ATTITUDE TOWARDS STEM AMONG MATRICULATION STUDENTS

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ABSTRACT

Purpose – This quantitative study was done to quantify the attitude towards STEM (science, technology, engineering and mathematics) among matriculation students in the new era of Industrial Revolution 4.0, and to differentiate the attitude based on gender and their learning modules.

Methodology – A questionnaire with 21 items for measuring attitude towards STEM was used with random sampling technique to collect the required data. The questionnaire consisted of seven items focusing on attitude towards science, seven items on attitude towards technology/engineering, and another seven items on attitude towards mathematics. As many as 748 students who were taking the subject of Biology at a matriculation college had been asked to answer the questionnaire. Data analysis was performed using the Microsoft Excel and Statistical Package for Social Sciences (SPSS) softwares. Score means were used to measure the attitude towards STEM while Mann-Whitney U Test was applied to determine the difference in attitude according to gender and the students' learning modules.

Findings – Research findings show that the students' attitude towards STEM are not in a good level for all. Meanwhile, the Mann-Whitney U Test proves that the difference in attitude towards STEM between male and female students is significant. Likewise, the difference in attitude towards STEM between learning Module A and learning Module B students is also significant. Thus, Null Hypothesis 1 and Null Hypothesis 2 in this study can be rejected.

Significance – These findings describe the attitude towards STEM among the matriculation students and hopefully this may give some inputs to educators when planning to make necessary actions for the students in encountering IR 4.0.

Keywords: attitude, STEM, matriculation students, gender, learning module

1.0 INTRODUCTION

The industrial revolution started from around the year of 1760 with the First Industrial Revolution (IR 1.0) which used water and steam power to mechanize production. During the Second Industrial Revolution (IR 2.0), electric power was used to create mass production. The Third Industrial Revolution (IR 3.0) used electronics and information technology to automate production and create global supply chains. IR 3.0 had brought semiconductors, mainframe computing, personal computing, the Internet and the Web as part of the digital revolution in which these technological advances have shrunk the world (Salmon, 2019). The world is now

entering into the Fourth Industrial Revolution (IR 4.0) at a very fast rate. IR 4.0 is beyond the enhancement of IR 3.0, where the advancement of new technologies blurs the lines between the physical, digital and biological worlds (Diwan, 2017). At present, IR 4.0 affects the education system as well, which definitely requires a major enhancement in the learning qualities especially for STEM subjects.

STEM refers to the disciplines of science, technology, engineering, and mathematics which have been the staple forms of all students' academic careers; especially science and mathematics. Science usually involves the fields of biology, chemistry and physics; while technology refers to fields concerning industrial designing, electronics, internet and information technology. Engineering typically covers civil engineering, chemical engineering, electrical engineering and other technical fields; while mathematics involves algebra, geometry, calculus and concept of numbers (Assefa & Rorissa, 2013). Most academicians had defined STEM as a combination or integration of all four disciplines of science, technology, engineering and mathematics (Tsupros, Kohler & Hallinen, 2009; Bybee, 2010; Breiner, Harkness, Johnson & Koehler, 2012; Assefa & Rorissa, 2013; Jayarajah, Saat & Rauf, 2014).

Problem Statement

We are now in the STEM generation in which the objectives are to fulfill social needs in order to face the rapid advancement in the world of science and technology; together with personal needs to become a well-balanced, productive and knowledgeable citizen (Zollman, 2012). The need for STEM exists as the demand for STEM-related jobs is higher when compared to other fields of work. Understanding scientific matters and mathematical principles, together with knowledge in the fields of technology and engineering, as well as skills in solving problems are the main criteria for the workforce of the future. Therefore, all students are required to have literacy in STEM, and this should become a priority in education (Bybee, 2010). STEM literacy would help individuals to compete in this world of new economics (Tsupros et al., 2009) which parallels with the IR 4.0.

