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Factors Influencing Young Women's Intention to Undertake Science, Technology Engineering and Mathematics (STEM) Education: A Review of Literature

*[1]Sadia Sajid, [2]A.M. Sultana , [3]Jin Kuan Kok , [4]Mobashar Rehman

ABSTRACT--*Globally, women are underrepresented in science, technology, engineering and mathematics (STEM) fields. Although women's participation in higher education is increasing, they are still significantly underrepresented in STEM fields. The under-representation of women in STEM translates into the loss of a critical mass of talent, thoughts and ideas, which hinders countries from reaching their maximum developmental potential. It is important to understand the forces at play, which drive women's choice of STEM education. This could be due to a variety of reasons, including personal (I.e. self-concept, self-efficacy, personal preferences, self-stereotyping and intrinsic motivation) as well as the external factors (i.e. role models, family, teacher's influence as well as low recruitment of women in STEM fields). This paper systematically reviews the literature on young women's intention to undertake STEM education in Malaysian context. The paper also highlights those personal and external factors which have not been studied extensively in Malaysian context. This paper can give readers a novel insight about factors influencing women's participation in STEM education in Malaysia.*

Keywords-- *Science, Technology, Engineering, Mathematics, Gender, Equality, Empowerment, Malaysia.*

I. INTRODUCTION

Gender equality in Science, Technology and Innovation is one of the Sustainable Development Goals of UNDP. The UN General Assembly identifies STE as the fulcrum for economic and social progress. Despite this importance of STEM education for a nation, there is a dearth of women participation in fields associated with STEM. According to a report by AASSA (2014), regardless of efforts by the United Nations (UN) and other international and local organizations, gender inequality and disparity in STEM are still prevalent all over the world. According to a report by UNESCO (2017), there is a global trend of decreasing interest of women in STEM education hence, women are underrepresented in STEM as students as well as a teacher, researchers or workers.

The importance of STEM for economic development of a country makes it imperative that both genders play their roles in this important endeavor. Despite this importance of STEM education for a nation, there is a dearth of women participation in fields associated with STEM. According to a report by AASSA (2014), regardless of efforts by the United Nations (UN) and other international and local organizations, gender inequality and disparity

[1]*Department of journalism, faculty of arts and social science, university tunku abdul rahman, sadiasajid@1utar.my.

[2]Department of journalism, faculty of arts and social science, university tunku abdul rahman.

[3] Department of journalism, faculty of arts and social science, university tunku abdul rahman.

[4] Department of information systems, faculty of information and communication technology, university tunku abdul rahman.

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in STEM are still prevalent all over the world. According to a report by UNESCO (2017), there is a global trend of decreasing interest of women in STEM education hence, women are underrepresented in STEM as students as well as a teacher, researcher or worker.

A number of studies showed that one of the biggest barriers to STEM programs is the continuous perception that it is a male-dominated profession (Lee, 2008). In a study, Sultana (2011) argued that female students are less attracted by engineering education and professions while a greater proportion of women like to enroll in arts, humanities and social sciences. There are several factors which influence women's lack of enrolment in STEM education. The author argued that the origin of this under representation of women in engineering education and profession is largely structural, cultural and ideological. However, according to Smeding (2012), the causes of the underrepresentation of women in STEM education "remain debated".

Furthermore, based on our knowledge, factors influencing young women's decision, especially as early as from high school, to pursue STEM education in Malaysian context, are less explored and are limited. A few studies have been conducted to fill this gap in higher education institutional perspective, however, research on young women's decision making at the high school level is relatively new in Malaysia. Hence, with the help of secondary data in the form of literature, the objective of the present research is to identify the factors underlying young women's decision in pursuing STEM education in Malaysia. Previous literature was reviewed to provide a general picture of the factors influencing the gender gap in STEM Education. For this purpose, data has been gathered from various sources such as journal papers, conference proceeding and theses.

