AC 2012-5444: PERSISTENT GENDER INEQUITY IN U.S. UNDERGRADUATE ENGINEERING: LOOKING TO JORDAN AND MALAYSIA FOR FACTORS TO THEIR SUCCESS IN ACHIEVING GENDER PARITY

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Persistent Gender Inequity in US Undergraduate Engineering: Looking to Jordan and Malaysia for Factors to Their Success in Achieving Gender Parity

Introduction

For more than three decades, the US federal government, industry and professional engineering societies has contributed millions of dollars to increase the number of women in US engineering programs with minimal impact. The research published on how to address the on-going United States (US) national challenge of increasing gender parity in undergraduate engineering programs is almost entirely US centric. The authors of this paper reached across borders and outside the STEM education literature to gain a different perspective on the US problem of persistent gender segregation in undergraduate engineering education. As we compared the issue of gender parity between the US, Jordan and Malaysia, three previously unexplored areas began to take shape:

1. The US has potentially inaccurately scoped the problem,
2. Different factors seem to contribute to greater gender equity in undergraduate engineering programs in Jordan and Malaysia than in the US, and
3. A sociological framework for analysis and interpretation (not previously published in the engineering education literature) helps us better understand the core causes of gender inequity in advanced industrialized countries, such as the US. Once we better understand the core causes, effective solutions can be designed.

The purpose of this paper is to begin to re-scope the problem of increasing the number of women in engineering education in the US, identify potential factors that contribute to gender equity in

Jordan and Malaysia, and to propose future areas of robust cross-national engineering education research.

Sociologists Charles and Bradley are the first to conduct a robust study of gender segregation in a variety of fields across 44 countries, using their Gender Essentialist and Self-Expressive Value Systems Framework.[1] The study's counter intuitive findings suggested that gender segregation in fields traditionally regarded as 'masculine', such as engineering, is much more pronounced in advanced industrialized 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. Their findings could possibly explain the core causes underlying the failure of US momentous efforts to increase the number of women in undergraduate engineering programs and the profession.

This paper provides a targeted cross-national comparison between the US, Jordan and Malaysia. The authors using Charles and Bradley's Gender-Essentialist and Self-Expressive Value Systems framework analyze to analyze the current case in Jordan, as well as the preliminary findings of two in-progress qualitative studies. [1] On the surface, the situations in Jordan and Malaysia seem to support Charles and Bradley's findings[1]. The two economically developing and predominately Muslim countries are perceived by the US to have more conservative values (than those held by the US and/or other advanced industrial Western cultures) with respect to women's roles and positions in society, yet the situation for the engineering profession is significantly better for women[2]. In Jordan, women made up approximately 40% of enrolled undergraduate

engineering students in 2009-2010 at the two largest universities in Jordan, the University of Jordan[3] and Jordan University of Science and Technology. [4] In 2010, women represented 30.9% of all registered engineers in the Jordan Engineers Association.[5] At the Universiti Teknologi Petronas in Malaysia, 40% of the members of the class entering engineering programs in 2009 were women, with a retention rate of approximately 50%, higher than that for men. [6] These percentages are similar for the Universiti Teknologi Malaysia. [6] Yet, in spite of these enviable percentages, women make up only 20% of the engineering workforce. [7] It appears that there are factors in the Jordanian and Malaysian environments that yield a significantly higher recruitment and retention rate in engineering undergraduate programs as well as in the profession for women, yet those factors remain largely undefined in the engineering education or STEM policy literature.

Our analysis confirms Charles and Bradley's counter-intuitive finding that gender segregation in undergraduate engineering programs and the profession is significantly greater in advanced industrialized countries in the western hemisphere, such as the US, than in less economically developed countries, such as Jordan and Malaysia. At the same time, our analysis uncovered findings that potentially contradict Charles and Bradley's hypothesis that self-expression and individualism is more prevalent in curricular and career choice in advanced industrialized countries.

The Analytical Framework: Gender-Essentialist Ideology and Self-Expressive Value Systems

Charles and Bradley studied gender segregation in a variety of fields across 44 countries using a gender-essentialist ideology and self-expressive value systems framework. Gender-essentialist refers to "cultural beliefs in fundamental and innate gender differences". [1] Self-expressive value

systems refer to the value systems frequently expressed in western economically developed countries as the expectation to pursue individual interests when making career choices. Charles and Bradley posited that deeply held beliefs about gender differences combined with self-expressive norms to "intensify gender typing of curricular choice in societies characterized by broad-based prosperity and material security." Their findings supported their hypothesis. This framework has not been used previously in the engineering education literature.