According to the Ministry of Education, our nation would be requiring 493,830 individuals to be involved in STEM-related industries in order to support the New Economics Model by the year of 2020 (Kementerian Pendidikan Malaysia, 2013). However, are Malaysian students really STEM-literate and well prepared in approaching IR 4.0? Meanwhile, according to the Ministry of Science, Technology and Innovation, the number of Malaysians who are interested in issues related to science and technology are very few if compared to the Americans. More than one third of Malaysian children are not interested in science and technology (Jayarajah et al., 2014). This limits the potential in preparing students to be involved in the expanding fields of STEM (Asghar, Ellington, Rice, Johnson & Prime, 2012). This study has given emphasis on the attitude of students towards STEM. Understanding the students' attitude towards STEM is important in efforts to ensure that the students will master the concepts of science, technology, engineering and mathematics; develop problem-solving skills; and able to apply STEM in their real daily life.

Research Objectives

The objectives of this study are to measure matriculation students' attitude towards STEM, and to determine the difference in attitude towards STEM according to gender and learning modules of the students.

Research Questions

The research objectives should be able to answer these research questions:

1. What is the score for matriculation students' attitude towards STEM according to gender and their learning modules?

2. Is there a difference in matriculation students' attitude towards STEM according to gender and their learning modules?

Significance of Study

Findings of this study should be able to describe the attitude towards STEM among matriculation students. Educators may take necessary actions in determining the course of STEM education since the application of STEM is highly crucial in the daily life of every individual. Furthermore, the effectiveness of teaching and learning STEM subjects can be improved if the educators understand their students' attitude towards the subjects. The information on attitude obtained shall be used by educators to plan appropriate teaching strategies in order to enhance the positive attitude which then leads to better achievement in this era of IR 4.0.

Scope and Limitation of Study

This study was done only on pre-university students who were persuing their studies at a matriculation college. The field of study concerning STEM is extremely vast. Therefore, this study focused only on the affective domain with the variable of attitude towards STEM.

2.0 LITERATURE REVIEW

Attitude is one of the variables within the affective domain which involves emotional reaction that can be expressed through statements of opinion or statements of belief (Smith & Ragan, 1999 in Miller, 2015). Attitude is an internal form which is difficult to understand (Azizi Yahaya, Jamaluddin Ramli & Yusof Boon, 2010). It can influence an individual in providing value to the object symbols of what is preferred or what is not. Hence, attitude is a result of feelings, beliefs or thoughts of an individual concerning the objects of psychology. Through attitude, people can learn a variety of new knowledge to improve self-esteem.

At present, many studies had taken into account the affective elements which may have connection with education and literacy. As an example, the international assessment of PISA (Programme for International Student Assessment) has been assessing components which are related to the attitude of students. According to Bybee, McCrae and Laurie (2009), students' attitude towards science has an important role in developing literacy in science. As in scientific literacy, STEM literacy also involves this affective variable (Bybee, 2010). Cavalcanti (2017) had even mentioned that STEM literacy includes attitude together with motivation which influence a certain personal action of an individual. This parallels with the statement by Zollman (2012) which stated that attitude is one of the affective elements which need to be considered in STEM literacy.

3.0 METHODOLOGY

This study applied a research design involving the quantitative approach. Data was collected through the process of survey using a questionnaire for measuring attitude towards STEM. The quantitative data obtained was then analysed with descriptive statistics and inferential statistics using computer softwares.

This quantitative study involved matriculation students who were taking Biology subject as the samples. There are two modules of learning which are offering the subject of Biology for the matriculation students at the Penang Matriculation College. Module A students are required to take the core subjects of Biology, Chemistry, Physics and Mathematics while Module B students are required to take the core subjects of Biology, Chemistry, Computer Science and Mathematics. The sample of this study consists of 748 matriculation students represents 61.01% of the total number of students. We used random sampling technique to collect the required data.