The aim of the present work is to systematically review the current literature on factors influencing female participation in STEM education. Moreover, the present study also aims to highlight those factors, which have been studied extensively in other contexts but have not been discussed extensively in Malaysian context. Hence, following question shall be answered by the present research:

1. Which factors have been identified in literature as for their influence on female participation in STEM education in Malaysian context?

2. Which factors have not been discussed extensively in Malaysian context?

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II. METHODOLOGY

In order to conduct the systematic review, following protocol was adopted, as shown in Figure 1. The protocol has been adopted from PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analysis) (Moher et al, & The PRISMA Group, 2010).

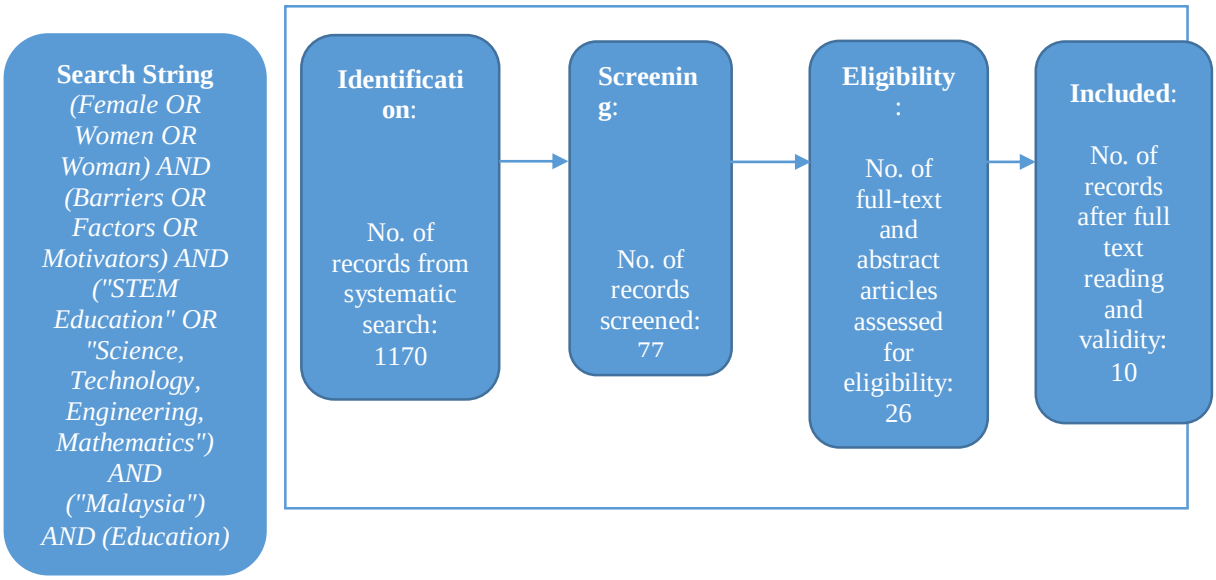

Figure 1: An overview of the search protocol (Moher et al, & The PRISMA Group, 2010)

Search Protocol and Source Selection

In order to answer the above question, search string was used to avoid bias in the search. For this purpose, synonyms of the word female, barriers and STEM were utilized along with Malaysia and Education. The search was conducted on Google Scholar, which provides search results from almost all the major databases. Table 1 illustrates the search string.

Table 1: Search Protocol and Source Selection

Main body of the search string	*(Female OR Women OR Woman) AND (Barriers OR Factors OR Motivators) AND ("STEM Education" OR "Science, Technology, Engineering, Mathematics") AND ("Malaysia") AND (Education)*

Execution of Search

The search on Google Scholar yielded 1,170 results. Firstly, the screening of the search results was conducted based on the relevance of the titles with the research question. As a result, a total of 77 titles were selected for further scrutiny. In the second step, these 67 titles were further scrutinized based on the reading of abstracts and

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full text reading, which resulted in only 26 titles, which were relevant to the objective of the study, hence the remaining 51 titles were discarded.

