quotas present in Qatar for women entering certain majors(Baki R, 2004; Benard C, 2006). Iraqi and Yemeni women in particular face severe obstacles in attaining education, with the girls from the lowest socioeconomic classes having 76% and 94% chances, respectively, of never entering any form of education throughout their lives(Assaad R, Hendy R, & Salehi-Isfahani D, 2019; Assaad R & Krafft C, 2016). And even more importantly, crucial barriers still remain in allowing women to apply their educational achievements: female labor participation in the Middle East has been far from proportionate to their educational enrollment and completion rates, and is well below the global average(UNDP, 2014; Dalacoura K, 2019).

As examples, women in Qatar are prohibited from undertaking dangerous or arduous work, and the Minister for Labor is still able to determine working hours that are deemed "suitable" for women(Issan SA, 2013). A not-insignificant cultural backlash is also present from the general populace, which by and large does not support the employment of women(Issan SA, 2013). In Saudi Arabia, women struggle to pursue careers outside the homes due to widespread gender stereotypes of their roles as homemakers, mothers, and wives, leading to a female presence of only 20% in the overall workforce(Al-Asfour A, 2017; Gallant M & Pounder JS, 2008). Fewer than one in every five workers is female in Qatar, Saudi Arabia, the U.A.E., and Oman(Ripley A, 2017). In Jordan, only 17% of women aged 20 to 45years work, compared with 77% of men in the same age group(Tweissi A et al, 2014).

Of particular note is that the majority of women in the Middle East, when employed, work almost entirely in the healthcare, education, and clerical professions(Issan SA, 2013; Metcalfe BD, 2008; Al-Asfour A, 2017). These are fields seen as "natural" to their gender, and extensions of their stereotypical domestic roles(Issan SA, 2013; Baki R, 2004; Tlaiss HA, 2013). Such gender segregation is unsustainable for the overall educational and workforce landscape of the Middle East. A clear example is that in Qatar, religious doctrine and social norms require children over age 11 to be instructed by teachers of the same gender, a practice replicated across much of the Arab world with differing age thresholds(Ripley A, 2017; Barnowe-Meyer B, 2013). Yet the classification of education as a "female" occupation has led male Qataris to prefer other fields, and few consider it to be an attractive career(Macleod P & Abou-El-Kheir A, 2017; Barnowe-Meyer B, 2013). In the last decade, Qatari women too have had a declining interest in the field(Barnowe-Meyer B, 2013). The fraught future of education in Qatar is obvious, and as these findings have been found to exist – in almost identical ways – in other Arab countries, including Jordan, the future of education appears to be fraught in the whole Arab world(Ripley A, 2017).

Notwithstanding the above, women face discrimination even within "feminine" occupations. Quotas exist in these fields in Iran to ensure places for males versus the higher- achieving women, and females have been discouraged from general surgery, orthopedic surgery, or pediatrics at the King Fahd Teaching Hospital in Saudi Arabia due to faculty resistance(Issan SA, 2013; Metcalfe BD, 2008). The optimal research and laboratory facilities are assigned to men(Baki R, 2004). In Saudi Arabia, only 1% of researchers in 2011 were women, a paltry number in comparison to the average of 30% globally(UNDP, 2014). Women, too, are expected to remain as nurses, rather than physicians; those who choose to become doctors face significant challenges in achieving promotion to leadership and administrative roles(Issan SA, 2013; Vidyasagar G & Rea DM, 2004; Tlaiss HA, 2013). They also face interruptions in their training owing to laws and social expectations, and suffer from poor supervision and systematic failures in training and development opportunities(Tlaiss HA, 2013). These all pose clear challenges to the nations of the Middle East, although much remains to be done even on the global stage: the Global Gender Gap Report of 2012 notes that the share of female leaders of institutions, across all fields, is below 2% not only in countries such as Saudi Arabia, Qatar, Bahrain, and the U.A.E., but also in nations such as Japan and the Republic of Korea(Tweissi A et al, 2014).

Overall, women in the Middle East appear to face a transition period flanked by polar realities. On one hand, the number of women achieving post-secondary education in Arab countries is increasing dramatically, with particular achievements noted in the Gulf States where years of education are on par with Muslim women in the United States(Benard C, 2006; McClendon D et al, 2018). For instance, the U.A.E. has achieved the rare feat of completely closing the educational attainment gap(Tweissi A et al, 2014). On the other, simply acquiring diplomas but being unable to act on them to achieve stable, formal-sector employment remains a systemic issue. The combination of civil, commercial, labor, and family laws that discourage women from the workforce in favor of the domesticity of marriage has led to female unemployment in Bahrain and Saudi Arabia, for instance, to be two to three times that of males(Nabli MK, 2007; Metcalfe BD, 2008; Gallant M & Pounder JS, 2008; Tlaiss HA, 2013). Though much has improved in the last few decades, much remains to be achieved.

In recent years, the international university campus has emerged as an intriguing option for Middle Eastern women. These institutions, such as in Qatar, have allowed women in particular to pursue high-quality, higher education opportunities without as many cultural and religious restrictions as domestic institutions might present(Macleod P & Abou-El-Kheir A, 2017). As this article will explore in the later sections, these international collaborations may be a critical pathway to creating a sustainable future for the Middle East that makes use of their most important asset: their high-achieving, ambitious women(Benard C, 2006). Studies have proved time and again that Middle Eastern women perform better than their male counterparts in examination results, school completion rates – when provided equal access and opportunity – and willingness to move into new job fields(Benard C, 2006; Ripley A, 2017). This is a trend not isolated to the Middle East: a 2015 reading test across 69 countries showed that teenage girls outperformed their male counterparts at every testing site(Ripley A, 2017). The success of future generations has been shown to be positively influenced by higher occupational status of mothers, and a low female-to-male labor force participation rate is strongly tied to the perseverance of the "origin effect" that can lead to poor education attainment(Momo MSM et al, 2019). Moreover, if the Middle East is to maintain a strong economic footing in the near future, decreasing the gender gap in education should be a top priority. Education is seen as possibly the most important factor contributing to women's departure from the agriculture and domestic sectors towards the corporate and governmental sectors(UNDP, 2014). Greater gender equality in education is also hypothesized to be able to close half of the gap in economic growth between MENA and East Asian countries(Assaad R, Hendy R, & Salehi-Isfahani D, 2019). The Middle East can surely rise to the top of the global stage, if they would offer equal opportunities to a critical half of their population.

