



**Abstract.** *Studies have shown that various factors (the role of formal education, informal education, and community) contribute to the lack of participation in STEM and STEM careers. This research aimed to understand the multi pathways of factors contributing to the interest in STEM careers (STEM careers in physical sciences and STEM careers in life sciences). This research was a survey research which administered a questionnaire randomly to 1485 secondary school students (14 years of age). Data analysis was based on the Structural Equation Modeling (SEM) approach using Analysis of Moment Structures (AMOS) to test the hypothesized model. A model containing five constructs, namely environmental factors (learning experiences, media, social influences), self-efficacy in science, technology, engineering and mathematics respectively, perceptions of STEM careers and interest in physical sciences and life sciences STEM careers was proposed in this research. The results show that students' interest in life sciences based careers is influence by their self-efficacy and perceptions of the career. Meanwhile, students' interest in physical sciences based careers is influence only by their self-efficacy and not influence by their perceptions of the career. The need to improve students' self-efficacy through STEM learning experiences is imperative to ensure continued interest in STEM careers.*

**Key words:** *environmental factors, life sciences STEM careers, perceptions of STEM careers, physical sciences STEM careers, self-efficacy, social cognitive career theory.*

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## A MODEL OF INTEREST IN STEM CAREERS AMONG SECONDARY SCHOOL STUDENTS

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### Introduction

With the advent of Fourth Industrial Revolution (4IR), workers with skills in STEM are considered important more than ever. Not only knowledge and skills in STEM are important for driving innovation but these knowledge and skills are important in order to survive the impact of 4IR. It is projected (MOSTI, 2015) that Malaysia needs 500,000 workers in STEM in 2020. However, involvement in STEM among students in Malaysia is declining, not only in schools but in higher education institutions as well (Halim & Subahan, 2016). Nonetheless, this problem is not unique to Malaysia as it is also faced by other countries. For instance, America announced having a tough time filling STEM careers which are unfilled because of a lack of participation in STEM fields (Wyss, Heulskamp, & Siebert, 2012).

According to Bahar and Adiguzel (2016) and Hawley, Cardoso and Mc-Mahon (2013), 20 percent of all vacancies in America require STEM related experts and some reports have indicated that there is a potential of 2.8 million job openings by 2018. Turkey likewise encounters a similar situation (Bahar & Adiguzel, 2016; Maltese, 2008) where 18 percent of all national vacancies in the country are for STEM-related jobs. The disparity in growth in the graduate and STEM-related vacancies demonstrates a widening gap, indicating the increasing demand for STEM experts. In other words, the chances of employments are higher for STEM graduates. However, while the demand for workers specializing in STEM-related fields is continuously growing, the enrollment at the graduate level is consistently recording a decline, leading to gaps in employment.

Tai, Liu, Maltese, and Fan (2006) argued that students tend to make decisions about their career at middle or lower secondary school. According to Eccles et al. (2003), teenagers have a tendency to investigate new things including making plans for their future. However, these students may not get enough exposure to STEM careers. Thus, the students may make decisions about their career based on insufficient information of the career. Therefore, it

is imperative that students are provided with accurate information and appropriate guidelines about STEM careers so that these lower secondary school students would be able to make effective decisions about their career choice and path. Along these lines, it is therefore critical to encourage students' attitudes, interest and perception that would lead to career aspirations in STEM-related careers (Wyss, Heulskamp, & Siebert, 2012).

There are many STEM careers offered to graduates, for example physics, chemistry, biology, zoology, environmental works, and computer science to name a few. In this research, the students' choice in selected STEM occupation is seen as students' interest in STEM careers which is divided into two categories, namely physical sciences STEM careers and life sciences STEM careers. Students' interest in STEM careers is affected by various factors and many studies have investigated the factors that influence interest in STEM careers (Bahar & Adiguzel, 2016; Franz-Odendaal, Blotnicky, French, & Joy, 2016; Kauffmann, Hall, Batts, Bosse, & Moses, 2009). This research continues the research of previous studies by adopting most of the factors investigated earlier but at the same time extends the research to the context of a developing country, specifically Malaysia where STEM careers are still viewed as a prestigious career. However, students are shying away from these STEM careers and one possible new factor is related to students' and parents' perceptions of the prospect in STEM careers.

## Literature Review

Various studies have examined the factors influencing interest in STEM careers. For example, Bahar and Adiguzel (2016) examined the factors affecting students pursuing profession in STEM based disciplines. They employed the Social Cognitive Career Theory (SCCT) theorized by Lent, Brown and Hackett (1994) as their theoretical framework. In Bahar and Adiguzel's (2016) research, the factors selected were founded on the hypothesis that students' interests in STEM jobs are formed by major constructs including self-efficacy, outcome expectations, and goal orientation as suggested by SSCT. Apart from these major constructs, there are sub-constructs which include people (family, teachers, peers, relatives, etc.), school-related factors (courses, clubs, competitions/fairs, classroom activities, outside classroom activities, etc.), self-motivation and occupational expectations.