This study was done to measure the attitude towards STEM, and to determine the difference in attitude towards STEM based on gender and the learning modules of matriculation students in approaching the IR 4.0. The instrument for this study was a questionnaire which consisted of two parts. Part A contained demographic items concerning the respondents while Part B contained 21 items for measuring the respondents' attitude towards STEM. Those 21 items were categorized into three dimensions of attitude towards STEM namely the attitude towards science, attitude towards technology/engineering, and attitude towards mathematics. Specifically, seven items of Part B focused on attitude towards science, another seven items focused on attitude towards technology/engineering, and the last seven items focused on attitude towards mathematics. All items were adapted from the instrument of S-STEM Survey (Unfried, Faber, Stanhope, & Wiebe, 2015). The items were given scores using the five-point Likert scale where the score '1' is for 'Highly Disagree', '2' for 'Disagree', '3' for 'Slightly Agree', '4' for 'Agree' and '5' for 'Highly Agree'.

The reliability test was done on the questionnaire and the results for the 21 items used in the questionnaire gave a Chronbach's alpha value of 0.94. According to Kline (2005), the alpha reliability can be classified into three, namely 0.70 (adequate), 0.80 (very good) and 0.90 (excellent). The results showed that the selected items were valid to be used in the study.

Analysis of the data was done using the softwares Microsoft Excel and Statistical Package for Social Sciences (SPSS) version 20. Data which was obtained in the form of Microsoft Excel was initially checked before proceeding with the statistical analysis process. The data needed to be checked first in order to detect any missing value. This was done through the process of 'data sort' using the Microsoft Excel.

Data based on the scores was taken as a dependent variable. The analysis was done separately according to the research questions. In order to answer Research Question 1, score mean was calculated according to the three dimensions of attitude towards STEM. The full score for each dimension is '5'. Score '0' indicates that the attitude is the least able to fulfill the requirements of the STEM discipline (science, technology/engineering, or mathematics) while score '5' indicates that the attitude is highly able to fulfill the requirements of the STEM discipline. Score analysis was then done by taking into account the value of score mean for each item according to dimension, as well as the mean for all dimensions of attitude towards STEM. The status of mean score for attitude towards STEM was determined based on the interpretation of mean by referring to Levin and Rubin (2000) plus some addition concerning the interpretation of attitude. Table 1 shows mean scores and the interpretation of mean for this study.

Table 1. *Mean and Interpretation*

Mean	Interpretation of Mean	Interpretation of Attitude
1.00 – 2.33	Low	Poor
2.34 – 3.66	Moderate	Acceptable
3.67 – 5.00	High	Good

The questionnaire for this study used the five-point Likert scale. Therefore, the score is typically ordinal. Mann-Whitney U test was performed to determine the difference in attitude towards STEM and subsequently to test these hypotheses:

Null Hypothesis 1: there is no significant difference in attitude towards STEM according to gender.

Null Hypothesis 2: there is no significant difference in attitude towards STEM according to learning modules.

Thus, the Mann-Whitney U test was applied to answer Research Question 2.

4.0 RESEARCH FINDINGS

This section concentrates on the results of the analysis in order to answer the research questions besides trying to fulfill the objectives of this study. Table 2 shows the distribution of students involved in this study according to gender and their learning modules. Module A respondents involved 117 (24.2%) male students and 367 (75.8%) female students. Meanwhile, module B respondents involved 49 (18.6%) male students and 215 (81.4%) female students.

Table 2. *Distribution of respondents according to gender and learning modules*

Learning Module	Gender		Total
	Male	Female	
Module A	117	367	484
Module B	49	215	264
Total	166	582	748

The analysis according to gender shows that on the whole, this study involved 166 (22.2%) male students and 582 (77.8%) female students.

Analysis on Students' Attitude Towards STEM

The questionnaire contained 21 items for measuring the variable of attitude towards STEM which were categorized into three dimensions namely the attitude towards science, attitude towards technology/engineering, and attitude towards mathematics. For the dimension of attitude towards science, item 5 (Module A) showed the highest mean of 4.26 while item 1 and 6 (Module B) showed the lowest mean of 3.88. Total means for male, female, Module A and Module B students for the dimension of attitude towards science were 4.14, 4.06, 4.13 and 3.97 respectively. Mean scores for items in this dimension are shown in Table 3.

