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STEM Career Interest: The Effect of Gender

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Abstract

The issue of women being underrepresented in STEM careers has become a global concern. Literature review shows that imbalance in STEM careers based on gender is due to intrinsic and extrinsic factors. Thus, this study investigated the intrinsic and extrinsic factors that contribute to STEM careers' interest. STEM career interest based on gender was also investigated. 354 secondary school students (14 years old) responded to a questionnaire. Descriptive and inferential statistics (MANOVA) were employed. The students showed a medium-high level of interest in STEM careers. Boys tend to show higher interest compared to girls. Therefore, all parties need to play their role in creating a positive perception of STEM careers by considering the needs of male and female students.

Keywords

Social Influences, Media, Self-Efficacy, Perception, STEM Career, Gender, Learning Experiences

1. Introduction

The science, technology, engineering and math fields are central to finding possible solutions in addressing sustainable development in areas of current global concern and challenges such as climate change and health epidemics (Cridge & Cridge, 2015). In addition, women tend to shy away from STEM (UNESCO, 2017). Hence, disparity in gender-based predisposition is an aspect that needs to be given attention in increasing the number of students in STEM (Department of Education UK, 2009; Riegle-Crumb et al., 2012). Moreover, this imbalance between male and female students will have an implication for the socio-economic and politics of a country in the long run (Jelas et al., 2014).

Previous studies have shown inconsistencies in findings on the time when students develop their predisposition towards the STEM fields despite male and female students having the same level of commitment in relation to Science and Mathematics (Xu, 2015). Studies by Riegle-Crumb et al. (2012), Bottia et al. (2015), Shapiro and William (2012) revealed that students' predisposition toward a certain field begins at the primary school level. Nevertheless, according to Wang and Degol (2013), what students learn at the secondary school level has a strong influence when they make choices regarding the field of study at the tertiary level. As students at 14 years old are in the exploration stage in Super's career development theory, it is therefore vital to examine students' predisposition in selecting STEM fields and careers at this stage to plan interventions that could lessen the gap between male and female students.

Previous studies have shown that researchers are keen to investigate factors that have influence on male and female students when making choices to further their studies in STEM-related fields. Among the factor that has been identified is achievement in Science and Mathematics (Wang & Degol, 2013; Griffith, 2010; Leaper, Farkas & Brown, 2012; Riegle-Crumb et al., 2012; Weeden et al., 2015). Nevertheless, students who were high achievers in STEM did not choose to involve in STEM. Hence, there are studies that reported lack of confidence in STEM-related fields (Morgan, Gelbgiser, & Weeden, 2012; Weeden et al., 2015; Balakrishnan, Foon, & Azman, 2015), lack of interest (Griffith, 2010; Morgan, Gelbgiser, & Weeden, 2012; Shapiro & Williams, 2012; Wang & Degol, 2013), and lack of social support which also influenced STEM career choices.

Additionally, perception of work is also a factor that contributes to the selection of a field. Among the factors that influence career selection based on gender are religion, culture, social and psychological factors. As an example, female students want to engage in health-related occupation such as medicine, pharmacy and education—it is a career associated with the desire to help others. The lack of involvement of women in the fields of STEM is also due to gender-stereotypes whereby the old assumption is that scientists having masculine quality are believed to be more competent. However, women having this quality are seen as aggressive. This biased situation benefits men but is a disadvantage to women in scientific careers (Buday et al., 2012; Atkins, 2013; Sahin et al., 2015). In addition, female students are seen as predisposed towards pursuing courses that provide them with a suitable job scope for when they are married (Morgan, Gelbgiser, & Weeden, 2012). Female students feel that STEM-based careers are not suitable when they later have a family of their own (Balakrishnan, Foon, & Azman, 2015).

Therefore, the aim of the study is 1) to determine the level of students' extrinsic (Learning Experiences, Social and Media Influence) and intrinsic factors (Self-efficacy, perception and interest in STEM Careers) and 2) to investigate the effect of gender on the extrinsic, intrinsic and STEM interest careers. Such findings aim to provide a solution to re-address the issue of imbalance in male and female involvements in the STEM fields. The identified solutions could provide a guide to the development of suitable interventions for students based on gender in improving career choice in the STEM fields. In addition, the novelty of this research, is to illuminate, what factors affect the STEM careers according to gender especially in the context of Malaysia—since Malaysia is seen, among the developing countries, as able to attract and sustain girls in STEM and STEM careers (UNESCO, 2017). Hence the findings could be served as a benchmark for other developing countries.

