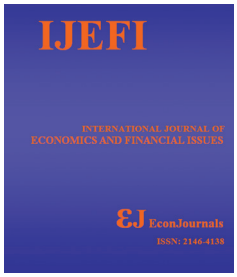

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Gender Gap in Science, Technology, Engineering and Mathematics: Barriers and Solutions

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ABSTRACT

The purpose of this study is to identify and discuss barriers facing females in the fields of science, technology, engineering and mathematics (STEM). The study looks at three developmental stages; first, school life (childhood) stage between the age of 6 and 18, second, university life (adulthood) stage from the age of 18 and 22, and third, professional life (maturity) stage from the age of 22 and above. The main findings are stereotyping and society's perception to women that lead to classification of roles and responsibilities based on gender. Parents and teachers' expectations, parents' profession, and community culture are the most factors that influence the childhood stage. Stereotyping, and low number of females in the classroom are characterized in the adulthood stage. The most important factors in the maturity stage are: (1) bias against women at work, (2) discouraging work environment for women, and (3) childbirth and maternity barriers. Few studies detailed gender barriers in STEM, especially in the region. In the light of these barriers, appropriate suggestions are put forward to overcome such barriers at each stage.

Keywords: Science, Technology, Engineering and Mathematics, Gender, School Life, University Life, Professional Life
JEL Classifications: I20, I24

1. INTRODUCTION

Bridging the gender gap is based on the basic premise that no country can truly compete without benefiting from female talents (World Economic Forum, 2017). Women represent just over half of the world population and the famous statement which says "woman is half the society" is not a general and random statement but this fact is clearly referenced in the World Bank statistics (The World Bank, 2018). As the study was conducted in Bahrain, classification of gender population shows that males are 337 thousand (50.7%) of total population, and Bahraini females are 328 thousand (49.3%) (Iga.gov.bh, 2018). Thus, women contributions to the economic growth and the development of their full potential in the labor market can indeed lead to significant economic gains. However, many studies show low contribution of women to economic activity in general and to the fields of science, technology, engineering and mathematics (SETM) in particular. The low level of women contributions can have serious economic consequences, as many specialized organizations in the world have indicated that most future occupations are expected to be in these four fields (Loko and Mame, 2009; Dollar and Gatti, 1999; Metz, 2018).

Many countries have succeeded in bridging the gap of male and female educational outcomes in terms of knowledge and skills required for future employment, with a view to achieving gender parity in the workplace. However, women in many of these countries have not always succeeded in joining the labor force as it should be. The women employment rate, worldwide, has reached to (54%) compared to (81%) for men. The number of women in senior positions is low compared to men, although the number of women with a university qualification is equal or exceeds the number of men in those countries. Women in only 4 out of 144 countries surveyed were able to achieve equality with men in top

government positions, senior officials and managers. Apparently, there is a weak relationship between the increasing number of educated women and the number of leadership positions assigned to them. While women represent the majority of students enrolled in universities in 97 countries, they are in specialized positions in only 68 countries and hold leadership positions in only four countries (World Economic Forum, 2017).

Cultural differences play an important role in STEM. Females are sent messages that math and science are male fields of study in the US and are not attainable in Africa due to racial issues. The women in Africa showed determination through STEM education and were eager to participate in a STEM career. To bridge the gender gap, parents, teachers, and community are to take their roles to support and encourage females to enter STEM (Miller, 2017). Obstacles occur during three developmental stages which are childhood and adolescence, emerging adulthood, and young-to-middle adulthood. learning environments, peers, and family might be obstacles to STEM interest and achievement in each stage. The gender mismatch creates barriers for girls' participation in STEM at every life stage (Dasgupta and Stout, 2014).

Bahrain has managed to close the gap in educational attainment by (98.7%) and ranked 84th out of 144 countries at the international level. As with economic indicators, Bahrain has managed to bridge the gap by (47.5%), which is less than the international average (58.6%) and ranked 127th among the participating countries. The gender gap at work which requires high skills has reached to (70%) in Bahrain. According to the Social Insurance Organization (2016), only a small percentage of women has reached higher management positions in the private sector where the percentage in the financial services sector has not exceeded (15%). Therefore, efforts need to be intensified to close the gender gap in these important areas. These efforts can help increase Bahrain's competitiveness by reducing barriers to women's participation in all areas of economic activity, including STEM. Therefore, more gender participation can increase the opportunity to have more scientists and innovators who are able to compete and innovate in the years to come, and reduce the reliance on outsourcing of jobs, or importing science from others.