Table 3. *Mean Scores for Items in the Dimension of Attitude Towards Science*

Item	Attitude towards Science	Male (n=166)	Female (n=582)	Module A (n=484)	Module B (n=264)
1	I am sure of myself when I do science.	4.14	3.89	3.99	3.88
2	I would consider a career in science.	4.23	4.11	4.22	3.98
3	I expect to use science when I get out of college.	4.06	4.06	4.12	3.95
4	Knowing science will help me earn a living.	4.10	4.12	4.16	4.02
5	I will need science for my future work.	4.19	4.19	4.26	4.06
6	I know I can do well in science.	4.14	3.91	4.00	3.88
7	Science will be important to me in my life's work.	4.10	4.13	4.19	4.00
	Total Mean	4.14	4.06	4.13	3.97

Meanwhile, Table 4 shows the mean scores for items in the dimension of attitude towards technology/engineering.

Table 4. *Mean Scores for Items in the Dimension of Attitude Towards Technology/Engineering*

Item	Attitude towards Technology/Engineering	Male (n=166)	Female (n=582)	Module A (n=484)	Module B (n=264)
8	If I learn engineering, then I can improve things that people use every day.	3.81	3.47	3.62	3.41
9	I like to imagine creating new products.	3.86	3.44	3.54	3.52
10	I am good at building and fixing things.	3.66	3.07	3.25	3.11
11	Designing products or structures will be important for my future work.	3.54	2.99	3.11	3.13
12	I am curious about how electronics work.	3.79	3.14	3.29	3.27

13	I would like to use creativity and innovation in my future work.	4.11	3.68	3.77	3.77
14	I believe I can be successful in a career in engineering.	3.52	2.97	3.17	2.95
	Total Mean	3.76	3.25	3.39	3.31

For the dimension of attitude towards technology/engineering, all items and total mean showed mean values that were found to be less than 4.0 except item 13 (Male) which showed a mean value of 4.11. Meanwhile, item 14 (Module B) showed the lowest mean of 2.95. Total means for male, female, Module A and Module B students for the dimension of attitude towards technology/engineering were 3.76, 3.25, 3.39 and 3.31 respectively (Table 4).

On the other hand, mean scores for all items in the dimension of attitude towards mathematics were also found to be less than 4.0. Item 19 (Module B) showed the lowest mean of 3.03 while item 20 (Male) showed the highest mean of 3.85 for attitude towards mathematics. Total means for male, female, Module A and Module B students for the dimension of attitude towards mathematics were 3.48, 3.29, 3.37 and 3.26 respectively. Mean scores for items in this dimension are shown in Table 5.

Table 5. *Mean Scores for Items in the Dimension of Attitude Towards Mathematics*

Item	Attitude towards Mathematics	Male (n=166)	Female (n=582)	Module A (n=484)	Module B (n=264)
15	I am the type of student who do well in math.	3.70	3.34	3.47	3.34
16	I would consider choosing a career that uses math.	3.43	3.25	3.27	3.33
17	Math is hard for me.	3.10	3.15	3.18	3.06
18	I can handle most subjects well, but I cannot do a good job with math.	3.16	3.25	3.27	3.15
19	I am sure I could do advanced work in math.	3.48	3.08	3.24	3.03
20	I can get good grades in math.	3.85	3.56	3.68	3.52
21	I am good at math.	3.67	3.40	3.50	3.38
	Total Mean	3.48	3.29	3.37	3.26

Henceforth, for the discipline of science, all students showed a good level of attitude regardless of gender and learning modules. For the discipline of technology/engineering, only male students showed a good level of attitude. The female students together with the Module A and Module B students were found to be at an acceptable level of attitude towards technology/engineering. Meanwhile, for the discipline of mathematics, all students were also found to be at an acceptable level of attitude regardless of gender and learning modules. Looking at the total mean for all disciplines, only male (mean = 3.79) students showed a good level of attitude while the female (mean = 3.53) students, Module A (mean = 3.63) students and module B (mean = 3.51) students were found to be at an acceptable level of attitude. Table 6 shows the interpretation of attitude towards STEM according to the three disciplines.