Moreover, prior studies have recognized a few important factors that directly and/or indirectly influence students' interest in STEM careers. For example, student's own self-motivation, the quality of science and mathematics courses offered at school, parents, teachers, and school-related factors have all been shown to have either direct and/or indirect influence (Halim, Abd Rahman, Zamri, & Mohtar, 2018; Kauffmann et al., 2009). Franz-Odendaal et al. (2016) found that factors influencing perception of students' interest in STEM careers include the students' own perception about STEM careers, classroom culture and self-efficacy in STEM related fields. In addition, Franz-Odendaal et al. (2016), Husin, Said, and Halim (2017), Kauffmann, Hall, Batts, Bosse, and Moses (2009) and Shahali, Halim, Rasul, Osman, and Zulkifeli (2017), in their research found that factors influencing perceptions in STEM careers also include employing the best curricular practices in the classroom, outside the classroom and in after-school activities. Based on the various factors identified, this current research categorized the factors into three main constructs in order to test the model. These factors affect secondary school students' interest in STEM careers either directly or indirectly.

### *Environmental Factors*

Vrankrijker and Napel (2017) defined environmental factors as the physical, social and attitudinal condition in which individuals live and direct their lives. The factors can act as a catalyst and barrier. In this research, three sub-constructs of environmental factors were tested in the model, namely learning experiences, social influences and media. Learning experiences and media are under the category of services, system and policies while social influences are under the category of support and relationship. Learning experiences include experiences inside and outside the classroom. For learning experiences in the classroom teaching strategies that are students oriented such as problem based learning are common in the STEM education literature (Wyss, Heulskamp, & Siebert, 2012). Meanwhile, informal STEM education can be implemented in places such as the museum and science center (Chi, Dorph, & Reisman, 2014; Franz-Odendaal et al., 2016; Husin, Said, & Halim 2017). According to Chukwuemeka (2013), STEM's education-related media include reading materials such as books, magazines or encyclopedia, and supplementary audio-visual materials such as radio and television. Media can also include any device with learning substance or capacity that is utilized for learning such as STEM kits for construction or practical work. For social influences, parents and friends are the closest inspiration to students and they may influence students' perceptions of STEM career and self-efficacy (Halim et al. 2018; Interactive, 2011; Kaiser, 2016).



### *Self-efficacy in STEM*

Burwell-Woo, Lapuz, Huang, and Rentsch (2015) stated that there are two aspects to address in order to encourage secondary students to plan for STEM jobs. The first is by expanding their initial enthusiasm and knowledge in STEM disciplines and the second is to improve their STEM self-efficacy. Self-efficacy is defined as individuals' beliefs about their capability to execute a specific task that in turn affect their lives (Burwell-Woo et al., 2015; Rittmayer & Beier, 2008). According to Rittmayer and Beier (2008), students with high science self-efficacy will motivate themselves to stipulate challenging goals and strive towards accomplishing those goals. In other words, STEM self-efficacy is able to envisage one's academic performance beyond one's earlier attainment because assertive individuals are inspired to succeed. Therefore, students' STEM self-efficacy is positively related to STEM task performance interest and engagement (Rittmayer & Beier, 2008).

According to Tracey (2010), career counsellors acknowledge the importance of using both the interest and self-efficacy assessments in identifying and determining one's possible career choice. Career counsellors acknowledge the importance of using both the interest and self-efficacy assessments in identifying and determining one's possible career choice. Lent, Brown, and Hackett (1994; 2000) concurred that both self-efficacy assessments and interest are crucial in career decisions but further argued that self-efficacy drives to interest development and hence induces career preferences. In this present research, self-efficacy for STEM refers to the students' beliefs about their ability to perform in science, technology, engineering and mathematics respectively.

### *Perceptions of STEM Careers*

STEM career requires individuals with skills in science, technology, engineering and mathematics and these people often have better job prospects and a wider choice of rewarding careers (Holman & Finegold, 2010). However, the requirements for STEM skills, qualifications, requirements and job prospects are not presented clearly to students (Holman & Finegold, 2010). Thus, students may not be interested in STEM careers (Wyss, Heulskamp, & Siebert, 2012). On the other hand, Morgan, Issac, and Sansone (2001) argued that when an undergraduate college student has positive perception of a career, it will most likely positively predict their career choice. Their research demonstrated a clear link between undergraduate college students' perception and interest in a career; however, this is relatively unexplored among students of a younger age range especially at the secondary school level.

Students' basic knowledge of career requirements, for example the skills needed and the job prospect, can significantly impact their perception of what a particular STEM profession entails (Franz-Odendaal, Blotnick, French, & Joy 2016; Wyss, Heulskamp, & Siebert, 2012). In their research of 568 middle school children, Franz-Odendaal et al. (2016) found that students will not follow careers that they are not familiar with. Wyss, Heulskamp, and Sibert (2012) further argued that when students have negative views of STEM professions, the students may be left out in developing interest in the process during the formal schooling. The research also revealed that students are unaware of the types of skills suitable for various types of STEM careers. (Franz-Odendaal et al., 2016). This is consistent with research findings by Wyss, Heulskamp, and Siebert (2012) who found that middle school students' interest of particular occupations is linked to their perceptions of the career.