3. Educational Barriers

3.1 Poor Scholarship and Teaching

Much has been discussed to date regarding the population and cultural barriers plaguing STEM higher education in the Gulf region and larger Middle East, but attention too must be paid to the quality of the education itself. Unfortunately, serious doubts are present about the quality of education in public institutions, at all levels(Assaad R & Krafft C, 2016). Private independent schools too, as will be argued, face severe obstacles in assuring quality teaching. Thus, it is clear that as much as social factors may play a role in preventing STEM success in the Middle East, systemic ones such as unqualified faculty and archaic teaching methods are equally at fault.

Hajjar et al. (2014), in their interviews of educators and administrators of Gulf nations, noted that the latter recognized the need for better STEM faculty, and that poor science education is partly to blame for a paucity of STEM students(Hajjar DP et al, 2014). In Qatar, 98% of independent school teachers held at least a bachelor's degree between 2011-2012, but only 67% possessed formal education qualifications(Macleod P & Abou-El-Kheir A, 2017). Similar numbers of 85% and 66%, respectively, were found in private Arabic schools(Macleod P & Abou-El-Kheir A, 2017). International schools, on the other hand, appeared to fare better with 82% of their faculty holding formal educational qualifications(Macleod P & Abou-El-Kheir A, 2017). Part of the blame may be accorded to the late implementation of Qatar's teacher licensure system, as well as strong faculty resistance to the licensure process as a "foreign" requirement wholly unrelated to their teaching practices(Macleod P & Abou-El-Kheir A, 2017). Further, schools have had difficulties recruiting sufficient numbers of qualified teachers to meet the demands of Qatar's growing school-age population, no doubt worsened by the requirement, as mentioned previously, of gender-separate education for children over a certain age(Macleod P & Abou-El-Kheir A, 2017).

The overall teaching trend of the Middle East, as well, pose significant worries in regards to its ability to prepare its population to meet the demands of a globalized world, in which proficiency in critical thinking and analytical processes is critical to success. The Middle East has long esteemed memorization and the importance of hierarchy in its educational approach, one that has been singled out by social anthropologist Nancy Dupree as one of the most significant causes of social stagnation, and criticized even earlier by Arab reformers and intellectuals(Qureshi S et al, 2016; Benard C, 2006; Abou-El-Kheir A & Macleod P, 2017). The United Nations Educational, Scientific, and Cultural Organization (UNESCO) report on Improving Science Education in the Arab States, too, argued that an over-emphasis on teacher-centered didactic approaches in most Arab countries has led to a negligence of the development of critical thinking, problem solving, inquiry, and investigative skills(UNDP, 2014; Qureshi S et al, 2016; Dagher ZR & BouJaoude S, 2011). In response, Middle Eastern countries such as Qatar implemented educational reforms that aimed to change the classroom learning environment to one that prioritizes alternative instructional tools and techniques, thus encouraging creative and critical thought processes(Qureshi S et al, 2016; Barnowe-Meyer B, 2013).

Change, nevertheless, is slow to arrive. Since Middle Eastern teachers have been trained in rote-learning methods and whole-class pedagogical approaches, to transition towards a student- centered and "individualized" approach has been difficult(Donn G & Al Manthri Y, 2013; Al Balushi S & Griffiths D, 2013). The adoption of these new educational

policies has also varied from school to school, with some embracing the call for flexibility, experimentation, and sensitivity to students' needs, and others remaining rooted in traditional methods(Barnowe-Meyer B, 2013). The newly created student-centered strategies, as well, may themselves be poorly constructed and not enriched enough for deep conceptual understanding(Qureshi S et al, 2016). As such, despite these top-down interventions, students in the Middle East – including in Qatar, Oman, and the U.A.E., where strong educational reforms have dominated – continue to fare poorly on the global stage. Qatar ranks near the bottom of education tables for the developing world despite its costly investments in local educational systems, with students continuing to lack the fundamental reading, literacy, and numeracy skills required for the mastery of advanced scientific knowledge and concepts(Qureshi S et al, 2016). Similarly, Omani students' performances in mathematics and science fall far short of their Western and Asian counterparts(Al Balushi S & Griffiths D, 2013; Salehi-Isfahani D, Hassine N, & Assaad R, 2014). And in the U.A.E., despite the Minister of Education christening education as the vehicle by which to catapult the country into a knowledge-based economy, students have yet to reach the international average in tests of student achievement(Gallagher K, 2019). For instance, while the U.A.E. and the other Gulf states outstripped the majority of Arab nations in the 2011 Trends in International Mathematics and Science Study (TIMSS), each scoring above 400, they still fall behind the international average of 500(UNDP, 2014).

In recognition of the difficulties faced in creating effective home-grown educational reforms, some Gulf region governments have turned to international collaboration as a sustainable alternative. One such partnership was undertaken between the Omani Ministry of Education and the University of Cambridge in 2010(Al Balushi S & Griffiths D, 2013; Education Reform, 2019). In a multi-pronged approach, the goals were to simultaneously provide local teachers with the skills, knowledge, and understanding of effective classroom practice, with particular focus on student-centered and formative assessment techniques, as well as to develop an effective, self-sustaining hierarchy(Education Reform, 2019). Two senior teachers would be placed in every school in the country, to then be tasked with training and supporting others in their respective institutions(Al Balushi S & Griffiths D, 2013).

3.2 Poor Working Environment for Educators

To achieve appropriate successes in student-centered teaching, it is an obvious corollary that professional development programs are required to guide Middle Eastern educators on the transition away from a didactic classroom. However, it would appear that these activities themselves may be haphazard and illogical when implemented, and far removed from the realities of the classroom(Barnowe-Meyer B, 2013). Further, despite education's reputation in the Middle East as "feminine" and thus dominated by women, female educators are still seen as incapable of holding management roles(Al-Asfour A, 2017). They are excluded from decision-making positions and deanships, and gender-segregated work environments combined with patriarchal organization cultures continuously reinforce gender stereotypes and limit female professional development(Al-Asfour A, 2017). Women have even more limited training and development opportunities – sparse as they already are – than men, suffer from poor mentorship, and are entirely excluded from informal networking processes(Al-Asfour A, 2017; Tlaiss HA, 2013). Though – as previously noted – these phenomena are not unique to the Middle East and are found the world over, they must nevertheless be stressed within the context of this discussion on the optimization of education in the Arab region.