Table 6. *Interpretation of Attitude Towards STEM According to Disciplines*

Attitude towards	Male	Female	Module A	Module B
Science	Good (4.14)	Good (4.06)	Good (4.13)	Good (3.97)
Technology/Engineering	Good (3.76)	Acceptable (3.25)	Acceptable (3.39)	Acceptable (3.31)
Mathematics	Acceptable (3.48)	Acceptable (3.29)	Acceptable (3.37)	Acceptable (3.26)
Total Mean	Good (3.79)	Acceptable (3.53)	Acceptable (3.63)	Acceptable (3.51)

Difference in Students' Attitude Towards STEM Between Gender

Results from the Mann-Whitney U test for difference between gender in the students' attitude towards STEM according to disciplines of science, technology/engineering and mathematics are shown in Table 7.

For the discipline of science, the mean rank for the male students was 393.65 (N = 166) which was slightly higher than mean rank of 369.04 (N = 582) for the female students. Thus, the Mann-Whitney U test showed no significant difference between the male and female students (Z = -1.300, p = .194) at the level of p < .05. On the other hand, for the discipline of technology/engineering, the mean rank for the male students was 478.81 (N = 166) which was higher than mean rank of 344.75 (N = 582) for the female students. Therefore, the Mann-Whitney U test for difference between gender in attitude towards technology/engineering (Z = -7.062, p = .0001) was significant at the level of p < .05. Meanwhile, for the discipline of mathematics, the mean rank for the male students was 423.04 (N = 166) which was also higher than the mean rank of 360.66 (N = 582) for female students. Thus, the Mann-Whitney U test for difference between gender in attitude towards mathematics (Z = -3.287, p = .001) was also significant at the level of p < .05.

Table 7. *Mann-Whitney U Test for Difference Between Gender*

Attitude towards	Gender	N	Mean Rank	Sum of Ranks	Z	Sig.
Science	Male	166	393.65	65346.50	-1.300	.194
	Female	582	369.04	214779.50		
Technology/ Engineering	Male	166	478.81	79482.50	-7.062	.000
	Female	582	344.75	200643.50		
Mathematics	Male	166	423.04	70224.50	-3.287	.001
	Female	582	360.66	209901.50		
Attitude	Male	166	457.79	75992.50	-5.632	.000
	Female	582	350.74	204133.50		

Overall, for attitude towards STEM, the mean rank for the male students was 457.79 (N = 166) which was higher than the mean rank of 350.74 (N = 582) for female students. Results from the Mann-Whitney U test for difference between gender (Z = -5.63, p = .0001) were significant at the level of p < .05. Therefore, there was a significant difference in students' attitude towards STEM between male students and female students in this study. Hence, Null Hypothesis 1 which stated that there is no significant difference in attitude towards STEM according to gender is rejected.

Difference in Students' Attitude Towards STEM Between Modules

Results from the Mann-Whitney U test for difference between learning modules in the students' attitude towards STEM according to disciplines of science, technology/engineering and mathematics are shown in Table 8.

Table 8. *Mann-Whitney U Test for Difference Between Modules*

Attitude towards	Module	N	Mean Rank	Sum of Ranks	Z	Sig.
Science	Module A	484	396.73	192016.00	-3.824	.000
	Module B	264	333.75	88110.00		
Technology/ Engineering	Module A	484	381.62	184703.00	-1.222	.222
	Module B	264	361.45	95423.00		
Mathematics	Module A	484	386.87	187243.50	-2.123	.034

	Module B	264	351.83	92882.50		
Attitude	Module A	484	391.28	189380.00	-2.877	.004
	Module B	264	343.73	90746.00		

For the discipline of science, the mean rank for Module A students was 396.73 (N = 484) which was higher than the mean rank of 333.75 (N = 264) for the Module B students. Thus, the Mann-Whitney U test showed a significant difference between the Module A and Module B students (Z = -3.824, p = .0001) at the level of p < .05. On the other hand, for the discipline of technology/engineering, the mean rank for the Module A students was 381.62 (N = 484) which was slightly higher than mean rank of 361.45 (N = 264) for the Module B students. Therefore, the Mann-Whitney U test for difference between learning modules in attitude towards technology/engineering (Z = -1.222, p = .222) showed no significant at the level of p < .05.