### *Interest in STEM Career*

STEM encompasses a wide variety of career paths, ranging from medical science, forensic research, data analytics and cyber security to game design and aviation just to name a few. However, students are not so familiar with these kinds of jobs unlike jobs like doctors, engineers, and accountants. The research conducted by Bodzin and Gehringer (2001) tried to make science authentic to students. Physicists were invited to talk to upper primary students about physics and the work of a physicist specifically and scientist in general. In their research, the students were asked to draw a scientist prior to the visit and four weeks after the visit. Studies such as the one by Bodzin and Gehringer (2001) showed that students have a stereotypical view of a scientist. The students' view was identified through the students' drawings of a scientist. The researchers suggested that students should be given a chance to interact with scientists during formal schooling as it would influence students' interest in STEM careers as well as overcome students' misconceptions of scientists as identified through their drawings.

According to Bodzin and Gehringer (2001), students are not interested in STEM careers because most schools do not disclose information about STEM professionals to their students. On the other hand, Wyss, Heulskamp, and

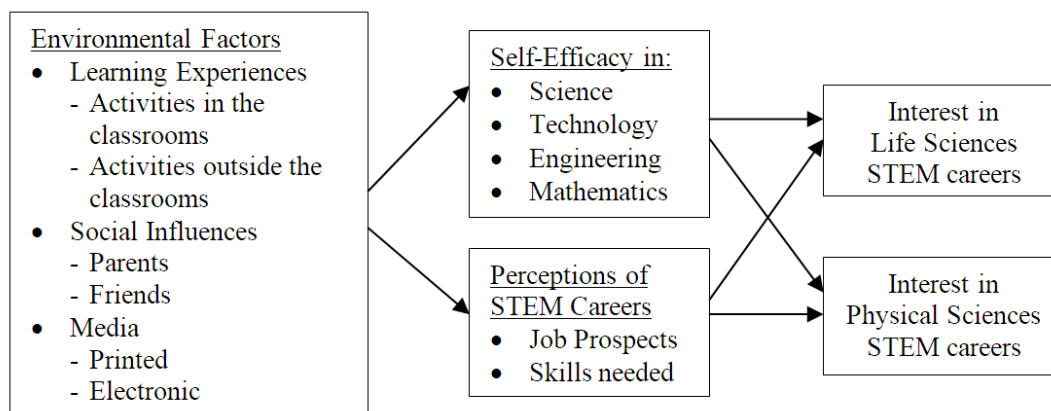


Siebert (2012) highlighted that if STEM professionals are brought to school, it might only meet a few of the students' personal interests. Furthermore, there are several factors that may affect interest in STEM careers among students such as self-efficacy (Burwell-Woo, Lapuz, Huang, & Rentsch, 2015; Rittmayer & Beier, 2008), perception of STEM careers (Wyss, Heulskamp, & Siebert, 2012) and environmental factors (Chi, Dorph, & Reisman, 2014; Chukwuemeka, 2013; Interactive, 2011; Kaiser, 2016; Dorph et al., 2017).

### Conceptual Framework

This research draws upon the social cognitive career theory (SCCT) (see Figure 1) which was developed by Lent, Brown and Hackett (1994) based on Bandura's social cognitive theory. SCCT claims that career aspirations result from personal factors, environmental factors and behavior (Bahar & Adiguzel, 2016; Maltese & Tai, 2011). SCCT has been applied in numerous researches to investigate the factors influencing interest in STEM careers (Bahar & Adiguzel, 2016; Kier, Blanchard, Osborne, & Albert, 2014; Nugent, Barker, Welch, Grandgenett, Wu, & Nelson, 2015; Sahin, Gulacar, & Stuessy, 2015). According to SCCT, career interest, choices, and educational and occupational success are influenced by thoughts, beliefs, and personal and environmental factors (Petersen, 2014).

The theory draws upon factors related to cognition of a person (e.g., self-efficacy, outcome expectations, goals) and on how the person's cognition interacts with his environment that in turn forms one's career development. Thus, in this research, following on the theory and previous studies, five constructs have been proposed for the tested model. The independent variables or factors include environmental factors, self-efficacy in STEM, and perceptions of STEM careers while the dependent variables are interest in physical sciences STEM careers and interest in life sciences STEM careers. According to the theory, interest in STEM careers is influenced by students' perceptions of STEM careers and self-efficacy in STEM. Perceptions of STEM careers involve two perspectives, namely job perspective and skills needed while self-efficacy involves four fields, namely science, technology, engineering and mathematics which were studied separately. The theory also suggests that the environmental factors in the framework are linked indirectly to interest in STEM careers (physical sciences and life sciences).