2. DISCUSSION

Several studies (Beede et al., 2011; Dasgupta and Stout, 2014; Ertl et al., 2017) discussed reasons for the low women participation in these specialized fields, but few studies were conducted on these topics in the region, particularly in Bahrain (Kadhim et al., 2017). This paper aims to identify and discuss these reasons along with barriers through three developmental stages: School life (childhood) stage, university life (adulthood) stage, and professional life (maturity) stage.

2.1. First Stage: Factors in Childhood and Adolescence (School Life)

This stage begins from the age of six when a child enters a school at different levels and ends at the age of 18. The researchers believe that there are several factors that influence the attitudes of females towards STEM. These factors deepen over time and become barriers to female enrollment in the disciplines associated with these areas in the university. These factors also make females unwilling to work in mentioned fields and if entered, they soon withdraw. The most important factors in this stage are:

2.1.1. Stereotypes

Many researchers believe that one of the most important factors that make females avoid the themes of science, technology, engineering, and mathematics in childhood and adolescence stage lies in the negative and stereotypical perceptions of these subjects (Schuster and Martyny, 2017). It is also attributed to the society's view of the roles of males and females and what society expects from them. In childhood, girls begin to confront gender roles, which are meant to learn roles as defined by societal norms based on gender (Ismail, 1986). Children learn about gender from early childhood, and the behavior of individuals is determined by beliefs, values, models and attitudes. These roles or stereotypes are shaped by the adoption of specific expectations for both males and females by the family and the community. Parents and educators teach males to behave in a certain way. In this context, Lenore (2010) finds that male stereotypes lead males to acquire applied skills, discover the physical world, and focus on activities that emphasize problem solving, financial gain, information technology and numeracy skills, that encourage them to progress in the areas of STEM in the future. Female stereotypes also guide females to household management, focus on family and family formation, and on activities related to personal relationships, which limit their future orientation and involvement in areas such as mathematics and engineering, even if they excel in these areas. Therefore, parents begin to facilitate the male path towards mathematics and engineering and directing females to other fields such as natural sciences and education. According to the Trends in International Mathematics and Science Study (TIMSS) 2015 Assessment Frameworks, the number of males enrolled in advanced mathematics programs exceeds the number of female students in 6 countries, while the number of females exceeds the number of males in only two countries (Mullis et al., 2016). This indicates that males are encouraged by their families and teachers to engage in these areas more than females.

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2.1.2. Parental expectation

Parents expectations about the abilities and roles of their children play a major role in shaping and enhancing academic and professional paths. Frome and Eccles (1998) believe that parents' beliefs about the potential of their children in mathematics exceed their actual scores on math tests. The results of a longitudinal study by Bleeker and Jacobs (2004) show that mothers' beliefs about gender roles are what shape their perceptions of their abilities when they reach the age of twelve, and that these perceptions continue to affect the occupational choices of their daughters when they reach the age twenty-four. A study by a team of psychologists at the University of Wisconsin-Milwaukee (UWM) in 2008 also tracked girls and boys in middle and high school as well as second year of college in Milwaukee and Phoenix, to identify barriers to girls and how are affected. The results indicated that the self-confidence that parents cultivate in their children and parents' views of the roles of their children, are more important for young females in the study of mathematics and science in the future. Bleeker and Jacobs (2004) argue that parents often rely on stereotypical evaluations that do not correspond to the actual achievements of their children. For example, parents tend to regard girls as less gifted in math and science, which is an explicit threat to females not to go into these areas in the future. This type of long-term impact by parents can have a significant impact not only on motivation and achievement but also on career choices.

2.1.3. Parental career

Parents' profession is one of the important forms that affect the self-efficacy of their children and hence their future career trends. Mothers' profession has a stronger influence than fathers on females and males career choices, but females are more inclined to follow their mothers' career than males. Many researchers (Hartung et al., 2005; Whiston and Keller, 2004) have found that girls whose mothers work in non-traditional jobs are more likely to compete with males in fields of science and mathematics as girls' professional aspirations are highly associated with their mothers' professions. Ertl et al. (2017) said that parents who work in the fields of STEM support their daughters to follow same and help them overcome difficulties.

2.1.4. Teachers expectations

Stereotypes can be emphasized when children attend school. Teachers reinforce a stereotyping framework that a child brings from the family, with the belief that males are more capable in mathematics than females and such capability is innate (Cooley et al., 1984). Fennema et al. (1990) found that teachers often believe that males' success in mathematics is associated to their own personal factors, while females' success can be attributed to other factors such as dedication and persistence, which again directs males towards mathematics, but not females. The study by the team of psychologists at the UWM referred to earlier has supported this finding, as such study found that both males and females believe that males are stronger in math and science than females. For males, this belief represents a strong support for future orientation towards these two areas but is not so for females. Females are aware of these frustrating expectations by teachers at an early stage, which undermines their confidence and see themselves to be less capable and less efficient than what they actually are. This belief negatively affects females' future orientation towards studying and specializing in these subjects (Beach, 2011).