2. Literature Review

Psychologists often carry out research to investigate the differences that exist between gender (Guimond et al., 2007). Psychology introduced the concept of gender-stereotype which refers to the differences between male and females in all things (Deaux & Major, 1987). Research on gender disparity in science education was pioneered by Field and Copley (1969) whereby their study focused on gender differences (in Australia and the United Kingdom) in terms of their cognitive styles and achievement. The study suggested that there are psychological differences between gender in terms of information processing whereby is an advantage for male students compared to females.

Basically, the percentage of women who further their studies at the tertiary level compared to men is higher globally (Department of Education UK, 2009; Yazilitas et al., 2013). However, the percentage of women in STEM in higher education is lower compared to men because women have lower abilities in those subjects (Riegle-Crumb et al., 2011; Beede et al., 2011; Riegle-Crumb et al., 2012; Yazilitas et al., 2013). As an example, the field of physical sciences and engineering is dominated by men (Beede et al., 2011; Balakrishnan, Foon, & Azman, 2015). In contrast, female students are more likely to choose fields such as humanities (Riegle-Crumb et al., 2012; Institute of Physics, 2015), literature (Shapiro & Wlliams, 2012; Institute of Physics, 2015) and education (Myers, 2008; Beede et al., 2011).

The same scenario also occurs in Malaysia where enrolment of females is higher than males in public institutions of higher learning (IPTA) (MOE, 2014); however, the involvement of female students pursuing courses in STEM fields is lower compared to male students. Results of a study conducted by the MOE (2013) showed that females were concentrated in the fields of social sciences, education and law. In contrast, males were more likely to choose engineering, manufacturing and construction (MOE, 2013).

The involvement of women in Science is often constrained by several factors such as family, classroom teaching, attitude as well as cognitive ability. In addition, the limitation of female involvement in STEM fields is due to limited employment opportunities and lack of support (Xu, 2015), resulting in the lower number of women participating in Science compared to men. In addition, the involvement of female students during sessions of science learning is passive compared to male students who are often very active (Jovanic & King, 1998; Arsaythamby & Nor, 2012). Female students are seen as more likely to be reading instructions and recording the findings of the experiments compared to male students who would be actively using the equipment and materials while conducting experiments (Jovanic & King, 1998) especially during the teaching and learning of physics (Arsaythamby & Nor, 2012).

Therefore, in order to overcome the problem of male and female students' ability, Harwell (2000) suggested active approaches such as experiments, hands-on, observation or a combination of the approaches to encourage female students to be more predisposed towards learning science-related fields. Through such an approach, the involvement of female students which oft-times is passive can be altered to become more active. The study by Scantlebury (1994) recommended that teachers diversify their feminine-natured teaching style which could enhance the female students to pursue pursuing studies in fields related to Science. Hands-on activities are aimed to enhance female students' interest towards education and career in Science and subsequently contribute to more students in STEM. Furthermore, Griffith (2010) argued that the element of school environment and promotion carried out by schools or institutions was found to be able to attract the interest of students to pursue STEM fields when at the secondary level and subsequently continuing studies at the tertiary level in those fields (Hayden et al., 2011).

It can therefore be concluded that the women in STEM fields is lacking due to both the environmental and internal factors. Internal factors such as self-efficacy, perception of and STEM careers are influenced by environmental factors, namely learning experience, social influence from parents, family, teachers, peers, counsellors, community and influence from the media. Thus, interaction between each of these factors impacts female and male students in choosing their career.

3. Research Methodology

Study Context

This study was carried out in the Malaysian context, involving Form Two students (14 year olds). The research questions were i) To determine the level of extrinsic and intrinsic factors among students in general and ii) To compare the effect of gender on extrinsic and intrinsic factors and on STEM career interest.

Sample

The respondents were sampled from various types of schools (public, boarding and Junior Science College). These type of school were selected to represent all categories of students in terms of level of achievement in Malaysia. A total of 101 Form Two students were selected from a public school, 119 Form Two students from a boarding school, and 134 Form Two students from a Junior Science College. The number of respondents was 354 students.

Research Instrument

The questionnaire used in the survey was mostly adapted from literature except for the sub construct of learning experiences which was constructed by the researchers. The items constructed focused on classroom STEM teaching and learning strategies while for items of STEM outdoor activities, focused on visiting science centers and participating in STEM camp programs.