**Figure 1. Conceptual framework.**

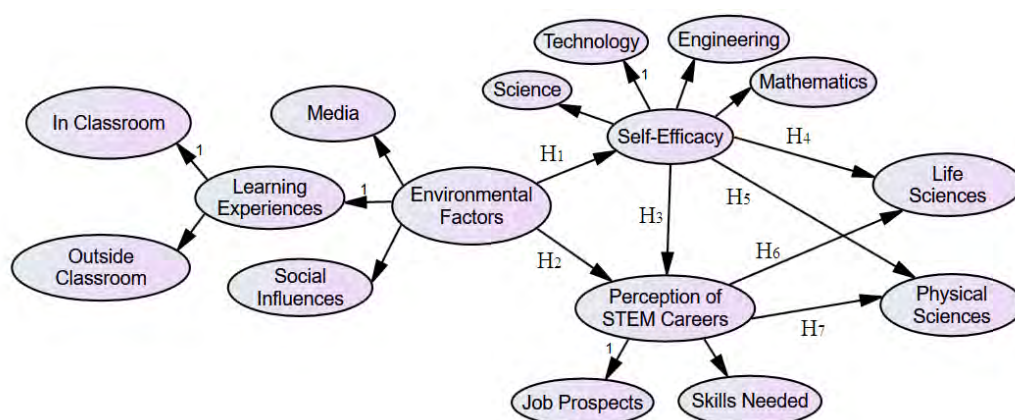
The environmental factors involve three sub-factors, namely learning experiences, social influences and media. For learning experiences, two aspects were studied, namely activities in the classroom and activities outside the classroom while for social influences, two aspects were examined, namely influence by parents and friends. Media influences consist of the internet, television programs, books, comics, magazines, newspapers, movies, social media and the radio. According to SCCT, the environmental factors are linked indirectly to interest in careers through self-efficacy expectations and outcome expectation (Lent, Brown, & Hackett, 2000). In this research, the factor on perceptions of STEM careers was used instead of outcome expectation. In the Malaysian context, perception of STEM careers has been the factor commonly associated with the decline of interest in STEM careers. Thus, for this research, the environmental factors are linked indirectly to interest in STEM careers through self-efficacy and



perceptions of STEM careers. Self-efficacy is the students' beliefs about their task capability in science, technology, engineering and mathematics separately. Perceptions of STEM careers take into consideration job prospects and required skills in STEM. These factors are inter-related and influence interest in STEM careers and should be considered in the context of Malaysia. This research was based on the assumption that students' aspirations are formed based on both personal and environmental factors. Previous research has reported that interest is one of the strongest predictors of the choice of subjects and courses (Regan & DeWitt, 2015; Maltese & Tai, 2010). Therefore, this research focused on interest in physical sciences STEM careers and interest in life sciences STEM careers as a final predictor for choosing STEM careers. Physical sciences STEM careers such as electrical engineer, industrial, agricultural, business scientists, and life sciences STEM careers such as pollution control analyst, geneticist, zoologist, geologist and medical scientist. Hence, these factors, namely self-efficacy in STEM and perceptions of STEM careers are more relevant and have direct links to interest in STEM careers.

### Hypothesis Model

Based on the conceptual framework, a hypothesis model (see Figure 2) was constructed using AMOS software. Figure 2 shows the five latent constructs examined in this research: (i) environmental factors, (ii) perceptions of STEM careers, (iii) self-efficacy, (iv) interest in physical sciences STEM careers, and (v) interest in life sciences STEM careers. Three of the constructs (perceptions of STEM careers, environmental factors, self-efficacy) include sub-constructs and all five constructs (including interest in physical sciences and life sciences STEM careers) are represented by items in the questionnaire. In this model, the items that represent each construct and sub-construct were drawn with an oval. Each item was measured based on a 10-point Likert scale.



**Figure 2.** Hypothesis model of factors that affect interest in STEM careers.

There are seven direct correlations in the model and these associations are the hypotheses to be tested. Each hypothesis can be seen on each path and is labeled 'H'. Therefore, this research posited the following hypotheses:

- H<sub>1</sub>: Environmental factors have a significant effect on STEM self-efficacy.
- H<sub>2</sub>: Environmental factors have a significant effect on perceptions of STEM careers.
- H<sub>3</sub>: Self-efficacy has a significant effect on perceptions of STEM careers.
- H<sub>4</sub>: Self-efficacy has a significant effect on interest in life sciences STEM careers.
- H<sub>5</sub>: Self-efficacy has a significant effect on interest in physical sciences STEM careers.
- H<sub>6</sub>: Perceptions of STEM careers have a significant effect on interest in life sciences STEM careers.
- H<sub>7</sub>: Perceptions of STEM careers have a significant effect on interest in physical sciences STEM careers.

The aim of this research was to develop a model on interest in STEM careers among students in Malaysian secondary schools based on survey data which focused on three factors, namely environmental factors, self-efficacy and perceptions of STEM careers. Specifically, the research was conducted to determine a model which fits the hypothesized model and the causal directional effect between the five variables as shown in Figure 2. For this purpose, goodness-fit index and statistically significant  $p$ -value  $< .05$  were used to confirm the model fit and to test the significance of the correlation between the variables.

## Research Methodology

### *Design*

Survey research design was employed in the research in which a questionnaire was used as the research instrument. The survey was conducted throughout Malaysia using cluster sampling technique. The cluster for this research comprised the states in Malaysia where the states were divided into clusters. For Peninsular Malaysia, the clusters were referred to as the north, east, west and south. For East Malaysia, both states, namely Sabah and Sarawak were the clusters of the research.