Inclusion and Exclusion Criteria for Studies

The inclusion and exclusion criteria is shown in Table 2.

Table 2: Inclusion and Exclusion Criteria for Studies

Criteria for Inclusion	**Criteria for Exclusion**
1. The studies which are in the context of Malaysia	1. The non-English research work
2. The studies which are female based	2. The searches such as mini reports, keynote speeches, workshops etc.
3. The studies which mention factors, barriers, motivators about the 1 and 2 inclusion criteria	3. The studies which were not in Malaysian or female context

Validity of the Selected Studies

The validity of the selected studies was assessed by three researchers in the field of education and technology. The researchers scrutinized the list and, based on the research question and inclusion / exclusion criteria, provided their valuable suggestions. As a result, 16 papers were further eliminated which resulted in a total of 10 studies, which were relevant to the research questions and which complied to the inclusion/exclusion criteria set by the present study.

III. RESULTS AND DISCUSSION

Factors Influencing Women Participation in STEM Education In Malaysia

Table 3 highlights the studies as well as the factors which effect female participation in STEM education in Malaysian context.

Table 3: Inclusion and Exclusion Criteria for Studies

Factor	**STEM Area**	**Reference**
• Learning experience • Educational choice • Opportunity equality	Engineering Profession	Abdullah et al. (2018)
• Duration in Preschool	Mathematics	Pang, Mung & Ompok (2015)

• Governmental Policies • Interest • Family Influence • Role Models • Self-efficacy • High Salary • Health • Safety	General	Abu Lail et al (2012)
• Self-Efficacy • Interest	Physics	Halim et al. (2018)
• Work-family conflict • Technostress • Mentorship	Information and Communication Technology (ICT)	Rajenderan & Zawawi (2019).
• Self-Determination, • Grade Motivation • Career Motivation	Biology	Yeoh & Ierardi (2015)
• Governmental Investment	General	Garcia et al. (2015)
• Family structure and women's commitment to family	General	Kranov, DeBoer, & Abu-Lail (2014).
• Low Recruitment at the Point of Entry	General	Goy et al. (2018)
• Access & Skills • Relevance • Empowerment • Combating Stereotypes	Information and Communication Technology (ICT)	Nor, Alrafadi & Hussein (2015)

Apart from the aforementioned factors which are highlighted in the context of Malaysia, prior research in other contexts have also identified various important factors which effect female participation in STEM education, and which have not been studied extensively in Malaysian context. The present research also aims to highlight and elaborate such factors. These factors are personal as well as contextual. Present research highlights five such personal and four external factors.

IV. PERSONAL FACTORS

The first set of factors mentioned in the literature are those which are related to the person herself. Following sub factors have been identified in the literature:

Self-Concept: Self-concept can be defined as "an individual's perception of her skills and capabilities in a specific academic domain" (Kelly, 2016). It is one of the important construct in psychology as well as education (Flowers, Raynor & White, 2013). According to Moller and Marsh (2014), self-concept is formulated externally as well as internally. It is formulated externally when a person compares her performance to that of her peers whereas it is formulated internally when a person compares her performance in a specific subject domain with her performance in another domains. Self-concept can significantly affect a student's performance in a given subject. A student with a strong belief in her abilities can outperform the one who does not have self-belief (Chang, 2008). Based on the definition of science self-efficacy by Sahranavard and Hassan (2012), the present paper defines STEM self-concept as *"the confidence in* one's *own capability to accomplish STEM related tasks through organizing and executing knowledge and skills required to manage a science content or process".*

Self-concept can predict achievement (Hoffman, 2002) as well as a career aspiration (Nagengast & Marsh, 2012) in STEM related subjects such as physics. Prior research (i.e. Kaya, 2008; TIMSS, 1999; West & Fish, 2003) has also found a positive relationship of self-concept with science related achievement. However, according to a survey conducted across various countries, women are more critical about their STEM related self-concept than men (OECD, 2015). AS a result of overly critical self-concept, women believe that their skills in STEM fields are inferior (Wang et al., 2015, Eccles & Wang, 2016). Hence, it is essential to examine the impact of women's STEM related self-concept on their intention to pursue STEM education.