For the development of items related to the constructs of social influence, self efficacy, perception of STEM and interests can be found in Halim et al. (2018). The sub constructs of each constructs is shown in **Table 1**. To ensure validity of the instrument, a panel of experts comprising of science educators in the field of STEM was consulted. The pilot test was conducted on one class at a public school involving 36 students. All the items for each construct and sub-constructs have high realibility (0.817 - 0.933) (see **Table 1**).

Table 1. Constructs, sub constructs and Cronbach's alpha value.

No	Constructs	Sub constructs	Alpha Cronbach
1	Learning experiences	In the classroom	0.704
		Outdoor	0.833
2	Social influence	-	0.817
3	Media influence	-	0.933
4	Self-efficacy	Science	0.892
		Technology	0.849
		Engineering	0.856
		Mathematics	0.897
5	Perception of STEM careers	Prospect	0.858
		Needed skills in STEM careers	0.873
6	Interest in STEM careers		0.863

Data collection

The survey was administered to the respondents by the researchers themselves. Prior to the data collection, an approval letter was acquired from the Ministry of Education, District Education and the school principals respectively. The respondents were informed of the objective of the study, and explain the format of the questionnaire and what is expected of them. Finally, the students were informed that all responses will be anonymous and the outcome is for the purpose of research only.

Data Analysis

Descriptive statistics to measure the level of factors was determined through the mean value (see **Table 2**). MANOVA was used to determine differences in

Table 2. Mean value and interpretation.

Mean Score	Interpretation
1.00 - 2.50	Low
2.51 - 5.00	Medium Low
5.01 - 7.50	Medium High
7.51 - 10.00	High

(Adapted from Nunnally 1997).

terms of extrinsic and intrinsic factors based on gender.

4. Findings

Demographics of Respondents

The respondents were Form Two, secondary school students (14 years old). Of these students, 174 of them are male whereas 180 are female students (see Table 3).

Table 3. Demographics of respondents (N = 354).

Variables	Description	Total (No. of respondents)
Gender	Male	174
	Female	180

RQ1: What is the Students' Level of Extrinsic and Intrinsic Factors and Interest in STEM Careers

Based on Table 4, it was found that STEM-related learning experienced by the students was mostly acquired in the classroom compared to acquiring it from outside the classroom. For social influence, the students were most influenced by teachers, followed by friends, parents, family members, counselors and the community. The findings also showed that the community played the least role in fostering students' interest in STEM. Among the 10 types of media that provided information related to STEM, students were more likely to obtain it through comics, followed by movies, books, games, newspapers, television, the internet, magazines, radio and lastly social media.

Table 4. Level of learning experiences, social influence, media influence, self-efficacy, perception and STEM careers interest (n = 354).

Factors	Mean	Std. Deviation	Interpretation of Mean
Learning experiences	**5.008**	**1.358**	**Medium high**
Classroom activities	6.441	1.399	Medium high
Outside of classroom activities	3.781	1.744	Medium Low
Social Influence	**5.966**	**1.620**	**Medium high**
Teachers	7.768	2.182	high
Peers	6.766	1.994	Medium high
Parents	6.761	2.143	Medium high
Family members	6.220	3.412	Medium high
Counselors	4.486	2.719	Medium low
Community	3.285	2.301	Medium low
Media Influence	**5.485**	**2.372**	**Medium high**
Comics	6.274	3.169	Medium high

Continued

Movies	6.240	2.980	Medium high
Books	6.048	3.011	Medium high
Digital games	5.862	3.211	Medium high
Newspapers	5.819	3.066	Medium high
Television	5.788	3.073	Medium high
Internet	5.319	2.958	Medium high
Magazines	4.918	2.976	Medium low
Radio	4.322	2.843	Medium low
Social Media	4.254	2.703	Medium low
Self-Efficacy	**6.915**	**1.366**	**Medium high**
Technology	8.764	1.479	High
Mathematics	6.720	1.931	Medium high
Engineering	6.305	2.086	Medium high
Science	5.871	1.891	Medium high
Perception of STEM Careers	**7.448**	**1.330**	**Medium high**
Prospects in STEM careers	6.921	1.496	Medium high
Skills needed in STEM careers	7.265	1.572	Medium high
Interest in STEM Careers	**6.050**	**1.726**	**Medium high**
Medical science	6.859	2.704	Medium high
Computer science	6.463	2.647	Medium high
Entrepreneur or business scientists	6.314	2.714	Medium high
Physics	6.237	2.716	Medium high
Chemistry	6.209	2.629	Medium high
Biology and Zoology	6.161	2.807	Medium high
Earth science	6.116	2.661	Medium high
Educator scientists	5.963	2.775	Medium high
Mathematics	5.867	2.846	Medium high
Engineering	5.681	2.889	Medium high
Energy	5.444	2.724	Medium high
Environmental Works	5.282	2.587	Medium high