### *Respondents*

The questionnaires administered to the secondary schools in Malaysia were distributed based on the aforementioned clusters. One state was selected to represent each cluster for Peninsular Malaysia. Thus, in total six states were involved in this research. Three hundred ( $n=300$ ) students of the age of 14 were involved for every state, resulting in a total number of 1800 students as respondents. Of these 1800 students, 1780 returned completed questionnaires. However, for inferential statistical analysis, only 1485 respondents were included in this research; the other 295 respondents were dropped because of missing data and extreme outlier. The removal of outlier is in line with the requirement of the SEM- AMOS method of analysis. This parametric method requires certain assumption of the data- namely the data needs to represent the normal distribution. If the extreme outliers were not removed, then the research will not be providing the actual reflection of the phenomena that is being examined (Aguinis, Gottfredson, & Joo, 2013).

### *Instrument*

The questionnaire contained a total of 63 items after undergoing the exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) procedures. Table 1 shows the summary of the number and examples of items for each construct and sub-construct tested in this research. For the learning experiences factor, items for the sub-construct on activities in the classroom were developed by the researchers by focusing on teaching and learning strategies related to STEM. Similarly, items for the sub-construct on activities outside the classroom were developed by focusing on STEM-related activities such as visiting the science center and joining the carnival, camp and STEM-related club. For items related to the social influence factor, the items were adapted from the instrument developed by Nugent et al. (2015) and Kier et al. (2014). The items focused on the closest social factors influencing students' interest in STEM careers. Two social influences were measured in this research, namely parents and peers. Items related to media influences were also developed by the researchers with focus on the influence of books, radio, newspapers, television, movies, the internet, social media, scientific magazines, comics and digital games on interest in STEM careers

Self-efficacy refers to one's perceived ability in completing an assignment task. In this research, self-efficacy in STEM was measured through items on one's self efficacy in Science, Technology, Engineering and Mathematics. Instruments from Nugent et al. (2015) and Kier et al. (2014) were referred to and adapted for this research, especially for the items related to self-efficacy on science, technology, engineering and mathematics. In addition, items from Buday et al.'s (2012) instrument were adapted for items related to self-efficacy on mathematics. For the perceptions of STEM careers, items were entirely developed by the researchers by taking into account STEM job prospects and the required skills in STEM careers. For the instrument on interest in STEM careers, items were based on STEM careers as proposed by Faber et al. (2013). These STEM careers were then categorized into two



main careers in the STEM fields: a) Life sciences (e.g. environmental works, biology earth science, medical science, and chemistry) and b) Physical sciences (e.g. energy, engineering, entrepreneur and business scientists).

**Table 1. Number and examples of items.**

Construct	Sub-construct	Number of Items	Examples of Item
Interest in Physical Sciences STEM Careers		3	<ul style="list-style-type: none"> <li>• Energy: Electrical engineer, heating, ventilation and air conditioning.</li> <li>• Engineering: Civil, industrial, agricultural.</li> </ul>
Interest in Life Sciences STEM Careers		5	<ul style="list-style-type: none"> <li>• Biology and Zoology: Biological scientist.</li> <li>• Earth Science: Geologist, weather forecaster, archaeologist.</li> </ul>
Perceptions of STEM Careers	Job Prospects	7	<ul style="list-style-type: none"> <li>• Careers in STEM fields are prestigious.</li> </ul>
	Skills Needed	6	<ul style="list-style-type: none"> <li>• Workers in the STEM fields require higher-order thinking.</li> </ul>
Self-Efficacy	Science	5	<ul style="list-style-type: none"> <li>• I can solve problems related to science concepts well.</li> </ul>
	Technology	5	<ul style="list-style-type: none"> <li>• I can handle everyday technological products easily (e.g., blender, microwave, toaster, rice cooker).</li> </ul>
	Engineering	5	<ul style="list-style-type: none"> <li>• I can build electronic circuits.</li> </ul>
	Mathematics	5	<ul style="list-style-type: none"> <li>• I can solve mathematical problems properly.</li> </ul>
Environmental Factors	Media	10	<ul style="list-style-type: none"> <li>• I like reading books about STEM.</li> </ul>
	Activities in the Classroom	3	<ul style="list-style-type: none"> <li>• I conduct experiments or science projects in the laboratory or in the school environment.</li> </ul>
	Activities Outside the Classroom	5	<ul style="list-style-type: none"> <li>• I visited the science center.</li> </ul>
	Social Influences	4	<ul style="list-style-type: none"> <li>• My parents encourage me to pursue a career in STEM.</li> <li>• Most of my friends want to engage in STEM careers.</li> </ul>
Total		63	