2.1.5. Community culture

Societal culture plays a major role in stereotyping as some studies conducted in the US have shown that from the age of 12, girls are less interested in science and mathematics because they do not expect to work in these areas, (Buck et al., 2002). The American culture tends to agree that a mathematics subject is normally associated to males (National Science Foundation, 2003). Herbert and Stipek (2005) found that children between the ages of 6 and 7 go with this culture, and by age of 10, females, unlike males, tend to read subjects other than mathematics.

2.2. Second Stage: Factors in Adulthood (University Life)

This stage starts end of secondary school and continues to the end of the university. At this stage, many females graduating from high school possess required skills to succeed in the felids of STEM, but are less likely to pursue such specializations than males (National Science Board, 2010). This is attributed to the following factors:

2.2.1. Classification of specialties based on gender

Studies indicate that the stereotypes which were brought from school begins at this stage to activate the negative messages and destabilize the girls and raise doubts about their abilities and appropriateness to join these specializations as well as career prospects. This belief is also supported by the social environment which classifies specialties on a gender basis. Many girls begin to think that these specializations for men only and consequently reduce their academic performance and their ability to continue (Miyake et al., 2010). Females who enroll in these four fields soon begin to lose confidence in their ability to continue studying, even if they achieve the same results as their male counterparts. In this context, Margolis and Fisher (2002) in a four-year study of females studying computer science at the Carnegie Mellon

University in the US, found that females who showed a good level of confidence, desire and interest in studying computer science in the first interview, declined in the second and third semesters. This finding made the researchers to say that the problem of gradual loss of confidence among females enrolled in these four areas should be addressed as an institutional problem and efforts should be made to limit females' withdrawal from study in these important areas.

2.2.2. Fewer female students in classrooms in STEM

In some studies, the number of females enrolled in STEM is lower than males. According to the Organization for Economic Co-operation and Development, for every three males, only one female graduates from engineering. In Australia, females represented (15.5%) of total enrolled in information technology, and only (15.2%) in engineering. In Canada, (25%) representing females enrolled in mathematics and computer and about (19%) in engineering (Statistics Canada, 2017; Catalyst, 2018). In Europe, although the gap in mathematics and computer sciences has shrunk significantly (42.2%), the gap in engineering and related sciences remains at (27%) in 2015 (Eurostat, 2017). The United Nations Educational, Scientific and Cultural Organization (UNESCO) report of 2017 entitled "Cracking the code: girls' and women's education STEM," stated that the enrollment of girls in STEM in higher education constitutes only (35%), and does not exceed (28%) in research (UNESCO, 2017).

In Bahrain, females in higher education institutions reached (60%) in 2013-2014. Females graduated from science reached (66%) that shows a positive indicator for females' interest to study this specialization. However, female graduates only (27%) which reflects a large gap between males and females. As a result of the low number of females' enrollment in these majors, the number of females in the classroom is shrunk compared to males, which increases the feeling among females that they do not fit as many begin to drop out from these areas and move to other suitable areas seen by the society (Ministry of Education, 2017).

2.2.3. Lack of female faculty members in Universities in the fields of STEM

The number of males' faculty is much higher than females which deepens the gap and sense of isolation among females. For example, the National Science Foundation (NSF, 2013) affirms that the number of males' faculty in engineering is four times females. In Bahrain, male faculty members at the University of Bahrain in engineering college are almost twice the number of females, and thrice in mathematics Department (University of Bahrain, 2017). Dasgupta and Stout (2014) stated that lack of successful models of female faculty members at the universities is an obstacle for female students to continue to specialize in these areas.

2.3. Third Stage: Factors in the Maturity (Professional Life)

Many girls enroll in all fields of higher education, including science, technology, engineering, and mathematics, but not sufficiently present at work or as effective decision makers. According to the National Science Board (2014) females represent (50%) of BSc holders, but they represent a small number of overall manpower in general and in STEM in particular. Furthermore, female representation in jobs related to STEM does not exceed (25%) of the workforce in the US (Beede et al., 2011). A study conducted by the Association of American Psychologists, mentioned that although (20%) of graduates of engineering are females in the past two decades, only (11%) work in engineering. The study, which lasted six years and was conducted on more than (200) universities, (30) of which female graduates are more than males, showed (62%) of the female respondents continued their work as engineers, (11%) did not join the field, (21%) left the job after five years of work, and (6%) of them left the job in <5 years. Within this latter group, two thirds preferred to work in other areas more suitable for them, while a third preferred to sit at home and look after family affairs. They attributed their decision to the inadequate work environment, negative policies towards women, lack of work confidence, and difficulty to manage between work and family requirements (Fouad and Singh, 2011).