Meet the Authors

The authors representing the US are:

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- Robert G. Olsen is Associate Dean of Undergraduate Programs and Student Services for the College of Engineering at Washington State University. Dr. Olsen has worked to increase the number of women and other underrepresented populations for the past 7 years at his institution and began wondering why Malaysia seemed to be doing so much better recruiting and retaining women that the US on one of his many trips to universities there.
- Rochelle Williams is Educational Research and Assessment Manager at ABET. Dr. Williams was recently awarded PhD in Science and Mathematics education. Dr. Williams chose to pursue education after receiving a master's degree in mechanical engineering in

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The Case in the US

In the 1950's women represented less than 5% of the graduating classes in schools of law, medicine and engineering in the US. [8] 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 (human and veterinary) without funding by the federal government or professional societies. Women now comprise 50% or more of the graduating classes in these professions.[9] Indeed, the 21st century heralds women majority ranking in higher education in the US.[10] 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.[1] Yet recent studies show that gender segregation is unrelentingly high in the US, and particularly in engineering, as it is in other advanced industrialized countries where legal and societal structures to encourage gender equality in educational and public spheres have been in place for a number of decades.[1] Further, and in contrast to experiences in law and medicine, there is no indication that women are fighting in courts of law or public opinion forums to be admitted into schools of engineering. [1]

Since the 1970's, millions of dollars have been spent by the federal government, industry and professional societies to increase the number of women in engineering programs in the US. These efforts have helped to increase the women graduating from undergraduate engineering programs from 2% in the mid-seventies to 17% in the nineties to 20% at the turn of the last century. The percentage has decreased slightly as we enter the second decade of the 21st century. The percentage of professional women engineers is discouraging at 11%. This percentage is even more discouraging when one learns that it has been stable for the last 20 years. [11] Studies published over the last ten years in the US "point to persistently high levels of [gender]

segregation in colleges and universities, particularly in science, engineering, and technology programs even in countries with high overall female employment rates". [1] Clearly, achieving the parity that exists in other previously male-dominated fields such as law and medicine has proven to be much more challenging than predicted for the US engineering discipline.

The 1981 Equal Opportunities for Women and Minorities in Science and Technology Act charged the National Science Foundation (NSF) to proactively recruit women and minorities in science and engineering in order to promote proportionate representation, with a varied annual budget of 7 million to 10 million dollars.[11] Institutions such as Harvard University have invested $30 million to change policies and practices that contribute to the slow integration and advancement of women in faculty positions in these fields.[12] 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 them once they are in engineering school by providing (among others) alternative instruction, mentors and role models.[11] The US federal government, industry and professional engineering societies continue to contribute millions of dollars to address this problem with minimal impact.

The 2011 report Stemming the Tide: Why Women Leave Engineering provides insights into the reasons why the percentage of women in engineering practice has stagnated at 11% for the last 20 years in the US.[13] Of the 3,700 female engineering graduates who participated in the study, one in five left the field because of working conditions (lack of advancement opportunities and low salaries were among reasons cited), unwelcoming workplace climate and culture, and to

spend more time with family. One third didn't enter the engineering workplace because of "their perceptions of engineering as being inflexible or the engineering workplace culture as being non-supportive of women." Of this third, 30% said they did not "pursue engineering after graduation because they were no longer interested in engineering or were interested in another field." Of those remaining in engineering, their decisions to stay were primarily related to "psychological factors and factors related to the organizational climate" perceived to be supportive of their professional growth and contributions to the overall organization. Those who were continually treated in a condescending manner by supervisors and colleagues indicated a desire to leave not only their current place of employment, but the field of engineering entirely.

According to a 2010 study, women in the US (87% of the women in this study were of European American descent) were found to be less likely to perceive that STEM careers would fulfill communal goals [8] In addition, women were found to place greater value on communal goals than men when choosing an academic or professional field. More specifically, the authors state, "One important reason women remain underrepresented in STEM is that STEM careers are perceived (by women in the US) as less likely than careers in other fields to fulfill communal goals (e.g., working with or helping other people). Further, women tend to endorse communal goals more than men and STEM careers, relative to other careers, were perceived to impede communal goals."

The above findings could be interpreted as follows. In medicine, it is easy to identify a real flesh and blood human who has been helped by a physician. For example, a physician might be able to say, "*This specific person* is one whose cancer was cured because of my intervention on his/her behalf." In law it is also easy to identify a real flesh and blood human who has been helped by an attorney. An attorney might say, "*This specific person* is one who received justice

because of my intervention on his/her behalf." Here, this type of contact will be labeled "direct human assistance." Now it is arguably true that engineers have saved more lives than physicians (e.g., clean water to prevent cholera epidemics or electric power to provide relief from cold or hot weather). But while prevention may impact a greater number of lives, it is just not as "personal" as cure because *it is impossible to know who* specifically has been impacted. We label this type of contact "indirect human assistance."