For intrinsic factors, students revealed a high level of self-efficacy in the field of technology, followed by the other fields. Students' perception of STEM careers (i.e. prospects and required skills in STEM jobs) were scored at a high level. The field of STEM career that is most in demand by the students was medical science, followed by computer science, business and entrepreneurial scientists, physics, chemistry, biology and zoology, earth science, scientists, educators, mathematics, engineering, energy and environment.

In general, students showed medium high interest in the varied STEM careers with the top interest in the medical sciences careers and the least interest in careers that appear to be less oriented person types of jobs such as in the field of energy and environmental works.

RQ2*: *Comparison of Extrinsic Factors* (*Learning Experiences, Social and Media Influence*) *Based on Gender

Three factors were measured under extrinsic factors i.e. learning experiences, social influence, and media influence. M Box test was conducted to determine whether MANOVA analysis could be pursued. The outcome of the test the variance-covariance was not significant. Similarly, there were no significant differences found in Levene's test. Hence the multivariate test—MANOVA was appropriate for analysis. The MANOVA analysis (see Table 5) showed there were no significant differences in terms of gender for the three extrinsic factors.

Table 5. Comparison of MANOVA analysis on the extrinsic factors (Learning experiences, social influence, and media influence) based on gender.

Groups	N	*Wilks' Lambda Value*	F	Df between group	Df within group	Sig.	Partial η^2
Male	174	0.985	1.722	3	346	0.162	0.015
Female	180						

*Significant at level < 0.05

Comparisons of Intrinsic Factors* (*Self-efficacy, perception and interest in STEM Careers*) *based on Gender.

Three factors were measured under the intrinsic factor category. Findings in Table 6 showed there exists a significant difference for all the intrinsic factors based on gender. The value of Wilks' Lambda = 0.960; F (3, 346) = 4.845, p = 0.003 ($p < 0.05$). The partial eta squared = 0.040 η^2 showed that 4% of variance in intrinsic factors was contributed by gender differences. Nevertheless, the effect size was small (Cohen 1988).

Table 6. Comparison of MANOVA analysis on intrinsic factors (Self efficacy, perception and interest in STEM Careers) based on gender.

Groups	N	*Wilks' Lambda Value*	F	Df between group	Df within group	Sig. Level	Partial η^2
Male	174	0.960	4.845	3	346	0.003*	0.040
Female	180						

*Significant at level < 0.05.

Results in Table 7, showed there were no significant differences in self-efficacy and perception of STEM careers based on gender. For interest in STEM careers, there were significant differences based on gender (male higher interest compared to female) as indicated by the Alpha Bonferroni level (0.05/3) = 0.017.

Table 7. Test of between-subject effects on intrinsic factors based on Gender.

Intrinsic Constructs	Groups	Mean Score	F	Sig. (p)	Partial η^2
Self-efficacy	Male	6.877	0.591	0.443	0.002
	Female	6.774			
Perception of STEM Careers	Male	7.348	0.331	0.566	0.001
	Female	7.428			
Interest in STEM Careers	Male	6.291	10.166	0.002*	0.028
	Female	5.717			

*Significant at level < 0.017.

5. Discussion and Implications

The STEM fields that the students are interested in were the medical sciences, followed by computer science, business or entrepreneur scientists. The students showed less interest in the field of environmental works. This finding indicates that the students do not know much about the job prospect in that field. Therefore, counselors need to actively disseminate information on job opportunities in STEM (Dahir, Perepczka, & Shea, 2014; Hall et al., 2011). This is because the students only recognized 'famous' or 'popular' work in the field of STEM or those jobs they are familiar with such as doctors, engineers, architects, teachers, astronauts, and pilots. However, STEM careers such as surveyors, and air traffic controllers were not well-known by the students. Students need introduction to these jobs need thus students' might change their perception of STEM careers. In addition, the school counselors should foster cooperation among school administrators, teachers, scientists, students, family, community and colleagues as an effort to increase students' interest in STEM careers (Dahir, Perepczka, & Shea, 2014).