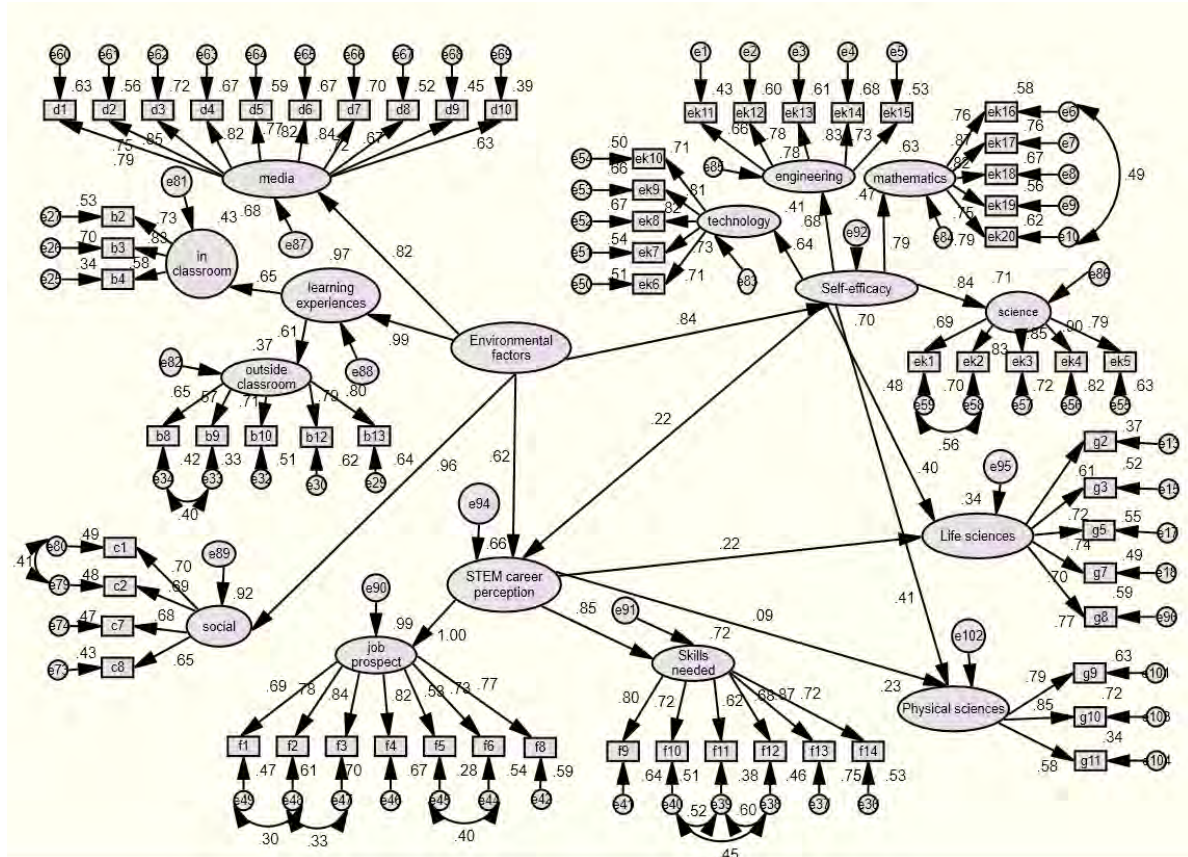
### SEM-AMOS Analysis

SEM approach was used to analyze data in order to evaluate the hypothesized model. For maximum likelihood estimate, a set of goodness-of-fit index comprising chi-square ( $\chi^2$ ), root mean square error of approximation (RMSEA), comparative fit index (CFI), Tucker–Lewis index (TLI) and Incremental Fit Index (IFI) was used to evaluate model fit. The significant  $p$ -value was used to explain the causal directional correlation while the regression weight or known as beta value ( $\beta$ ) was used to explain the strength of the correlation. Additionally,  $r$  squared ( $r^2$ ) value was used to explain the variation of the model. All analyses were performed using AMOS18. Before the SEM analysis was carried out, the items had been performed by validity and reliability procedures. Two types of validity were involved in this research, namely content validity and construct validity. For content validity, two experts related to STEM education in Malaysia were consulted to validate each item. Both the exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were applied to determine the construct validity.



**Research Results**

The structural model of interest in STEM careers is displayed in Figure 3. The normed chi square  $\chi^2$  was 3.847, implying compatibility the hypothesis model fits with the survey data,  $\chi^2$  was greater than 1 and less than 5, and the Root Mean Square Error of Approximation (RMSEA) was .044 which is less than .08. Thus, the model was considered good. The Comparative Fit Index (CFI) was .912, the Tucker-Lewis Index (TLI) was .908, and the Incremental Fit Index (IFI) was .912. Each of the values obtained was larger than the suggested value of .90, showing a well-fit model (Byrne, 2010; Hair et al., 2010). Thus, the above findings showed that the structural model fits the data well.



**Figure 3. Structural model of interest in STEM careers.**

For hypothesis testing, the overall findings showed that six out of the seven hypotheses were supported. Table 2 shows the results of the hypothesis testing for hypothesis 1 to 7 (direct effect path coefficient). Based on the beta ( $\beta$ ) standard value, the factor of self-efficacy was the greatest contributor to the interest in life sciences STEM careers ( $\beta = .401; p < .001$ ) and physical science STEM careers ( $\beta = .414; p < .001$ ). This is followed by perceptions of STEM careers ( $\beta = .217; p < .001$ ) towards interest in life sciences STEM careers. Research findings also showed that self-efficacy also affected perceptions of STEM careers in terms of job prospects and skills needed ( $\beta = .217; p < .001$ ). Environmental factors contributed 70% of the variance in self-efficacy ( $\beta = .838; p < .001$ ) while 66% of the variance in perceptions of STEM careers was predicted by environmental factors and self-efficacy. The environmental factors affected self-efficacy the most ( $\beta = .838; p < .001$ ) compared to perceptions of STEM careers ( $\beta = .621; p < .001$ ). One important finding is that the direct correlation between perception on STEM career and interest in physical sciences STEM careers was found to be not significant ( $\beta = .089; p < .001$ ).