Another indication that this issue of "direct vs. indirect human assistance" rather than engineering topics per se may be an essential issue in understanding the lack of participation of women in engineering comes directly from undergraduate engineering program statistics. More specifically, gender parity is much closer in bioengineering than others. According to the American Society for Engineering Education, in 2005-2006, 38% of all bioengineering graduates in the US were women.[14] It is tempting to argue that this is because of the perception that the connection between this discipline and "direct human assistance" is clearer. In addition, biology has long been the one science field in the US long dominated by women. [1] Examples of the impact of pacemakers or devices designed to assist physically impaired persons on specific "flesh and blood" individuals abound.

In their study of gender segregation across a variety of fields (not just STEM) and 44 countries, Charles and Bradley found a tendency for greater gender segregation in academic fields traditionally regarded as "masculine" or "feminine" in advanced industrialized countries such as the US. [1] In the US, where women majority in higher education is now the norm and where curricular and career choices abound, women participate in perpetuating an interesting conundrum: self-expression and individual interest trump economic and prestige factors, yet intrinsic preferences based on gender-based curricular and professional stereotypes drive choice

for both women and men. In a diverse society, those who make the decisions concerning infrastructures, public policy, and engineering needs should be both representative of the people and their diversity. Charles and Bradley's findings and their analytical framework offer an unexplored in the US engineering education literature approach to scoping the persistent problem of recruiting women into undergraduate engineering programs and into the profession in general. Just as in engineering design, if the problem isn't scoped accurately, the solution will not be robust. It's time for our solution to target the core issue(s).

The Case in Jordan

According to the Jordan Engineers Association (JEA), female engineers represented 18.6% of all the registered engineers in JEA between 1948 and early 2011. [4] This reflects 15,680 female engineers registered currently in six engineering disciplines (civil, architecture, mechanical, electrical, metallic and chemical) from a total of 84, 265 engineers registered in JEA[4]. In 2010, women accounted for 30.9% of registered engineers[4]. It's worth noting that a 10-20 increase in the percentage of female engineers was evident for all engineering disciplines in 2010, including those traditionally considered "masculine" job such as mechanical engineering. In chemical engineering and architecture, female engineers outnumbered the male engineers registered in the JEA in 2010 by 15.2% and 10.6 %, respectively. According to statistics provided by the University of Jordan, the largest and oldest public university in Jordan, the entering undergraduate engineering class for the academic year 2009/2010 was 5,742 students with 41% female[3]. Similarly, female students accounted for 37.3% of entering engineering class at the 2nd largest public university, the Jordan University of Science and Technology (JUST) in 2009.[5] When all Jordan universities were accounted for in 2009, women made up 34.1% of all engineering students with 32.2% graduating.[5]

According to the Jordan Department of statistics, females who graduated with a B.S. degree or higher were 11.6 and 12.7% of the total country female population over the age of 15 in 2008 and 2009, respectively compared to 14.3 and 15.3 for males in the same age group.[15, 16] Thus, unlike the US, women do not comprise the majority of students in higher education.

In Jordan, the choice of a discipline to study is largely influenced by future possible careers, unemployment rates, as well as the expected entry salary.[17] Choice of discipline is thus largely based on other prioritizing factors compared to those valued in the self-expressive value system in which career choices are pursued based on individual interests. For example, women are considered to be a minority in the US in all STEM fields including science and mathematics. In comparison, women in science and mathematics are considered to be a majority in Jordan. In 2009, the percentage of entering female undergraduate students in science disciplines in the University of Jordan was 80% of the entering science class and ~9% of all entering females' class.[3] This is largely influenced by the fact that graduating women with science degrees can be employed as school teachers. According to Jordan Department of Statistics, 66.7% and 51.1%, respectively, of elementary and secondary education teachers in the kingdom were women.[16] The profession of a K-12 teacher in Jordan is well respected. Teaching is conceived as a very suitable career for women who will be raising families due to the considerably short and consistent working time spent at the job compared to time spent for other careers such as engineering. In addition, teachers are in demand always, thus obtaining a job in a country where unemployment rates for women are higher than 20% is considerably easy. [18] Third, teachers are considered to be government employees and thus enjoy a wide range of benefits, including early retirement options for women after only 15 years of employment.[19] All the above factors are in line with the gender-essentialist ideology in which deep rooted societal perspectives about appropriate careers

affect curricular and career choices, yet in this case for the traditionally “female” profession of K-12 teaching.