Self-Efficacy: According to Social Cognitive Career Theory (SCCL), one of the important factors which affects a student's decision about career, is self-efficacy (Lent, Brown and Hackett, 1994). It can be defined as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances". (Bandura, 1986). It is different from self-concept (Pajares, 2005), as it is more futuristic and focuses on a person's confidence that he/she can achieve a particular target.

Self-efficacy is also considered as one of the important predictors of persistence, achievement and understanding of STEM related subjects (Cavallo et al., 2004; Lent et al., 1984; Sawtelle et al., 2012). An individual with high STEM related self-efficacy is expected to perform better and persist the STEM discipline (Rittmayer & Beier, 2008). Studies such as Britner and Pajares (2006) found that self-efficacy in science predicts the grades of the student in science class. Although self-concept and self-efficacy are often positively correlated with each other, at times they are distinct. For example, a student might have a high STEM related self-concept but has a low self-efficacy to pass a particular STEM related subject (Rittmayer & Beier, 2008). Similar to self-concept, self-efficacy also strongly predicts women's vocational choice compared to men (Larose et al., 2006). Furthermore, studies like predicted that women lack the belief that they can achieve STEM related goals such as the grades or professions resulting in decreased interest in pursuing STEM (Eccles, 1994; Seymour, 1995). Hence, when studying women's choice in pursuing STEM education, it is imperative to study self-efficacy.

Personal Preference: The personal preference of women in choosing STEM related fields is also one of the important personal factors. According to Sahin et al (2014), personal preferences significantly affect the career choices among students.

According to Kelly (2016), if women find the STEM related subjects as interesting and relevant to their lives, they are more likely to choose them. However, research indicates that due to many reasons, women prefer STEM education lesser than men. Men like STEM subjects more than women, whereas the decrease in interest in STEM education is higher among women compared to men (Akinsowon & Osisanwo, 2014). Hence, it is important to study women's personal preferences in choosing and pursuing STEM education.

Self-Stereotyping: According to the Self-Categorization Theory (SCT), self-stereotyping refers to "a form of depersonalization, by which a person perceives himself or herself as an interchangeable exemplar of a social group rather than as a unique individual". (Turner et al., 1987).

In the case of STEM education, according to Zhu (2006), young women have deep-rooted educational prejudices that science and technology favor male applicants. Hence, they lack self-esteem in high technology fields despite their often much higher grades and performance than their male counterparts. Furthermore, they struggle to balance between family and work life, often feeling that the former has to take precedence over the latter. In a study, Marks and Houston (2002) revealed that the career plans of girls between 15 and 17 years old are heavily influenced by their perception that their 'expected duty' is to take care of children. The study argued that, due to this perception, girls tended to gravitate towards career paths that they believed would offer them the option of work-life balance, or which would be easier to quit in order to raise a family. For such beliefs, women in general prefer to enroll in occupations which are traditionally believed to be feminine. Furthermore, Gadassi and Gati (2009) reported that the tendency towards gender-stereotypical preferences becomes even stronger after university, when some women's aspirations to establish a family encourages them toward more traditionally feminine occupations.

In a study conducted by Farenga and Joyce (1999), it was reported that science and technology was considered to be appropriate careers for boys by both genders. Hence, one can assume that the stereotyping prevalent in the society becomes ingrained in the women's psyche and they start self-stereotyping.