Educators of both genders also suffer from the overall poor educational landscape in Middle Eastern nations. Though independent schools have been more adept at embracing educational reforms, the vast majority of teachers in focus groups and studies led by organizations such as the RAND Corporation have found that teachers by and large prefer ministry jobs(Barnowe-Meyer B, 2013). Independent schools, despite offering higher salaries, usually demand higher workloads and the self-development of curricula, and have less stringent guarantees in regards to job security(Barnowe-Meyer B, 2013). In fact, job turnover for independent schools was 38% in Qatar between 2012 and 2013, and 64% for private Arabic schools(Qureshi S et al, 2016). Teaching too, as mentioned in a previous section, is seen by many as a career of low social prestige, and has contributed to severe recruitment difficulties across the Middle East(Macleod P & Abou-El-Kheir A, 2017). In Jordan, male teachers in particular appear to suffer: their low salaries, coupling with a societal expectation of being breadwinners, produce individuals more focused on financial stability than quality teaching(Ripley A, 2017). Working second or third jobs is not uncommon, job satisfaction remains low, and few men aspire to the career(Ripley A, 2017). Unsurprisingly, the quality of teaching suffers as a result.

Change, however, may be arriving. Much as international collaborations have been seen as potential solutions to the issue of educational reforms, they have been similarly viewed in regards to bettering professional development and working environments. In 2014, the University of Calgary Qatar hosted its second post-secondary teaching and learning conference, and the Qatar Foundation for Education, Science, and Community Development hosted the inaugural teaching and learning forum(Qureshi S et al, 2016). The Foundation is an independent, private, non-profit,

chartered organization created in 1995 by an Emiri decree, and the main entity through which Qatar seeks to develop a knowledge-based society(Chouchane L et al, 2011; Macleod P & Abou-El-Kheir A, 2017). As per its goal, the Foundation was the founder of the prominent World Innovation Summit for Education in 2009(Qureshi S et al, 2016; WISE, 2019). Hosted every two years in Doha, Qatar, it is an international conference designed to generate dialogue and productive partnerships among education stakeholders from 200 countries(Qureshi S et al, 2016; WISE, 2019).

Further, in 2014 Weill Cornell Medicine-Qatar (WCM-Q) established a specialized division of Continuing Professional Development to participate in the enhancement of knowledge and skills of the healthcare practitioners in the state of Qatar and the region(Arayssi T, 2019). This division delivers close to 60 courses, conferences, and workshops each year that are accredited by local and international organizations(Arayssi T, 2019). In 2018 alone, 2500 participants attended the activities that covered topics in medical education, clinical care and research skills; Figure 2 provides the breakdown of attendees by profession(Arayssi T, 2019).

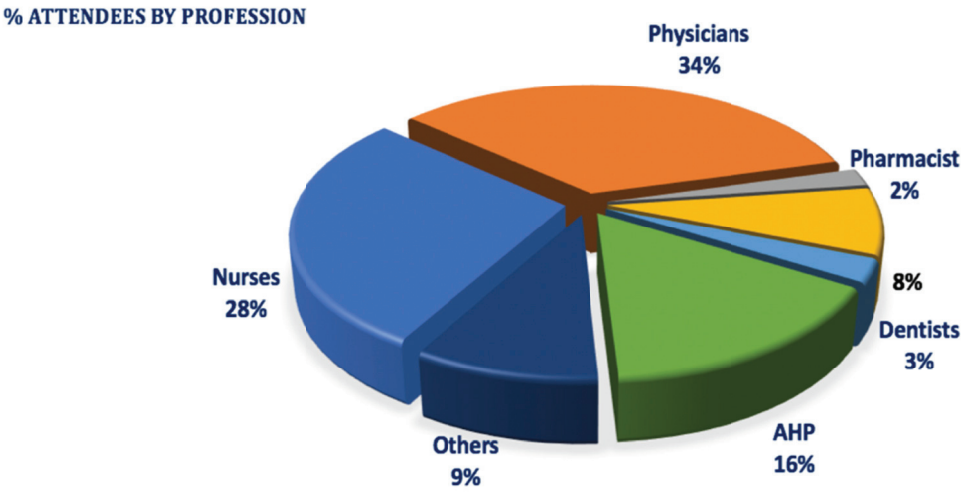

Figure 2. Participants by profession who attended workshops, conferences, and courses sponsored by Weill Cornell Medicine-Qatar's division of Continuing Professional Development(Arayssi T, 2019)

4. Visions for the Future

In light of the above discussion, the question remains on the optimal way forward to ensure a sustainable future for the Middle East on the global STEM stage. Many theories have been proposed and many will no doubt follow, but we will argue for stronger international collaboration, above all others, as a critical factor. Within this approach will lie science diplomacy, female-targeted initiatives, and the creation of long-term opportunities as a result of such global partnerships. Finally, the case study of a medical college in Qatar, the Weill Cornell Medicine-Qatar (WCM-Q), will be presented as an example of how such partnerships can be successfully implemented and thrive, and serve as a model for future endeavors.

4.1 Science Diplomacy

At its core, science diplomacy is defined as "cooperation among countries to solve complex problems through scientific research and education(Hajjar DP & Greenbaum SG, 2018). Classically described as a form of "soft power," science diplomacy encourages partnerships that transcend politics, borders, and cultures, a key trait in light of the fraught relationships – especially between Western and Middle Eastern nations – that currently exist(Hajjar DP, Richardson J, & Coleman K, 2015; Greenbaum SG & Hajjar DP, 2017; Hajjar DP, 2015). And certainly, science diplomacy aims to improve overall human health around the globe, to the benefit of all involved. When considering recent pandemics such as severe acute respiratory syndrome (SARS), Middle Eastern respiratory syndrome (MERS), and Ebola, the utility of science diplomacy in improving global scientific and medical competencies need little explanation(Greenbaum SG & Hajjar DP, 2017). And in the particular case of the Ebola epidemic, which still rages on in parts of Africa, diplomacy plays a crucial role both in sweeping partnerships among governments, as well as in the countless daily interactions among patients, communities, and front-line health workers(Nguyen V-K, 2019). Without diplomacy, all health interventions, no matter how well-intentioned, grind to a stop(Nguyen V-K, 2019).