Meanwhile, for the discipline of mathematics, the mean rank for the Module A students was 386.87 (N = 484) which was higher than the mean rank of 351.83 (N = 264) for Module B students. Thus, the Mann-Whitney U test for difference between learning modules of this discipline (Z = -2.123, p = .034) was significant at the level of p < .05.

All in all, for attitude towards STEM, the mean rank for the Module A students was 391.28 (N = 484) which was higher than the mean rank of 343.73 (N = 264) for Module B students. Results from the Mann-Whitney U test for difference between the modules (Z = -2.877, p = .004) were significant at the level of p < .05. Therefore, there was a significant difference in students' attitude towards STEM between Module A students and Module B students in this study. Hence, Null Hypothesis 2 which stated that there is no significant difference in attitude towards STEM according to learning modules is also rejected.

5.0 DISCUSSION

Findings of this study have shown that the attitude towards STEM among the matriculation students was at an acceptable level for female, Module A and Module B students. Nevertheless, the attitude towards STEM among the male students was found to be at a good level. The students' attitude was considered good towards science while it was found to be at an acceptable level for mathematics. The students' attitude towards technology/engineering was also found to be at an acceptable level for all except for male students.

There was a significant difference in attitude towards STEM between the male students and the female students in this study. The male students had shown a better attitude towards STEM when compared with the female students. This finding almost parallels with the study by Ismail, Permanasari and Setiawan (2016) which found that the attitude towards science among male students was higher than female students.

This study has also shown that there was a significant difference in attitude towards STEM between the Module A students and the Module B students. Students of Module A who were taking Biology, Chemistry, Physics and Mathematics had shown a better attitude towards STEM when compared with students of Module B who were taking Biology, Chemistry, Computer Science and Mathematics. This finding is in line with the results of a study by Dahiya and Verma (2015) which found that there was a meaningful difference between students of different learning streams in provision of attitude towards internet technology.

Nowadays, students are actively using technology to retrieve information and as a tool for presentations in classes of the 21st century learning. However, it is found that the attitude towards STEM among the matriculation students was not in a good level for all. Thus, the educators involved need to integrate more applications of Information and Communication Technology (ICT) with the process of teaching and learning especially for subjects of STEM. The educators should highly promote the use of ICT among the students to retrieve more

information concerning concepts of STEM subjects and also on STEM issues. ICT and digital classroom courses should be organized by the Ministry of Education for the educators of STEM subjects in order to coach them in integrating ICT in their teaching and learning sessions. This will certainly enhance the students' attitude towards STEM especially during this era of IR 4.0. The educators should also plan appropriate teaching strategies which are suitably tailored for both male and female students of various learning modules in order to enhance the positive attitude towards STEM among all students.

Further studies on attitude towards STEM should be done by focusing on the cognitive domain. A study on the relationship between students' attitude towards STEM and the students' performance in a cognitive test concerning STEM should be able to give better insights regarding factors which affect the students' attitude. This study involved only the pre-university students who were persuing their studies at the matriculation college. Another study which involves pre-university students who are studying in Form Six learning programme should also be done. Future studies should also involve the educators as they have tremendous influence in shaping positive attitudes towards STEM among the students. It is a fact that the process of teaching and learning in the class involves the combination of students, educators and content instruction (Atan Long, 1980).

6.0 CONCLUSION

The Internet of Things (IoT), big data, cloud computering and similar others are definitely changing our lives during this era of IR 4.0. The 21st century learning requires Malaysia to move progressively together with other developed countries in encountering IR 4.0. In this rapid advancement of IR 4.0, students are required to have literacy in STEM to fulfill their personal and social needs. Thus, educators need to plan and make necessary actions for their students especially in shaping a more positive attitude towards STEM among the students as the teaching of the educators will determine the learning outcome of their students. Positive outcome of attitude will affect students' achievement. It was proven that the relationship between attitude and achievement of students for a particular subject is significant in which a higher performance correlates with a more positive attitude towards the subject (Neal, Gill & Tismer, 1970; Siti Rahayah, 1988; Abu Bakar Nordin, 1991).

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