In Bahrain, the level of women's participation in high-skill jobs does not exceed (20%) and the gender gap is about (80%) (World Economic Forum, 2017). This is an indicator that females do not tend to benefit from engineering and mathematics specializations for many reasons. Based on literature, the main factors for women's low participation in these important sectors can be summarized as follows:

2.3.1. Bias against women in the work environment

2.3.1.1. Classification of jobs on the basis of gender

The division of functions based on gender, in the contest of stereotypes, is one of bias against females in the society where certain jobs are linked to males and others for females. For example, professions like nursing and education are seen to be related to females, while management positions are more closely related to males (Doering and Thebaud, 2017).

2.3.1.2. Employment bias

Females generally face bias in employment and in STEM in particular, even if females have the same qualifications as their male peers. Williams (2015) found that both males and females prefer to hire males than females in professions that require numeracy skills. Moss-Racusin et al. (2012) conducted a double-blind study, where fictitious application files (CVs and qualifications) were given to faculty members in the science department with male and female names were randomly assigned to each file. It was found that both male and female faculty members in that department rated males as more efficient and more suitable than females to fill in the job and that they deserved higher salaries than females despite having same qualifications. Reuben et al. (2014) found that the probability of male recruitment is twice more than female in jobs related to mathematics.

2.3.1.3. Bias in performance evaluation

One aspect of bias against women is the assessment of scientific outcomes, as females are often considered to be less than male even if the work indicators are identical (Dasgupta and Stout, 2014). Wenneras and Wold (1997) examined the peer review scores given by the Sweden Performance Indicators Review Panel to applicants for postdoctoral grants and found that the review process was full of bias against females. Even when male and female performance

indicators were identical, female indicators were assessed as being less efficient, thus reducing their chances of receiving the grant.

2.3.2. Discouraging work environment

Biases against women create a discouraging work environment and many challenges in women's midlife career, including feelings of isolation, lack of belonging, work overloaded, and unclear rules of success and development (Hewlett et al., 2008) that make females withdraw from professional life.

2.3.3. The inability to create a balance between work and family requirements

Women who work in the fields of engineering and mathematics often fail to create a balance between work demands and family requirements. As a result, stereotypes prevail in pushing women to leave work, as these areas are not suitable for them and create a feeling that women's role is only for family and children caring (Fouad and Singh, 2011).

2.3.4. Birth and maternity barrier

Many women feel guilty after returning back from maternity leave, as the society views the role of mother more than the role of working women, since the first task of women is to take care of children and may lead to weaken performance after childbearing. Williams (2015) conducted a study on a sample of working women, in which two-thirds of women, scientists having children, said that there was a bias against them by their co-workers and doubt on their abilities to carry out work after childbearing. Co-workers assumed that women competences decline after childbearing. Also, women in the study showed that they had to devote more efforts in work to prove themselves and to create a balance between work and children care.

3. CONCLUSION AND SUGGESTIONS

Previous discussion shows that the low number of females in STEM is attributed to cumulative factors including stereotypes that start from childhood and extend to professional life. It is, therefore, important to have a joint effort to overcome these stereotypes and raise awareness with the involvement of all concerned parties including family, school, university, and other community institutions such as media and religious institutions, as these institutions play an effective role in changing concepts and ideas. To bridge the gap, the following suggestions are put forward:

3.1. First: Suggestions for school life stage

3.1.1. Family level

- Change the female stereotype that limits her role and responsibilities in housework such as preparing food and caring for children and encourage her to specialize in simple but professional fields that do not conflict with such responsibilities such as education, health, or professions that do not require high capacities such as agriculture and arts. Make children aware that females and males are equal in capacity, rights and duties in society, and that there is no difference between gender excepts biological composition
- Make male children participate in care of children and carry out household responsibilities to help reduce the burden on future working woman. This step takes her away from the role of stereotyping and the traditional views, to better situations where she can be successful at work and take effective leadership positions
- Involve females in non-school activities related to STEM to deepen their association with these areas.