Intrinsic Motivation: Motivation is "an internal state that arouses, directs, and sustains science-learning behavior" (Glynn et al., 2011). Motivation is further divided into two types including intrinsic motivation and extrinsic motivation. Intrinsic motivation refers to an individual's choice of STEM related subjects because she finds them interesting and enjoyable. On the other hand, extrinsic motivation is derived through external factors (Ryan & Deci, 2000). According to Kelly (2016), motivation is important in order to choose a long term career in STEM related subjects. Whereas for women, they place more importance to interests where they are intrinsically motivated (Haussler & Hoffman, 2000; Koul et al, 2011). According to the self-determination theory (STD), proposed by Ryan and Deci (2000), intrinsic motivation is one of the most significant factors to determine the choice of career. Hence, it can be assumed that intrinsic motivation can derive women's decisions to undertake and pursue STEM related education.

V. EXTERNAL FACTORS

***Role Model Influence*:** According to Kelly (2016), presence of role models significantly affects the career preference of women. Similarly, Dimitriadi (2013) also stated that role models have an influence on a young woman's career choice. This study argued that young girls usually lack knowledge of the specific characteristics of occupations, the requirements to study them, and the available career paths, time-frame and career advancement options.

The presence of role models intervenes with the harmful effects of stereotypes surrounding the STEM education (Drury et al., 2011). Furthermore, according to Lockwood (2006), women who read about a female role model, who has successfully graduated in the same field, rated themselves higher for success in that field. Hence, female role models can play a great role in motivating young women to pursue and adopt STEM related education. A number of other studies (Gibson, 2004; DeSantis & Quimby, 2004; Quimby & DeSantis, 2006) elaborated the significance of role models in the career decision-making process.

Family Influence: Some studies show that family influences the decision-making process and inevitably the career choice among young women. According to Corcoran and Courant (1987) a mother's field of work relates to her daughter's choice of occupation especially if the mother is employed in 'traditional' female jobs, like education, administration, or domestic work. Ferry (2006) showed that work-bound youth's parents frequently teach skills that provide her with a broader understanding of parent's or mother's own aptitudes contributing to career choice. The knowledge of parents regarding STEM education also plays a key role (Hall et al., 2011). The study further reported that high school students rated parent's influence as one of the important factors in determining their career choice. Hence, it can be safely assumed that parents strongly influence the choice of STEM education in various ways.

Teacher's Influence: According to Rose Amnah (2016), it is essential for the STEM teachers to be equipped with the right knowledge and teaching approach right from the primary school onwards. The author further posits that the reason that Malaysia has been unable to achieve its targets of high enrollment in STEM education is first and foremost due to the lack of effective teaching approaches. According to Allen (2003), a teacher having a major in the STEM subject which he is teaching is directly linked with student's STEM related achievement. Students who pursue a particular STEM related subject relate usually relate it to their teacher of that subject in secondary school (Kessels & Taconis, 2012). In reference to women participation in STEM, according to Stout et al., (2011), the presence of a female teacher who teaches STEM related subject improved women's self-concept and attitude towards that particular subject. On the contrary, the lack of female teachers in the fields of STEM further strengthens the perception that STEM is a female related field (Kelly, 2016). Furthermore, the influence of a faculty member increases, as a role model and advisor, when he or she is perceived to be enjoying their lives outside work (Fehrs & Czujko, 1992).

Low Recruitment: The recruitment of women to STEM has historically been low. Goy et al (2017) conducted a study on gender disparity in STEM education in higher learning institutions and concluded that under-

representation of women in engineering was attributed to low recruitment at the point of entry. In order to improve female representation in STEM related subjects, it is important to improve the recruitment of women in STEM fields (Cohen & Deterding, 2009). Despite their ability to outperform men in the grades of STEM related subject, women are less likely to choose STEM career compared to their male counterparts (Ceci & Williams, 2010).

VI. CONCLUSION

Women are constantly underrepresented in STEM related fields and it is important to understand the precursors of such underrepresentation. Hence, based on literature, the present study has identified personal as well as external factors. Personal factors such as self-concept, self-stereotype, personal preferences and intrinsic motivation as well as external factors, including role models, family and teacher's influence are proposed to effect the self-efficacy of women. The self-efficacy will in turn effect the intention to pursue STEM education, moderated by the low recruitment.

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