In addition to the factors that influence career choices in Jordan and discussed above, societal and cultural factors play a role in women choices of engineering as a discipline. For example, if a male student could not compete for a seat in engineering in a public university, he can still study engineering abroad or can study engineering in a private university where tuition rates are three times more expensive than those in public universities.[20] For example, admission to engineering in the University of Jordan costs 29 Jordanian Dinar per credit hour compared to 80 JDs per credit hours at private universities. [21] It is unlikely for families to approve for their daughters to study abroad because that implies living alone at the age of 18 which is socially and religiously unacceptable.[22] It is unlikely, as well, that those families will be willing to pay three times more tuition to teach their daughters engineering.[22] The difficulty to obtain a permanent engineering job is another factor that drives females away from engineering. Engineering jobs are often temporarily or seasonal. This means that the salary will be intermittent. A lot of people believe that continuity in attainment of financial resources is important even if that meant a little but continual salary compared to high but intermittent salary. It seems, then, that in Jordan, choosing engineering as a discipline to study for women is largely influenced by societal cultural beliefs, societal values and economic opportunities, rather than by individual self-interests.

In comparison to science and mathematics, the percentage of engineering females graduating from the University of Jordan since it was founded in 1962 was 5.5% from all females graduating and 35.4% from all engineering students graduating [3] In comparison, male engineers accounted for 14.4% of all male students graduating and 64.6% of all engineering students graduating. [3] When graduate degrees were compared as well, females accounted for 30.6% of the

entering class in 2009 and 22.8% and 22.2% of all engineering students who earned a graduate M.S. and Ph.D. degrees from the University of Jordan since it was founded[3]. Finally, the share of faculty engineering women to the engineering faculty remains quite low at 8.1%.[3] The numerical figures above are still much better than the current situation in the US. Yet, in spite of these encouraging advances over the last 30 years in encouraging women to pursue the engineering profession, the need to increase the numbers remains.

According to the Jordan Department of Statistics, females constitute 51.5% of the population of the kingdom.[18] Female engineers are still ~ 20% shy from their demographic ratio, the fact that needs attention and continued effort to improve females' representation in engineering. Although Jordan has worked hard to increase the participation of women in engineering, discrimination against women engineers is evident. In the last ten years, unemployment rates among the Jordanian labor force was at least 10% higher for females compared to males[5] with unemployment for engineering reaching 12% in 2009 for men and 21% for women with expected 3% rise in successive years.[17] Salaries paid for women engineers doing the same job male engineers, especially in structural sites, were lower.[23] Women are less likely to be involved in decision making and policy development compared to male engineers.[24] To increase women participation in engineering, these barriers need to be overcome. However, even with these barriers, women have defined a strong position for themselves as essential contributors and players to the engineering profession in Jordan.

When compared to other professional degrees, engineering still attracts considerably more women than law or medicine in Jordan, opposite to the US. According to Jordan Department of Statistics, in 2009 women accounted for 6.2% of all judges, 20.7% of lawyers, 18.8% of medical doctors, 34.3% of dentists, 30.9% of engineers, 49.4% of nurses and 45.6% of pharmacists.[5]

Engineering careers are more appealing to women in comparison to medicine or law for several reasons, both societal and cultural. First, studying and practicing engineering take considerably less time than it takes to study and practice medicine or law. On average, engineering degrees in Jordan can be earned within five years while studying medicine requires six years without residency or specialization studies which generally require six or more additional years.[25] This is important as the average age for the first marriage for females in Jordan is 25.9 years.[18] Women who are still studying are less likely to get married in a society that values marriage.[26] The above again points to the importance of both societal and cultural values in decisions made to pursue engineering as a discipline. Second, seats available to study engineering are a lot more than seats available to study medicine or law in public universities. In 2009-2010 academic year, the number of students admitted to engineering disciplines in all ten public universities in Jordan was 36,342 students with 35.1% women, compared to 7443 students admitted to all medical degrees offered in these universities (medicine, dentistry and veterinary medicine).[27] This is largely due to the many types of engineering available to study in comparison to medicine. This means that if women are interested in engineering and do well in the national exam, they will be admitted to a public university. This is important as societal values in Jordan will be against paying elevated tuition rates required by private universities for women to study there if they were not admitted to a public university.

Add to that, women graduating from high schools usually have higher scores than men in the national exam.[28] A single common national exam is being used in Jordan to rank students according to their score on the tests. Students take this national exam at the end of their 12th grade. Students can choose a track for the exam. To study engineering, math or science, students have to choose the scientific track which is heavily focused on math, science and computer

skills. Based on students' scores, country needs and individual interests, students get admitted to different disciplines. The better performance for women in the test can be in part cultural. In Jordan, women are less free to leave their parents' house for outside activities compared to men.[29] This situation gives them higher chance to study and focus. Higher scores in national exams can allow females to choose the engineering discipline that interests them. It also implicitly indicates that women choosing such disciplines are analytically as capable as men choosing these disciplines. The lack of women engineers compared to male engineers is largely driven by social values encouraging men to pursue engineering and has nothing to do with lack of abilities on women part. Third, culturally, it is still unacceptable for lawyer women to argue for a case against men. Fourth, it is largely unacceptable as well for women doctors to diagnose male patients. Finally, there is the perception that men are strong and thus can suit medicine and law careers more than women as they involve more decision making.[30] On the other hand, engineering is perceived as an independent profession where a woman can prove herself quite a bit without interacting largely with men or depending on them. Women engineers can as well be employed in companies, firms as well as in the government and can lead normal family lives. It is true that time spent in an engineering job is longer compared to that spent by K-12 teachers at their jobs, however the much higher pay women engineers get in comparison to K-12 teachers can compensate for the job demands. [23] This is especially true during current times where life demands are much higher compared to ten years ago. People realize that without women working, raising a family can be quite challenging in Jordan.[31] Therefore, working women who get paid high salaries, such as women engineers, are valued in Jordan.