The U.S. has been a leader in science diplomacy, and is no foreigner to the goal of advancing STEM capabilities in the Middle East(Hajjar DP, Richardson J, & Coleman K, 2015). After all, American diplomats, STEM experts, and national leaders have long understood the intertwined natures of American global leadership in STEM research and American international relations. As an isolated example among countless others, President Obama announced several international STEM diplomacy programs in the MENA and South East Asia regions during his presidency, including funds for technological development in those nations(Hajjar DP, Richardson J, & Coleman K, 2015). Individual American educational institutions too have been promoting interdisciplinary collaborations for decades, in part as precautionary measures against future epidemics, but also to ensure mutual benefits in research and development(Hajjar DP, Richardson J, & Coleman K, 2015). It is no falsehood that the U.S. itself is heavily reliant on the graduates of other nations for its own scientific growth(Hajjar DP & Greenbaum SG, 2018).

Certainly, no discussion on science diplomacy and international collaboration can be held without considerations of security. Industrial espionage, national-level thefts of intellectual property, and other attempts to illegally and unethically obtain scientific advances are regrettable and adverse developments in today's society(Hajjar DP & Greenbaum SG, 2018). The advancement of science must thus be followed by greater diplomatic cooperation to balance the risks of industrial and governmental espionage, with those fundamental benefits acquired from foreign cooperation(Hajjar DP & Greenbaum SG, 2018). Calls have been made for an international panel of scientists and engineers, hailing from the National Academies of nations involved, to manage the protection of proprietary information, as well as the need for individuals to publish their research findings(Hajjar DP & Greenbaum SG, 2018). One too might expect that as countries increasingly enter the top tier of innovation space, that their own needs to protect their intellectual property can lead to an increase in global oversight of all intellectual rights(Hajjar DP & Greenbaum SG, 2018).

For the Middle East, science diplomacy has been recognized and welcomed by all involved. The United Nations and UNESCO have noted that the paradigm for success in the coming years in the region is the improvement of quality of life, with specific foci on education opportunities and healthcare; these are often achievable only through robust STEM interventions(Hajjar DP, Richardson J, & Coleman K, 2015; Hajjar DP, 2015). In turn, Middle Eastern nations themselves have welcomed science diplomacy. Between 2013 and 2016, Qatar, Oman, Jordan, and Saudi Arabia have all hosted regional conferences on the possibility of science diplomacy to bring about positive awareness on research tools and training opportunities for – critically – both men and women(Greenbaum SG & Hajjar DP, 2017). The U.S. must thus prioritize such partnerships, in light of the ongoing conflicts that have left such lasting scars on both sides; soft power through science may ultimately achieve more than any military display ever could(Hajjar DP, 2015). The use of collaboration, engagement and negotiation over the short-sighted methods of containment, sanctions, and gun-boat diplomacy will strengthen the not-dissimilar interests of the scientific and foreign-policy camps, in all nations, and lead to a healthier and safer global community(Hajjar DP, 2015).

4.2 Empowering Women

As extensively discussed in previous sections, economic growth is contingent upon the inclusion of highly-educated women in a nation's workforce. Within STEM, it therefore goes without saying that increasing opportunities for women, both in terms of access to education as well as employment opportunities post-graduation, will result in gigantic advances economically, socially, and politically.

The U.S. has long recognized the need for diversity in STEM and has thus developed countless programs to promote the inclusion of women and other under-represented minorities. Much work remains to be done on American soil before full equality is achieved across all populations. Nevertheless, certain U.S. initiatives warrant mention in regard to their contributions on the global stage to empowering women in STEM. For instance, the U.S. State Department Global Innovation Initiative fosters an international exchange of both students and faculty, with a particular emphasis on women with the scientific skill sets capable of assisting under-developed countries in STEM fields(Greenbaum SG & Hajjar DP, 2017). The State Department's Bureau of Educational and Cultural Affairs also hosts STEM-based educational and cultural exchanges for women(Hajjar DP, Richardson J, & Coleman K, 2015; Hajjar DP, 2015). Similarly, the Department of Defense, National Institutes of Health, and the National Science Foundation all have programs directed towards the creation of diverse workforces on local and global stages(Greenbaum SG & Hajjar DP, 2017).

Yet for all of these initiatives, the steep cultural, social, economic, and political barriers that are present in the Middle East work against the advancement of female STEM education and employment. Much work must be done in these areas and require the willing cooperation of nation leaders in the region. To this end, science diplomacy will be a crucial method through which to promote female inclusion, since scientific bodies are uniquely poised to address social

equity problems by inextricably intertwining social advancements to the exchange of scientific information(Greenbaum SG & Hajjar DP, 2017; Hajjar DP, 2015).

4.3 Long-Term Opportunities for a Knowledge-Based Society

No increase in STEM student or workforce populations – underrepresented or otherwise – will succeed if Middle Eastern nations do not possess sustainable, long-term STEM opportunities for their populations. The concept of "brain drain" is an unfortunate reality, with scientists, engineers, and physicians unable or unwilling to return to their home countries due to a lack of career opportunities(Greenbaum SG & Hajjar DP, 2017). The Arab region is one of the most affected areas in the world, with around 9% of graduates of higher education institutions migrating; this is more than double the global rate(UNDP, 2014). Certainly, many reasons exist for emigration, but one primary driver is that unemployment remains prevalent even for the educated cohort. 43% of graduates of higher education are unemployed in Saudi Arabia, 32% in Bahrain, and 22% in the U.A.E.; in comparison, only 3.5% of graduates are unemployed in the European Union(UNDP, 2014). And given that estimates suggest 20-30% of the Arab youth are unemployed – significantly above the global rate of 12.6% - it is unsurprising that 10% to 15% of them subsequently also migrate(UNDP, 2014; Dagher ZR & BouJaoude S, 2011; Beschel Jr. R & Yousef TM, 2016).