Students' learning experiences were acquired mostly through classroom activities than outside of the classroom activities. Thus, more classroom activities must be carried out outside the classroom as argued by Venville et al. (2013) curiosity about the world thus passion for science are important factors in STEM interest. In order to increase passion and curiosity, teachers are to arouse students' curiosity through fun-learning activities and by applying the skills that are required in the STEM fields. In addition, the instructors or facilitators engaged in informal learning should also have the competencies in STEM process skills as well as STEM pedagogical Content Knowledge to ensure the effectiveness of STEM activities.

Teachers are important to the enculturation of students' affinity in STEM careers. Therefore, teachers' teaching styles should support students' tendency towards STEM learning and careers. Teachers should use interesting teaching aids, have effective communication, be enthusiastic in teaching STEM and relate the subject matter with everyday life application through effective communication with students (Nugent et al., 2015; Sahin et al., 2015; Shumba & Naong, 2012; White & Harrison, 2012). Peer interaction could also foster students' attention in STEM education and careers. Peers often share the same interests and therefore could motivate each other in learning, and influence each other in course and career selection (Buday et al., 2012; Cridge & Cridge, 2015; Nugent et al., 2015).

Parents also play supporting roles in fostering students' STEM education and careers interest since parents are the first few individuals to provide an overview of careers to their children. Parents also strive to provide the best education for their children by sending them to tuitions, providing finances for education and helping their children in the decision-making of career selection. All of these indicate that parents have a crucial role in consideration of their children's future job planning (Hall et al., 2011). Therefore, the counselors should also inform parents of STEM careers. The effect of the community is not as strong as the role of teachers and parents from the students' perspective. Thus, informal STEM education such as carnivals, camps, and campaigns should also be actively implemented by the community.

Media also plays a role and the form of media that is mostly used by students to gain STEM knowledge is via comics, followed by movies related to STEM. This shows that students like fun-learning materials. Books are also an important source for students to get information on STEM. However, social media such as Facebook and Twitter are not used much by the students to discuss about STEM. Therefore, all relevant stakeholders should be actively involved in discussing and promoting STEM programs through social media. Social media is an attractive platform and is more user-friendly for fostering interest among students in this 21st century. STEM activities and prospects of STEM jobs can also be displayed in digital view in terms of providing the necessary resources for students as well as for teachers.

The interest in STEM careers that exist between males and females will cause an imbalance in job domination in the STEM fields based on gender. It will also lead to women facing the challenges of professional socialization (Xu, 2015). Previous research shows that women have less interest in engineering, but more interest in the field related to environment and energy (Sahin et al., 2015). These differences are due to the influence of cultural belief based on gender in making decisions related to career (Koul et al., 2011). For example, girls have the perception that STEM jobs are physical oriented,, involve working in research laboratories only, result in them having less time to socialize and with their family, and the pay is low (Xu, 2015; Wang & Degol, 2013). Thus, factors related to career identity (Atkins, 2013; Beede et al., 2011; Buday et al., 2012; Sahin et al., 2015) need further researched. In addition, teachers have an important role in bridging the gender imbalance occurring in STEM careers. Teachers need to plan activities that are more hands-on and minds on because these activities have been identified to be more relevant to female students (Hayden et al., 2011; Sahin et al., 2015). In addition, inviting women engineers as role models is one of the ways to encourage female students to engage in STEM careers (Sahin et al., 2015; Shapiro & Williams, 2012).

6. Conclusion

This study has examined factors affecting STEM careers in students and the role of gender. It has been shown that the STEM careers among students were at the medium-high level. Hence, the teachers, parents, counselors, the community and media should continuously play their respective roles in nurturing STEM careers interest. It is also important to note that regardless of types of factors, extrinsic or intrinsic, male and female students do not face significant differences. Thus, educational policies and strategies in Malaysia can be considered gender unbiased. Such findings can serve as underlying reasons for the consumption of countries that may face gender exclusiveness in STEM and its related careers. However, this study suggests gender does influence their interest in STEM despite the educational activities that are not seen bias by the students themselves. Thus, more effort in disseminating information and portraying role models in the varied STEM careers is necessary to avoid gender-stereotypes in STEM careers. In addition, other factors might contribute to this difference—such as one's identity in a STEM career—which would be an agenda for a future study.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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