Dr. Abu-Lail used a common qualitative interview methodology called the Focused Interview, to engage her female undergraduate and graduate students in conversations related to this papers

topic. [32] The Focused Interview is a semi-structured interviewing technique designed to collect qualitative data from respondents about their experiences and opinions on a given subject. Questions used in this technique may either be prepared in advance, or as they arise during the interview to fit the respondent's context. The wording of questions will not necessarily be the same for all respondents.

Dr. Abu-Lail was in the preliminary stages of a qualitative study when this paper was written, thus the numbers reported are low. When 7 US female engineering students in the Jordanian author's class here in the US were asked about why they chose to study engineering, answers were categorized in two categories. First, they all loved math and science and felt that engineering allowed them to apply math and science to help society. Second, they thought engineering is challenging career that can help in solving difficult problems that face the society. This agrees well with the characteristics of the expressive value system described by Charles and Bradley in which students choose careers that self interest them. In comparison, when 5 engineering women who graduated from Jordan, Turkey and India and who are pursuing graduate degrees in the Jordanian's author department were asked the same question, the answer was quite different. First, entering engineering was largely influenced by a national exam on which they did well and that made them feel distinguished and capable of majoring in engineering. This aligns well with Charles and Bradley analysis that women are less likely to regard themselves as exceptional women or pioneers in systems were female enrollment is taken for granted. In Turkey, Jordan and India, admission to engineering is competitive, earned, independent of gender and thus well deserved. Second, engineering is considered as a prestigious job in all three countries above. The third reason was economical. Engineers make more money than people who work in many other professions.

Even though the sample above is small, nonetheless, it points our attention to the fact that what women in less economically developing countries value in engineering is different than what those in more economically developed countries such as the US do. Second, the way engineering is perceived as a profession of importance in developing countries is not the same way it is perceived in the US. In Egypt, an engineer is still called "Basha" which is a noun that used to be bestowed upon noblest by the King. Therefore, it is very important to work hard toward improving the image and the importance of women participation in engineering and engineering in general in Jordanian society play an important role in attracting women to engineering. Jordan is a highly patriarchal society in which cultural traditions and societal norms continue to encourage discrimination against women. In recent years, the status of Jordanian women in society has improved somewhat; however, their economic and social opportunities are still not equal to those of men. [30]

The Case in Malaysia

In Malaysia, the role of women in professional work forces is significant. The percentage of female decision makers in the civil service has risen from 18.8% in 2004 to 32.3% in 2011. With this trend, in June 2011, the Prime Minister of Malaysia announced that the Cabinet has approved a policy that women must comprise at least 30% of those in decision-making positions in the corporate sector.[33] Some of the leaders in the governmental agencies, higher education institutions, multinational companies, professional bodies and so on are from among the women such as Tan Sri Dr Zetty Aziz, the Governor of Bank Negara Malaysia, Dato' Ambiga Sreenevasan, the former President of the Malaysian Bar Council, Yasmin Mahmood, the Managing Director of Microsoft Malaysia and Executive Director of YTL Communications, to give a few examples.[34]

Many of the political and professional bodies in Malaysia allocate a special branch for women to stay active in their fields. The Institute of Engineers Malaysia Women Engineers (IEM WE) was established in 2000 with the mission of building a large network connecting women engineers, to embrace and deliver the results of living on purpose, based on courage and joy.[35] It has been active with the vision to ensure the engineering profession values, supports the contributions of women in engineering, science and technology. It holds various types of events to enhance collaboration between IEM WE with others in the industry, sharing of experiences and identifying challenges faced by women engineers.[35] Various activities are conducted in an effort to encourage the involvement of Malaysian women into engineering and to keep them informed; evening talks, corporate connections, visits to universities and schools, annual tea party, overseas fellowship and charity projects. The purpose of visits to the universities is to encourage and promote enthusiasm amongst the future women engineers to practice engineering upon graduation.[35] Thus far, out of the 24,000 members of IEM, 8,000 of them are women[36] although the number of professional and graduate engineers registered with the Board of Engineers, Malaysia (BEM) is about 70,000. In appreciation of the role of women in engineering, IEM has awarded a few women engineers in Malaysia with the IEM Lady Engineer Award. Women's role in engineering has also been discussed in the 1st International Conference and Exhibition of Women Engineers held in November 2011.