On one hand, a cultural change must be enforced within the youth population of Middle Eastern nations. The next generation must be shown the value of science, and encouraged to actively participate in the arts, ethics, and STEM fields(Hajjar DP et al, 2014). Yet in a circular problem, the creation of such a cultural and social shift requires sufficient resources to promote science and technology in the region; not all Middle Eastern countries are capable of such investments(Hajjar DP et al, 2014). Alternatively, there is the need for changes at the governmental level, in which national priorities must align to ensure sufficient incentives exist to complete higher education(Hajjar DP et al, 2014). Governments must further identify and nurture a core group of nationals who wish to remain in their nations once trained, and who can subsequently take the lead in developing scientific policies for the upcoming generations(Hajjar DP et al, 2014). Expert organizations of educators and other professionals must also be created and supported by national leaders, so that any resources – monetary or temporal – can be pooled(Al Balushi S & Griffiths D, 2013).

Criticisms, however, have emerged in the global push to divert resources to STEM education. In large part, they stem from fears that such increases in scientific emphasis will lead to necessary, reciprocal decreases in the liberal arts(Donn G & Al Manthri Y, 2013; Al Balushi S & Griffiths D, 2013; Abou-El-Kheir A & Macleod P, 2017). These are valid fears, and every nation ought to take them into consideration. The sciences and the humanities must not be mutually exclusive; to give to the former cannot involve the taking away from the latter. Without the humanities, those in the technological spheres would fail to develop the necessary skills to effectively communicate with their local or global colleagues. And, critically, the skills and knowledge imparted by the liberal arts are precisely those required to thrive in a peaceful, modern society(Benard C, 2006; Abou-El-Kheir A & Macleod P, 2017).

4.4 Case Study – WCM-Q

As much of this paper has indicated, the challenges faced by the Middle East in ensuring quality, STEM-based higher education and employment are manifold, and stem from a myriad of causes with social, economic, and cultural roots. To state these issues have simple solutions would be an explicit falsehood, but it is the belief of the authors that certain approaches, such as science diplomacy and the unequivocal promotion of female education and employment, have perhaps greater merit than others. Specifically, encapsulated within these approaches is that of international collaborations. Though some have argued that the creation of a sustainable STEM future in the Middle East necessitates the nations to create reforms that fit local needs and conditions, and that all imported or externally-designed solutions should thus be avoided, the goal of the following case presentation is to prove the opposite(Al Balushi S & Griffiths D, 2013; Knight J, 2013). It remains true that an international partnership, like any other approach, has its deficiencies and valid criticisms. Yet in today's increasingly interconnected world, it represents, when well-conceived of and successfully implemented, an opportunity to establish sustainable foundations in line with the demands of a host population, and the possibility for mutual benefit and growth. In the Gulf states, international partnerships with foreign institutions have been credited with fueling the increase in diversity in higher education, as well as new programs such as distance learning and open education, all of which served to expand the reach of education throughout those societies(UNDP, 2014).

On January 25, 2001, Cornell University and the Qatar Foundation for Education, Science, and Community Development signed an agreement to establish a branch medical campus in Qatar: Weill Cornell Medical College-Qatar(Hajjar DP & Gotto Jr. AM, 2013). Now known as Weill Cornell Medicine-Qatar, it came from the Foundation's vision for establishing a premier academic medical center through a foreign partner, as well as the goal of Cornell University and its medical college in New York City – Weill Cornell Medicine (WCM) – to seek an

international partner(Hajjar DP & Gotto Jr. AM, 2013). Cornell University itself has had a long history of participating in global partnerships in Europe, Asia, and Central and South America, as it sees these international ties as essential to fulfilling its academic mission and strengthening its position in the global marketplace for education(Hajjar DP & Gotto Jr. AM, 2013).

WCM-Q, in its organizational structure, exists as an international campus of the main institution of WCM(Miller-Idriss C & Hanauer E, 2011; Chouchane L et al, 2011). The Dean of the Faculty at WCM-Q reports to the Dean of WCM, who simultaneously serves as Cornell University's Provost for Medical Affairs; it is through the latter that the former reports to the President of Cornell University, the WCM Board of Overseers, and the Cornell University Board of Trustees(Hajjar DP & Gotto Jr. AM, 2013). All admissions to WCM-Q are reviewed by admissions officers at WCM, with the requirements being the same for both campuses, and an American M.D. is awarded to all graduates(Hajjar DP & Gotto Jr. AM, 2013). As a co-educational institution, WCM-Q has maintained approximate equality in male and female enrollment numbers(Hajjar DP & Gotto Jr. AM, 2013).

The curriculum for WCM-Q was adopted in its entirety from that of WCM, so as to avoid a two-tier system and ensure uniformity in education quality(Hajjar DP & Gotto Jr. AM, 2013). Such an approach also allowed for ease of curriculum content control, as well as the determination of educational content ownership(Hajjar DP & Gotto Jr. AM, 2013). All faculty are reviewed, compensated, and supervised according to Cornell University and WCM policies(Hajjar DP & Gotto Jr. AM, 2013). Similar to WCM students, WCM-Q students are exposed to patient care from the earliest stages of their medical education, through instruction at the hospitals of Hamad Medical Corporation – a Qatari state health provider that became affiliated with WCM-Q in 2004 – Sidra Medicine, and the network of the Primary Health Care Corporation(Hajjar DP & Gotto Jr. AM, 2013).

Despite the almost exact mirroring of WCM-Q and WCM, fundamental differences exist between the two institutions that reflect the difference in both culture and education. For instance, WCM-Q faculty and staff are careful to observe the customs of Qatari society, especially those relating to gender, though all classes remain co-educational(Hajjar DP & Gotto Jr. AM, 2013). With regards to curriculum, WCM-Q offers a fully integrated six-year program, of which two years are a pre- medical, non-degree component that is not available at WCM(Qureshi S et al, 2016; Hajjar DP & Gotto Jr. AM, 2013). The pre-medical program consists of courses in the basic sciences and mathematics, writing seminars, introductions to medical ethics and laboratory research, as well as Cornell University's Psychology 10 via e-Learning(Hajjar DP & Gotto Jr. AM, 2013).