3.1.2. School level

- Promote the right image of women in the curriculum, by combating stereotypes (Bian et al., 2017; Al Sarabi, 2010; Sulaiman, 2003) instead of restricting the women role in preparing food, washing dishes, and arranging the place. Limiting women's roles within the context of motherhood and household, or in traditional professions such as education or health only are inappropriate. Instead, focus on new roles of women in the society in areas such as engineering, science, leadership and other roles to encourage them achieve better and take leading positions in the future
- Strengthen the cooperation between school and community institutions interested in these areas and organize periodic visits to institutions like scientific exhibitions to provide opportunities for female students to apply theoretical concepts in STEM. This makes them feel important, able to solve people's problems in the society, and develop positive image towards them
- Focus on school communal activities related to these areas as females tend to work collectively, especially if the work is directed towards solving life problems
- Provide appropriate support to encourage female students to participate in international competitions in these areas, such as the Gulf Mathematics and Physics Olympiad competitions, with the need to follow up with the winners and encourage them to specialize in these areas
- Work on developing spatial skills of females, which are essential for success in engineering and scientific fields as studies have shown that males outperform females in these skills (Harris, 1981; Voyer et al., 1995). This can be improved by making females participate in various courses and training activities to enhance their skills and motivate them to think of STEM as options for study and specialization
- Conduct awareness workshops for teachers in general and for mathematics teachers in particular, train them on how to deal with students in mathematics and provide equal gender treatment. Many studies have shown that teachers often care more on male students in the class of mathematics, for example, classroom activities in mathematics are often designed to be more attractive to males than females (Fennema and Person, 1987). This bias in treatment has negative implications for future female professions that are related to mathematics such as engineering and technology. A biased teacher influences the students' desire to enroll in advanced mathematics courses in the secondary school and in their future career choices. Therefore, taking advanced courses in mathematics and science in secondary school is a prerequisite for post-secondary education in engineering and computer science (Lavy and Sand, 2015)
- Incorporate in the curriculum inspiring experiences and biography of outstanding female leaders (especially those were in school) who can be emulated in STEM. The inclusion of successful models is an important positive factor in increasing

the interest of females in these fields. It is preferable to focus on the biography of leading women in the local community because it can inevitably be more convincing for females.

3.2. Second: Suggestions for University life Stage

- Provide good models of successful females in the fields of STEM. This gives opportunities for female students to believe more in their potential to choose scientific careers by seeing other women who have followed this path (Benitez-Herrera et al., 2019), and to meet and learn from the experience of these models of scientists, engineers, researchers, and winners of distinguished prizes in these areas. The number of girls interested in STEM across Europe doubles when they have a role model to inspire them (KRC Research, 2018). Therefore, it is important to connect female students in these fields with successful local and international models through forums and committees specialized in the four fields. Such forums and events include the Association of Women in Engineering, the World Association of Engineers of Electricity and Electronics that provides support for females in engineering. Also, the Committee of Female Engineers in the World Federation of Engineering Organizations chaired by Kuwait, the Engineers Committee of Aramco, the Kuwaiti Engineers Association of the Kuwaiti Society of Engineers, the Association of Omani Engineers, and the Committee of Arab Engineers. All these initiatives and contributions can encourage females to enter these fields and at the same time reduce a number of females leaving such fields
- Eliminate gender bias in faculty recruitment in universities and enact laws that support equal opportunities, thus enhancing the procedures for recruitment and promotion of females in these areas and retaining them. The principle of equality of opportunities should be understood as a principle based on the provision of fair and suitable opportunities for both gender and not necessarily same opportunities
- Cooperation between universities to finance and organize workshops that combat gender bias.

3.3. Third: Suggestions for Professional Life Stage

- Combat labor market divisions and stereotypical perceptions of gender functions, by encouraging women's access to non-traditional vocational training and non-traditional educational programs in the fields of science and technology, and also encouraging men to take part in caring and work usually is conducted by females
- Present models that both males and females play in the transfer of non-discriminatory social norms to positively influence their children's behaviors
- Provide support services for females working in STEM fields, such as providing caring homes and kindergartens in companies they work for at reasonable prices
- Provide training workshops to raise awareness for the importance of avoiding work bias against women and to develop employment standards based on fair criteria
- Increase females' work remuneration in STEM areas to close gender differences
- Extend paid maternity leave of at least six months, where women can work in these areas from home through social media, to encourage them to continue their work
- Amend the labor laws to allow women to work part-time, especially during maternity stage without affecting their rights and status at work
- Combat stereotypes in media which keep women's roles in family, fashion and cooking only. Instead, they should focus on issues related to scientific development and leadership roles in the society
- Promote successful female stories in STEM areas to change society's perception and encourage future female generations to follow and succeed.

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