Siti Hamisah Tapsir and Norliza Mohd reported that in 1969, out of 351 engineers, none of them were women.[37] However, the trend began to improve steadily to 20% in 2003 where most of them are involved in less physically demanding fields of engineering such as civil, electrical and chemical engineers compared to mechanical, marine, aviation and petroleum engineering. This trend is similar at the higher education institutes where the enrolment of female students into

undergraduate engineering programs is showing an upward trend from 5% in 1981 to 30% in 1999 and now it is nearly equally distributed between male and female students.[37] According to a report by the Ministry of Higher Education (MOHE) Malaysia, in 2010, the female students' enrollment in engineering programs at Public Higher Education Institutes was 7367 of 20609 (or 35.7%).[38]

Female enrollment in the four public higher education institutes in Malaysia showed a drastic increase in 2011, ranging from 46% to 68%.[39] Although it may be argued that the swelling number of female students in engineering programs can be attributed to the phenomenon of more female students enrolling in public higher education institutes (65% in 2011, up from 50% in 1990), the ratio of male to female students at school level is at 50:50.[40] Tapsir and Mohdstated that more women are enrolling in engineering programs because the National Education Policy treats both men and women equally based on merits, not gender.[37] Policy initiatives at the national level to increase the number of technical professionals are common in both economically developed and developing countries, particularly in engineering and computer science.[1]

According to a 2009 study of engineering faculty and students at the Universiti Teknologi Petronas (UTP), 90% of Malaysian women students (74% of the respondents to this survey were Muslim Malays) believed that engineering is an appropriate career for women.[7] Yet, only 20% of the male engineering students at UTP agreed that professional engineering is an appropriate career for women. The 587 study participants were primarily final year students; out of the 217 female participants, the number of female participants who would give up engineering profession was almost as many as those who would stay in engineering. Surprisingly, too, 40% of the 370 the male respondents said they would change their career paths to other than engineering.

A set of preliminary interviews using the Focused Interview technique were carried out to understand why some female students enroll in engineering programs and to determine their perceptions of women engineers in Malaysia. 29 first year Muslim female undergraduates studying at a public Malaysian Technolgy University (MTU I) from various fields of engineering (Chemical, Civil, Electrical, Mechanical) and backgrounds were interviewed and the data was analyzed qualitatively. There are a few factors that seem to affect female students' choice in pursuing their study in engineering programs and careers in Malaysia. However, the most important factor is their individual interest as evident in the following elaboration.

The major reason to enroll in engineering programs for almost all of the female students interviewed is interest. It is either the interest in engineering itself or interest in:

- Producing Something (a typical quote: "I would like to make something, especially new things.")
- Physics, Chemistry or Mathematics (most students said something along this line: "I like to physics/chemistry/mathematics since school...")
- Practical Works (many students said: "I like to do practical activities")
- Taking up Challenges (an example quote: "… I want to prove that women can also survive and take the challenge with men in engineering jobs.")

Their interests were mainly developed when studying at pre-university level (or matriculation colleges in Malaysia). All of them were introduced to engineering through coursework, or career talks organized by the matriculation colleges which offer pre-university courses that students have to take before enrolling in public universities degree programs in Malaysia. Some of them had been interested since school, but this was not the major contributing factor at MTU I because

not many of them underwent their secondary school education at technical secondary schools, although all of them were in the science stream.

Another major contributing factor towards their choices was the influence of family, teachers and friends. About half of the students interviewed had at least one of their immediate family members (parents or siblings) as an engineer or studying engineering. Their family, teachers and friends also encouraged them to study engineering. This certainly shows the influence of having positive role models or encouragement from those who are close and well respected by the students. Out of 29 students, only one said that she took the engineering program because she was channeled into studying the technical stream at matriculation level and that there was no other better choice for her than engineering due to the subjects that she has taken previously. Therefore, although almost all the students chose engineering because of their interest in the field, there was a minority who chose it because it was the best alternative left after going into a pre-university stream specifically suited for engineering.

To investigate the reasons for choosing engineering at a different university, seven female candidates for the Foundation Engineering Program at another Malaysian Technology University (MTU II), which is a premier private university in Malaysia, were interviewed using the Focused Interview Technique. The study was in its early stages when this paper was published. The seven prospective students of MTU II also said that they chose engineering mostly because of interest, while the influence of family or teachers comes in second, which is consistent with the findings in MTU I.