Other curricula changes also reflect the realities of education in Qatar. As was evidenced by the discussion on educational difficulties encountered by Qatari students in previous sections, one critical hurdle had been to ensure that local students entering the pre-medical program at WCM-Q would subsequently meet admissions standards for the medical program(Hajjar DP & Gotto Jr. AM, 2013). Concern grew that Qatari secondary schools did not adequately prepare students for higher education as rigorous as that within international universities in Education City(Qureshi S et al, 2016). As such, WCM-Q established a "Foundation Program," combining one year of mathematics, science, and English as a Second Language (ESL) instruction with study skills to improve critical reasoning and analysis(Qureshi S et al, 2016; Chouchane L et al, 2011; Hajjar DP & Gotto Jr. AM, 2013). Beyond providing the necessary technical knowledge, the Foundation Program served to ease the "culture shock" of Middle Eastern students when encountering American teaching methods(Qureshi S et al, 2016). Within the Foundation Program were initiatives such as Progress-Oriented Guided Inquiry Learning (POGIL), composed of small-group interactions with learners – within highly-structured environments facilitated by faculty – to identify concepts and refine their meanings by critically-exploring information(Qureshi S et al, 2016). Thus, POGIL allows students to master problem solving, communication, and critical thinking skills. Annual feedback has proven its necessity, as students continuously offer resistance at the beginning of each academic year, as they struggle to transition from years of didactic learning into a learner-centered paradigm(Qureshi S et al, 2016). In light of previous discussions on Middle Eastern pedagogical techniques, such a phenomenon is unsurprising; POGIL is thus another example of WCM-Q adapting to the needs and requirements of local populations. Yet more examples include WCM-Q targeting high-school students interested in pursuing medical careers with English courses, as well as a "teach-the-teacher" program to develop the Qatari educational landscape(Hajjar DP & Gotto Jr. AM, 2013). In the latter, WCM-Q faculty update Qatar high school teachers on new developments in science, to ensure relevant and well-informed education of Qatari students(Hajjar DP & Gotto Jr. AM, 2013). Finally, WCM-Q created the "Medicine Unlimited" program, a series of seminars for high school students and their parents to increase their enthusiasm for the medical sciences; it is one initiative among many to change the population's ambivalence towards STEM(Hajjar DP & Gotto Jr. AM, 2013).

One of the main criticisms levelled at WCM-Q has been that the import of an American school produces individuals trained for global knowledge-driven economies, rather than domestic ones(Knight J, 2013; Kane T, 2013). Yet the driving force behind WCM-Q has been, first and foremost, to train Qatari doctors, and to help nationalize the health-care sector by reducing its subsequent dependency on foreign expertise and to assert domestic control of the system(Hajjar DP & Gotto Jr. AM, 2013; Kane T, 2013). The number of Qatari nationals graduating from WCM-Q has been steadily increasing since the college's founding, making up close to 20% of the graduating class in 2019. Further, and perhaps more importantly, graduates are returning as physicians to serve the country.

Through both the initiatives of WCM-Q itself at the local level – such as its targeted improvements of the local educational environment – and those of the Qatar Foundation, which has actively pursued efforts to enlist and train more Qatari students, it is clear that domestic needs are premier priorities(Hajjar DP & Gotto Jr. AM, 2013). It just so happens that in the development of a knowledge-based society in Qatar, the growths of infrastructure and human capital occur through the medium of a Western-style medical school. Though concerning at superficial glance, the details reflect a transnational, educational partnership between Qatar and Cornell University that is mutually beneficial and a true collaboration; it is the very essence of a symbiotic co-venture(Kane T, 2013).

5. Conclusions

The Middle East is a region unique in today's global landscape, as a result of the social, political, economic, and security challenges it faces that are unparalleled elsewhere. To achieve its goal of becoming a knowledge-based economy thus represents a gargantuan task, and requires a renewed focus across the various nations on STEM higher education and employment. Though governmental leaders have recognized this need and instituted a myriad of interventions, the region continues to fall below the international average in regards to educational access, gender equality, student performance, and technological output and capabilities.

The reasons for the Middle East's paucity of STEM achievements are many, of which the major ones have been highlighted in this article. These include an overall social ambivalence towards both higher education and STEM-specific education, as well as severe gender inequality in both educational access and employment opportunities. Women tend to be relegated to fields such as education and healthcare, which are extensions of their stereotyped domestic roles, but face steep odds in promotion and advancement even within these careers. The quality of Middle Eastern educators as a whole is low as well, owing either to poor or absent qualifications, or archaic, didactic teaching methods that fail to prepare students for a society increasingly reliant upon critical thinking and analytical skills. Poor working environments and a paucity of well-created professional development opportunities have contributed to slow improvements in educational quality, as well as an international "brain drain."

To combat such systemic issues, we propose the avenues of science diplomacy and the empowerment of talented women, as macro-approaches. Examples include the welcoming of women into leadership positions in the health sciences, the removal of quotas on the number of women in certain disciplines, and most importantly, the removal of antiquated restrictions on the ability of women to participate fully in the workforce. In addition, international collaborations specifically have great potential in creating bright futures for STEM in the Middle East. Not only do women find these institutions less restrictive, but these collaborations can help elevate the overall quality of the Middle East's educational landscape; prioritizing these collaborations, from the earliest kindergarten years to the pinnacle of specialized graduate education, is critical. Finally, the case study of Weill Cornell Medicine-Qatar further shows the range of possibilities when local governmental support for the sciences is combined with an international sensitivity to host country sociocultural norms, and guidelines are in place to ensure adequate oversight. As such, though such specific partnerships require much time and effort to develop, we encourage replicas of these in the near future, due to the overwhelming number of benefits reaped by all involved.

WCM-Q, though, only represents one example of the countless approaches available. Collaboration in STEM describes the opportunities to enhance educational quality and productivity through the sharing of information, academic exchange, pursuit of joint work, and synergies between institutions(Frenk J et al, 2010). As the global community proceeds towards a shared vision of STEM success and a knowledge-based economy, it remains imperative to be cognizant of the dangers of cultural imperialism in these endeavors(Goh L, 2019). The culture and autonomy of a nation and its people must be preserved, with local traditions respected; only then can a sustainable future be created, and the needs of the populations in the Middle East be met with solutions that are acceptable, valid, and ultimately effective.