**Table 2. Significant effect path coefficient (direct effect).**

	Path	Beta value	Standard Error	<i>t</i>	<i>p</i>	Results of the Hypotheses
Self-efficacy	<-- Environmental factors	.838	.031	20.350	***	Supported (H <sub>1</sub> )
Perceptions of STEM Careers	<-- Environmental factors	.621	.038	10.396	***	Supported (H <sub>2</sub> )
Perceptions of STEM Careers	<-- Self-efficacy	.217	.047	3.941	***	Supported (H <sub>3</sub> )
Interest in Life Sciences	<-- Self-efficacy	.401	.064	7.444	***	Supported (H <sub>4</sub> )
Interest in Physical Sciences	<-- Self-efficacy	.414	.088	7.198	***	Supported (H <sub>5</sub> )
Interest in Life Sciences	<-- Perceptions of STEM careers	.217	.064	4.472	***	Supported (H <sub>6</sub> )
Interest in Physical Sciences	<-- Perceptions of STEM careers	.089	.093	1.713	.087	Not supported

\*\*\* Significant at level  $p = .001$

## Discussion

This research determined the factors contributing to interest in life sciences and physical sciences STEM careers. In general, the results contribute to our understanding of the correlation between environmental factors, internal factors (self-efficacy and perceptions of STEM careers) and interest in life sciences and physical sciences STEM careers. The findings indicated that environmental factors which consist of learning experiences, social influences and media play an important role in triggering self-efficacy and good perceptions of STEM careers, which in turn affect interest in STEM careers. These factors must be considered in planning STEM activities in order to enhance students' interest in STEM learning and occupations. However, an insignificant correlation was found between perceptions of STEM careers and interest in physical sciences STEM careers.

Based on the model developed in this research, only 34% of the identified factors affected interest in life sciences STEM careers and only 23% of the identified factors affected interest in physical sciences STEM careers. Despite the low percentage of contribution to any of the interests in STEM careers, one could argue that since this research is one of the early researches on modeling of factors contributing to interest in STEM careers, the current finding is said to be acceptable. Another possible reason for the low percentage of contribution to interest is that for this research, the factor of outcome expectancy that was proposed by Lent et al. (2000) was replaced by perceptions of STEM careers (job prospects and skills needed in STEM careers). The adaptation of the model was a result of the uniqueness of the factor, i.e. perceptions of STEM careers in the Malaysian context. Common reasons cited for students shying away from STEM career is the low job prospect of STEM careers. This result empirically proved that perceptions of STEM careers are not the main factor contributing to lack of interest in STEM careers.

In summary, self-efficacy affects interest in life sciences and physical sciences STEM careers while perceptions of STEM career only affect interest in life sciences STEM careers. The findings from this research indicate that interest in STEM careers is derived from task ability and good perception of STEM careers rather than good achievement in the subject matter. This idea supports the findings from a research by Maltese and Tai (2011) in which the researchers argued that not all students choose STEM-related courses even though they have good achievement in STEM subjects. The best students in school also choose other social science courses such as law, thus shying away from the STEM pipeline. Previous research has reported that female students especially do not choose STEM courses if they think that they are not proficient in STEM (Bamberger, 2014). The results of this research indicate



that self-efficacy is crucial in cultivating interest in STEM careers and in strengthening the reason for students to choose STEM trajectories.

Additionally, students' beliefs about their capability in STEM provide good perceptions of norms as STEM workers and in meeting the requirements of the STEM workforce. Therefore, students must be exposed to real life STEM workers in order to give them understanding about STEM job prospects and the required skills in STEM fields. Thus, schools must have good collaboration with universities and industries. Accordingly, the STEM mentor-mentee program should be implemented in order to engage more students in STEM trajectories.