The findings in MTU I, which are also supported by those from MTU II, are that female engineering students choose mainly because of their interests, aligns with the self-expressive

value system, where engineering is pursued out of interest in challenges and tasks associated with engineering, as well as the foundation knowledge used in engineering. Difficulties and obstacles associated with engineering are not deterrents, but serve as impetus for the students to rise up to the challenges. What is significantly different from the US is that in Malaysia self-expression seems to manifest itself less gender segregated ways.

As the above factors pertain to perceptions held prior to their university studies, respondents at MTU I were later asked about the courses in engineering that they have studied so far and if the courses challenged their initial interest to engineering.

An interesting answer given was that a course named "Introduction to Engineering," which all the engineering students must take in their first semester, helped them to improve their understanding of the field and career of engineering, thus increasing their interest in engineering as a curricular field and career choice.

The more the students studied engineering, the more they seemed to be interested in this field. The engineering courses offered did not weaken their enthusiasm to excel in their study, although some felt that they were competing with the male students to do well. One of the students admitted: "I want to follow my father's footsteps and go on with engineering. Yes, I do feel the challenge from male students."

Almost all of respondents were confident that they will do well in their study and graduate with an engineering degree. They did not believe that they were in any way inferior compared to their male counterparts. They saw that the number of female students taking engineering programs equaled the number of male students. They understood that there would be a competition, but that the competition would be fair.

To probe these students further, they were asked if there were any factors that might prevent them from taking engineering, nearly all of them said that there is no hindering factors except a few minor ones, such as some female classmates and close relatives who believe that it is inappropriate for women to become engineers. However, with the support of their families, they were confident that they would become good engineers. In analyzing their responses, the hindering factors seemed only come from external influences because they all had strong internal beliefs about their reasons for pursuing engineering.

When queried if they would continue to be engineers after graduation, almost all believed that they would because of their strong interest in engineering. One of the biggest attractions of becoming an engineer is the high salary, although this come in second compared to individual interest. Many of them see that there are a lot of successful women engineers in Malaysia. This fact gives them the confidence that they will also become engineers in the future. They believe that women engineers play an important role in engineering, especially in complementing the shortcomings of male engineers.

In order to probe further, the students were asked of the factors that might hinder them from becoming engineers after graduation. They believe that if they were not married, they would stay in an engineering career, but they doubted that if they became married they would because they thought that the priority after marriage is family. However, some of them insisted that they would try to divide their time between career and family and manage their time properly.

It is interesting, however, to explore the reasons why these Malaysian female undergraduates pursue engineering degrees in spite of seeing their future roles as mothers and home-makers. So, marriage and family may not be the top reason for not choosing the career as engineers because

they have thought about this before they enroll in this program. Some other more contributing factors that may affect their future decision include:

- Health
- Safety (e.g., dangerous or remote workplaces, such as offshore oil platforms)

The findings of the overall interviews, especially those focusing on hindering factors and engineering as a career for women point to the underlying beliefs that while there is equality between women and men, women and men are not the same. All the students interviewed believed that engineering is a suitable career for both women and men, although they acknowledged that certain requirements and environment may not be suitable for women and should be avoided. Among the unsuitable roles are those that require physical strength, and inappropriate locations or conditions that may potentially compromise their safety and well-being. The findings conform to the prevalent view on the types of careers that are suitable for women that is generally held in Malaysia, that engineering is suitable for both genders. This explains the encouragements received and almost non-existent discouragement from those around the students when they wanted to major in engineering. These findings support Charles and Bradley's conclusions that curricula and career choices in a developing country, such as Malaysia, are not heavily influenced by gender typing.

Discussion

The following discussion focuses on three roles that seem to promote or hinder gender parity in curricular and career choices for each of the three countries analyzed using the Charles and Bradley[1] framework: 1) national prosperity; 2) societal and cultural value systems, such as self-expression; and 3) educational policy related to pre-university curricular requirements. The goal

of the discussion is to unpack the implications of our initial findings, which both confirm and contradict those published by Charles and Bradley, as well as to suggest further areas of research.

Charles and Bradley found that in countries with greater national prosperity, that women's curricular and career choice were more strongly driven by a desire to express themselves and their individual interests rather than by economic factors. According to Charles and Bradley, the material prosperity of the society in general combines with what they categorize as a predominately Western cultural value of self-expression that manifests itself in the pursuit of individual interests to create greater gender segregation in curricular and career participation.

Their findings also showed that in many economically developing countries, women's curricular and career choice were influenced by the need to obtain credentials that would allow them to provide direct and lucrative financial assistance to their families. While our initial analysis found this to be generally the case in Jordan, it did not seem to be the case in Malaysia. Malaysian women frequently cited their interest in engineering was based on the fact that they found it intellectually challenging, that they had strong professional engineering role models, and that they wished to prove that women were as capable as men to excel in engineering.