References

Abou-El-Kheir A & Macleod P. (2017). English Education Policy in Bahrain – A Review of K-12 and Higher Education Language Policy in Bahrain. In: Kirkpatrick R, ed. *English Language Education Policy in the Middle East and North Africa,* 9-32. https://doi.org/10.1007/978-3-319-46778-8_2

Al Balushi S & Griffiths D. (2013). The School Education System in the Sultanate of Oman. In: Donn G, Manthri YA, eds. *Education in the Broader Middle East: Borrowing a Baroque Arsenal* (pp.107-126). United Kingdom: Symposium Books.

Al-Asfour A. (2017). Saudi women's work challenges and barriers to career advancement. *Career Development International, 22*(2), 184-199. https://doi.org/10.1108/CDI-11-2016-0200

Al-Razouki MM. (2019). An Arab Science Spring. In: Arezki R, Belhaj F, Shah P, eds. *Promoting a New Economy for the Middle East and North Africa (*pp.63-68). Washington, D.C.: International Bank for Reconstruction and Development / The World Bank.

Arayssi T. (2019). *Annual report 2018-2019: Continuing Professional Development (CPD) Dvision.* Weill Cornell Medicine-Qatar (WCM-Q).

Assaad R, Hendy R, & Salehi-Isfahani D. (2019). Inequality of opportunity in educational attainment in the Middle East and North Africa: Evidence from household surveys. *International Journal of Educational Development, 66*, 24-43. https://doi.org/10.1016/j.ijedudev.2019.02.001

Assaad R & Krafft C. (2016). Inequality of Opportunity in Human Development. In: Diwan I, Galal A, eds. *The Middle East Economies in Times of Transition* (pp. 131-158). United Kingdom: International Economic Association. https://doi.org/10.1007/978-1-137-52977-0_5

Baki R. (2004). Gender-segregated education in Saudi Arabia: Its impact on social norms and the Saudi labor market. *Education Policy Analysis Archives,* 12. https://doi.org/10.14507/epaa.v12n28.2004

Barnowe-Meyer B. (2013). Qatar's Independent Schools: Education for a New (Or Bygone?) Era. In: Donn G, Manthri YA, eds. *Education in the Broader Middle East: Borrowing a Baroque Arsenal (pp.* 63-84). United Kingdom: Symposium Books.

Barro JR & Lee J-W (2010). *A new data set of educational attainment in the world, 1950-2010.* Working Paper 15902. National Bureau of Economic Research. https://doi.org/10.3386/w15902

Benard C. (2006) Fixing what's wrong-and building on what's right- with Middle East education. *SAIS Review, 26*(2), 29. https://doi.org/10.1353/sais.2006.0026

Beschel Jr. R & Yousef TM. (2016). Public Sector Reform. In: Diwan I, Galal A, eds. *The Middle East Economies in Times of Transition* (pp. 259-275). United Kingdom: International Economic Association. https://doi.org/10.1007/978-1-137-52977-0_11

Chouchane L, Mamtani R, Al-Thani MH, Al-Thani A-AM, Ameduri M, & Sheikh JI. Medical education and research environment in Qatar: a new epoch for translational research in the Middle East. *Journal of Translational Medicine, 9*(1), 16. https://doi.org/10.1186/1479-5876-9-16

Country Rankings. SCImago, 2019. https://www.scimagojr.com/countryrank.php.

Dagher ZR & BouJaoude S. (2011). Science education in Arab states: Bright future or status quo? *Studies in Science Education, 47*(1), 73-101. https://doi.org/10.1080/03057267.2011.549622

Dalacoura K. (2019). *Women and gender in the Middle East and North Africa: mapping the field and addressing policy dilemmas at the post-2011 juncture.* MENARA; March 2019.

Dickson M, Fidalgo P, Cairns D. (2019). The 'S' and 'T' in STEM: Integrating Science and Technology inEducationintheUAE. In: Gallagher K, ed. *Education in the United Arab Emirates: Innovation and Transformation* (pp. 95-112). Singapore: Springer Nature. https://doi.org/10.1007/978-981-13-7736-5_6

Donn G & Al Manthri Y. (2013). Education Policy Transfers - Borrowing and Lending Education Policy: A Conceptual Expedition into Baroque Arsenals. In: Donn G, Manthri YA, eds. *Education in the Broader Middle East: Borrowing a Baroque Arsenal* (pp. 9-22). United Kingdom: Symposium Books. https://doi.org/10.15730/books.81

Education Reform. (2019). Partnering with Oman's Ministry of Education. https://www.cambridge.org/gb/educationreform/case-studies/partnering-omans-ministry-education/. Accessed July 30 2019.

Frenk J, Chen L, Bhutta ZA, Cohen J, Crisp N, Evans T,...Zurayk H. (2010). Health professionals for a new century: transforming education to strengthen health systems in an interdependent world. *The Lancet, 376*(9756), 1923-1958. https://doi.org/10.1016/S0140-6736(10)61854-5

Gallant M & Pounder JS. (2008). The employment of female nationals in the United Arab Emirates (UAE). *Education, Business and Society: Contemporary Middle Eastern Issues, 1*(1), 26-33. https://doi.org/10.1108/17537980810861493

Gallagher K. (2019). Introduction: Education in the UAE—Context and Themes. In: Gallagher K, ed. *Education in the United Arab Emirates: Innovation and Transformation* (pp. 1-18). Singapore: Springer Nature. https://doi.org/10.1007/978-981-13-7736-5_1

Goh L. (2019). Human Capital Development and Technological Innovation. In: Arezki R, Belhaj F, Shah P, eds. *Promoting a New Economy for the Middle East and North Africa* (pp. 47-52). Washington, D.C.: International Bank for Reconstruction and Development / The World Bank.

Greenbaum SG & Hajjar DP. (2017). Can Science Diplomacy Advance STEM Education Particularly for Women in the Middle East? *American Diplomacy.* 2017(Summer Issue).

Hajjar DP. (2015). U.S. Science Diplomacy as a Seed for the Advancement of Democracy in the Near East. *Seton Hall Journal of Diplomacy and International Relations, 17*(1), 37-53.