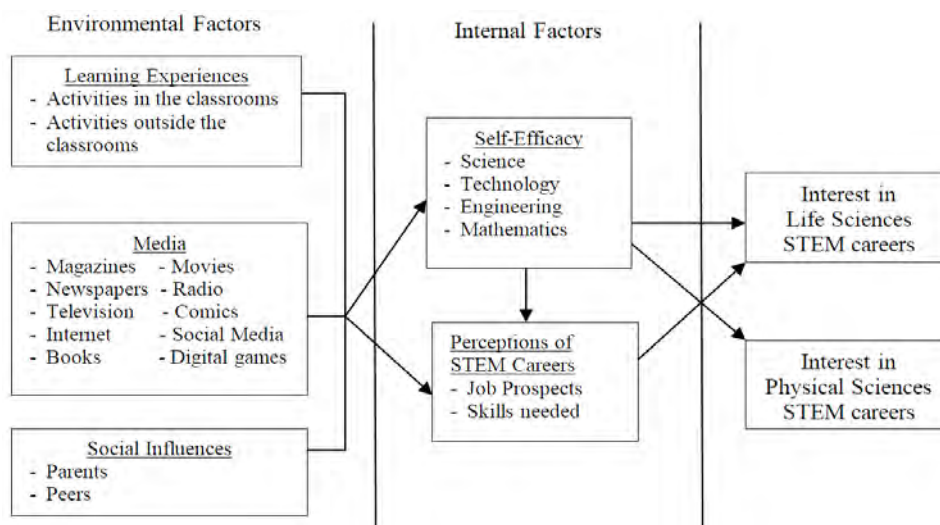
One of the reasons that led to the significant correlation between perceptions of STEM careers and interest in life sciences STEM careers is due to job prospects that meet the students' needs. For example, the career as a doctor is the career most demanded by the students because they want to help other people and because such a career gives them more satisfaction in terms of the possibility of contributing to the society. Additionally, the job as a doctor is perceived to be a prestigious occupation. For the aspect of skills needed, students think that the life sciences STEM careers require higher order thinking, creative problem solving and required work as a team. While, the insignificant correlation found in this research between perceptions of STEM careers and interest in physical sciences STEM careers questionnaire seems to suggest that students may be less aware of the kinds of skills required in physical sciences STEM careers. This is in line with Depieri and Lopes' (2014) research where they explained that people generally have a reasonable idea of what a dentist or a doctor does. However, the scope of the activities covered by the STEM careers in physical sciences such as engineering is more difficult to summarize. A research by Shahali, Halim, Rasul, Osman, & Arsad, (2019) on students' interest in STEM careers found that students are unaware of the various types of responsibilities of an engineer. In other words, the diversity of STEM careers in physical sciences such as engineering requires skills that the student does not know and is not aware of.

Thus, Depieri, and Lopes (2014) and Shahali et al. (2017) emphasized that in order to attract young people to physical sciences STEM careers such as engineering, there is a need to build better understanding of young people's perceptions of STEM as well as to develop appropriate programs, activities or interventions that will positively influence their perceptions of STEM. Such an intervention should take into consideration students' perceptions of STEM careers especially on awareness related to physical sciences STEM careers.

Teachers and parents play a vital role in giving learning experiences and supporting students' interest in STEM learning and careers (Hall et al., 2011; Halim et al., 2018). Teachers must focus on task ability and emphasize skills in STEM such as creative thinking, higher order thinking, making decisions wisely, working as a team, and being able to create products based on STEM concepts. Teachers should organize activities in groups so that students can collaborate with their peers and share their interests together. Furthermore, teachers should take into consideration the different needs of students based on student diversity, particularly in relation to gender disparities and the level of cognitive ability, in the STEM teaching and learning process.

Parents can help their children in STEM career selection by providing facilities such as putting them in additional classes, allocating financial provisions to engage their children in outside of school science activities, promoting the culture of science at home and encouraging their children to explore science-related careers. Accordingly, information related to opportunities and demands in STEM should be disseminated to the parents so that they could get accurate and the latest information as this would enable parents to provide their children with the necessary information and the support their children need to develop interest in STEM careers (Halim et al., 2018). The media should collaborate with the STEM stakeholders in providing-quality materials to cultivate interest in STEM learning and careers. The media should consider the diversity of students in terms of disparities related to gender and ability. In sum, the final model of this research is presented in Figure 4.





**Figure 4.** The final model of interest in STEM careers.

Further research could involve exploring students' perceptions of identity in STEM careers. Interviews with students and workers in the STEM fields would help to divulge how and why they make the decision to choose STEM fields and careers. Venville et al. (2013) in their qualitative research reported that the passion for science and curiosity about the world are important factors that contribute to students' decision making about their trajectories. Thus, researching into the other factors that contribute to students' decisions may be able to provide better understanding of how students interact with their experiences to make decisions about their careers.

## Conclusions

The model of interest in STEM careers developed showed that the environmental factors (learning experiences, social and media) influence STEM self-efficacy and perceptions of STEM careers which, in turn, influence interest in STEM careers except for the correlation between perceptions of STEM careers. Results suggest that in developing students' pathway to STEM careers, these factors should be taken into consideration in the intervention effort of nurturing interest in STEM careers among students. In addition, the roles of social factors, namely teachers, parents, and peers should be given emphasis as these individuals would be able to provide the necessary support to the students in inculcating their interest in STEM careers. Additionally, the media should give support in terms of providing the best quality materials for students to cultivate science learning as well as interest in STEM careers. In order to be more efficient, the media should collaborate with STEM stakeholders to meet the students' needs. Overall, the factors are inter-related with each other and play a significant role in developing students' interest in STEM careers.

## Acknowledgements

The authors sincere thanks to the Center for Research and Instrumentation (CRIM), National University of Malaysia for supporting this research. This research is funded by Arus Perdana Grant (AP-2015-001), CRIM, National University of Malaysia.

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Received: November 21, 2018

Accepted: May 23, 2019

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