If we look at each country using Gross Domestic Product (GDP) as a metric, the US is ranked number 8 out of 182 countries at $48,147, Malaysia is number 59 at $15,578, and Jordan is number 109 at $5900. This shows that Malaysia enjoys greater economic prosperity than Jordan. This, therefore, may potentially explain why the two studies' preliminary findings indicate that self-expression through the pursuit of individual interest plays a greater role in women's curricular and career choices in Malaysia than in Jordan. This made us question Charles and

Bradley's suggestion that self-expressive value systems are more prevalent in Western societies. We note, however, that unlike in the US, what seems to be evidence of self-expressive value systems in Malaysia does not result in greater gender segregation in curricular or career choice. One variable to consider is that Malaysia is one of the many Asian countries with strong female representation in the sciences and engineering, which could partly be a result of cultural beliefs that the ability to excel in math is not fundamentally or innately greater in men.[44]

There are more women in undergraduate engineering programs in Jordan and Malaysia than in the US, as well as in the engineering profession. This confirms Charles and Bradley's findings that engineering programs are more integrated in those societies where there are more women working as professional engineers.

What role does national educational policy related to pre-university curricular requirements potentially play in the number of women in undergraduate engineering programs? Charles and Bradley note studies which posit that limitations on choice in secondary school, "either through universal requirements for math and science coursework throughout secondary school or through stronger reliance on merit-based curricular placement, results in stronger representation of women in scientific and technical fields and a weaker influence of peers on students' educational aspirations." Both Jordan and Malaysian national governments play a significantly stronger role in secondary school curricular requirements than in the US, which result in students receiving greater exposure to math and science prior to university. In addition, both countries have rigorous national exams that students are required to pass in order to matriculate into one of the few public universities in each country. On the surface, this seems to be a potentially major reason why there are more women in undergraduate engineering programs in Jordan and Malaysia than in the US.

Additionally, in many developing countries, national economic and educational policy makers frequently invest "effort into expanding the supply of engineering and scientific labor because these fields are today seen as engines of national development and because of historically large outflows of qualified technical professionals to the West.[1]" Both Jordan and Malaysia national policy treat men and women equally based on merits, not gender, when it comes to matriculation into a given field or institution. Size of the tertiary education system also plays a role in the number of women in engineering undergraduate programs and in the profession. According to Charles and Bradley's findings, women are more strongly represented in engineering in countries with a larger non-university sector with selective merit-based matriculation requirements. It would be worth exploring if this is a potential explanation for the cases in Jordan and Malaysia.

All three countries reviewed in this paper seem to have a "separate but equal" category within which men and women cluster when making educational and career choices. This category plays out in both similar and different ways in each country.

In the US, women are widely regarded to have a fully equal range of educational, career and life options as men. In spite of this, or perhaps because of this, in addition to the relative material prosperity that the US enjoys, women consistently choose curricular and career paths that address "communal goals," such as directly helping others. This could explain why women have made such significant strides in previously male-dominated fields such as law or medicine where direct assistance to an individual or a community is integral to the job.

While women in Jordan are not restricted in curricular choice, they do have societal and cultural restrictions that do not afford them the opportunity to work in certain fields, such as law and

medicine. In Malaysia, women seem to participate in public policy making and public sphere in more direct ways than in Jordan.

Conclusion

Further research into the fundamental reasons driving gender disparity in both curricular choices and professional fields is important for three reasons underscored by Charles and Bradley: 1) to provide a comprehensive range of educational, career and life options to both boys and girls; 2) “separate but equal” distribution principles frequently do not result in equal pay or power; and 3) there continues to be a global shortage of technical expertise that could be filled by competent women. We won’t be able to solve the underproduction issue if we don’t’ solve the underrepresentation issue.

Because our preliminary analysis of data from three countries both confirm and contradict Charles and Bradley’s findings in important and interesting ways, further exploration into the multi-faceted core causes in each country will allow the US, Jordan and Malaysia to design better solutions. The nature of women in engineering education and one's (women within each respective country) attitudes regarding them seem to be determined by two main types of factors: environmental/societal and cultural. Cultural principles that dictate action have their origin in the values that women in engineering hold. Despite this importance of values in the formation of sex segregation ideology, there appears to be no well-established, systematic framework for a discussion of value related issues when discussing women in engineering, globally. As a next step to this preliminary analysis, this research team intends to develop an intrinsic value system framework to determine what factors play into the construction of value in the different cultures.

Charles and Bradley raise the call for more "cross-national and historical research on how macrocultural beliefs, economic opportunity structures and educational transformations influence aspirations, curricular affinities, and patterns of sex segregation in more and less economically developed countries. In particular, historical case studies and in-depth qualitative research conducted in countries that vary on key dimensions here could help specify the mechanisms underlying relationships that we have identified." This author team has started the exploration in this preliminary analysis and is prepared to embark on further robust research together to address this issue of international importance.

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