Hajjar DP & Greenbaum SG. (2018). Levaraging Diplomacy for Managing Scientific Challenges: An Opportunity to Navigate the Future of Science. *American Diplomacy.*

Hajjar DP & Gotto Jr. AM. (2013). Launching of an American Medical College in the Middle East: Educational Challenges in a Multicultural Environment. *International Journal of Higher Education, 2*(2), 67-75. https://doi.org/10.5430/ijhe.v2n2p67

Hajjar DP, Moran GW, Siddiqi A, Richardson JE, Anadon LD, & Narayanamurti V. (2014). Prospects for Policy Advances in Science and Technology in the Gulf Arab States: The Role for International Partnerships. *International Journal of Higher Education, 3*(3), 45. https://doi.org/10.5430/ijhe.v3n3p45

Hajjar DP, Richardson J, & Coleman K. (2015). Role for Diplomacy in Advancing Global Science, Technology, Engineering, and Mathematics (STEM) Policies in the Twenty-First Century Where Do We Go Now: Examining the Causes and Consequences of Mass Displacements and Immigration Policies. *Seton Hall Journal of Diplomacy and International Relations, 16*(2), 93-100.

Issan SA. (2013). Gender and Education in the Arabian Gulf States. In: Donn G, Manthri YA, eds. *Education in the Broader Middle East: Borrowing a Baroque Arsenal (pp.* 145-170).United Kingdom: Symposium Books.

Kane T. (2013). Higher Education in Qatar: Does a US Medical School Break the Baroque Arsenal? In: Donn G, Manthri YA, eds. *Education in the Broader Middle East: Borrowing a Baroque Arsenal (pp.* 85-106). United Kingdom: Symposium Books.

Knight J. (2013). Crossborder Education in the Gulf Countries: Changes and Challenges. In: Donn G, Manthri YA, eds. *Education in the Broader Middle East: Borrowing a Baroque Arsenal (pp.* 171-202). United Kingdom: Symposium Books.

Macleod P & Abou-El-Kheir A. (2017). Qatar's English Education Policy in K-12 and Higher Education: Rapid Development, Radical Reform and Transition to a New Way Forward. In: Kirkpatrick R, ed. *English Language Education Policy in the Middle East and North Africa (pp.* 171-198). Springer International Publishing. https://doi.org/10.1007/978-3-319-46778-8_11

McClendon D, Hackett C, Potančoková M, Stonawski M & Skirbekk V. (2018). Women's Education in the Muslim World. *Population and Development Review, 44*(2), 311-342. https://doi.org/10.1111/padr.12142

Metcalfe BD. (2008). *Women, Management and Globalization in the Middle Eas, 83*(1), 85-100. https://doi.org/10.1007/s10551-007-9654-3

Miller-Idriss C & Hanauer E. (2011). Transnational higher education: offshore campuses in the Middle East. *Comparative Education, 47*(2), 181-207. https://doi.org/10.1080/03050068.2011.553935

Momo MSM, Rud I, Cabus SJ, De Witte K & Groot W. (2019). The relationship between contextual characteristics and the intergenerational correlation of education in developing countries. *International Journal of Educational Development, 66*, 173-183. https://doi.org/10.1016/j.ijedudev.2018.10.002

Nabli MK. (2007). Long-term Economic Development Challenges and Prospects for the Arab Countries. In: Nabli MK, ed. *Breaking the Barriers to Higher Economic Growth: Better Governance and Deeper Reforms in the Middle East and North Africa* (pp. 3-28). Washington, D.C.: The International Bank for Reconstruction and Development / The World Bank. https://doi.org/10.1596/978-0-8213-7415-3

Nguyen V-K. (2019). An epidemic of suspicion - Ebola and violence in the DRC. *New England Journal of Medicine, 380*(14), 1298-1299. https://doi.org/10.1056/NEJMp1902682

Pasha-Zaidi N & Afari E. (2016). Gender in STEM education: An exploratory study of student perceptions of math and science instructors in the United Arab Emirates. *International Journal of Science and Mathematics Education,14*, 1215-1231. https://doi.org/10.1007/s10763-015-9656-z

Qureshi S, Bradley K, Vishnumolakala VR, Treagust DF., Southar DC.,Mocerino M, Ojeil J. (2016). Educational Reforms and Implementation of Student-Centered Active Learning in Science at Secondary and University Levels in Qatar. *Science Education International, 27*(3), 437.

Ripley A. (2017). Boys are not defective. *The Atlantic*.

Said Z. (2016). Science education reform in Qatar: Progress and challenges. *Eurasia Journal of Mathematics, Science & Technology Education, 12*(8), 2253-2265. https://doi.org/10.12973/eurasia.2016.1301a

Said Z & Friesen HL. (2013). The impact of educational reform on science and mathematics education in Qatar. Paper presented at: *1st Annual International Interdisciplinary Conference,* AIIC 2013; Azores Islands, Portugal.

Salehi-Isfahani D & Hassine N, Assaad R. (2014). Equality of opportunity in educational achievement in the Middle East and North Africa. *The Journal of Economic Inequality, 12*(4), 489-515. https://doi.org/10.1007/s10888-013-9263-6

Tweissi A, Abu Lebdih K, Ababneh I, & Hamed S. (2014). Gender gap in student achievement in Jordan study report. *National Center for Human Resources Development (NCHRD) Publication Series: Monitoring & Evaluation Partnership (MEP) project.*

Tlaiss HA. (2013). Women in healthcare: barriers and enablers from a developing country perspective. *International journal of health policy and management, 1*(1), 23. https://doi.org/10.15171/ijhpm.2013.05

UNDP, MBRF. (2014). *Arab knowledge report 2014: Youth and localisation of knowledge.* Dubai, United Arab Emirates 2014

United Nations Development Programme. (2019). *Human Development Reports.* http://hdr.undp.org/en/data.

Varghese NV. (2013). Globalization and higher education: Changing trends in cross border education. *Analytical Reports in International Education, 5*(1), 7-20.

Vidyasagar G & Rea DM. (2004). Saudi women doctors: gender and careers within Wahhabic Islam and a 'westernised' work culture. *Women's Studies International Forum, 27*(3), 261-280. https://doi.org/10.1016/j.wsif.2004.06.008

WISE. (2019). About WISE. https://www.wise-qatar.org/about/. Accessed July 30 2019.