THE EFFECTS OF INTEGRATING STEM EDUCATION THROUGH STEM MODULE: TOWARDS A SKILLED WORKFORCE AND CONSISTENT LEARNING SOCIETY.

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ABSTRACT

Science Technology Engineering Mathematics (STEM) especially in TVET circles appears to be critical to transform the typical teacher-centred classroom by encouraging a curriculum that is driven by problem-solving, discovery, exploratory learning, and requires students to actively engage a situation to find its solution. Hence, this research aims to investigate the effect of integrating STEM education through STEM module (Inspirational Module, Reactivity of Metals, Adruino, Gas Around Us, Ninja. The sample who was from School A involved in the experimental group consisted of 20 form 3 subjects (mentees) and 20 subjects (mentors) for Control group. The research instruments used are questionnaire and has high reliability of .67, .78 and .68. The mean, standard deviation, and t-test were used to analyse the pretest and post-test data. Interview and observation were also used to analyse the treatment effectiveness. The results of the study were the comparison of soft skills before and after undertaking the STEM module treatment was different at significant 0.05. (1) Overall soft skills were higher (post-test data) than before the STEM treatment module. 2) The mean of interest in Science subject, Mathematics subject and perception towards STEM of experimental group increased, The comparison of interest in Science subject, interest in Mathematics subject and perception towards STEM before and after undertaking STEM module was different at significant 0.05.

Keywords: *STEM Education, STEM Module, perception, Skilled worker.*

INTRODUCTION

The Shared Prosperity Vision 2030 is a document that outlines 10-year goals to restructure Malaysia's low-skill labour-intensive economy to a knowledge-based economy, where her citizens will enjoy a decent standard of living. The official definition of SPV2030 which reads that Shared Prosperity Vision 2030 is a commitment to make Malaysia a nation that achieves sustainable growth along with fair and equitable distribution, across income groups, ethnicities, regions, and supply chains. The commitment is aimed at strengthening political stability, enhancing the nation's prosperity, and ensuring that the people is united whilst celebrating ethnic and cultural diversity as the foundation of the nation-state". STEM", especially in TVET circles where it appears to be critical in the development of technical minds.

It has been argued that STEM Education attempts to transform the typical teacher-centred classroom by encouraging a curriculum that is driven by problem-solving, discovery, exploratory learning, and requires students to actively engage a situation to find its solution" (Stevens, Andrade & Page, 2016). The main aim of the Shared Prosperity Vision (SPV) is to provide a decent living standard to all Malaysians, regardless of their ethnicity, social class, and location by the year 2030. In order to enable the country towards its goal, the government has eight focus points. Among them is the Education and Technical and Vocational Education and Training (TVET) which is to increase skilled workforce, a consistent learning society and outcome-based education

STEM Education is important for a country to be advanced in economy and technology. It is achieved through skilled and multi-talented workforce produced by TVET which is a component of STEM Education (Edy Hafizan et al, 2017). As TVET students, there are reasons for picking up STEM as part of their studies. Regardless of their technical and vocational trades they are bound to encounter STEM subjects and understanding at least the fundamental knowledge gives them the advantage to succeed in TVET. This is because with TVET's hands-on nature, they have a better chance of applying the theories and concepts that they've learnt in STEM subjects compared to their counterparts who've opted to forego TVET.

When they are able to integrate and practise the knowledge and skills they have gained from STEM-related disciplines, they are better prepared in addressing real-world problems with practical solutions. Such capabilities will then give them the opportunity to inculcate soft skills such as complex problem solving, critical thinking, creativity, communication, and collaboration, which continue to be in demand among employers irrespective of fields (Ugras, 2018).

The current problem faced by Malaysia and in most parts of the world is the critically decreasing number of students opting for the science stream in secondary schools and higher education institutes, regardless of high academic performance in science (Edy Hafizan et al, 2017). The first National Science and Technology Enrolment Policy of 60:40 is implemented in 1970 which states that 60% of students must be enrolled in science, whereas the remaining 40% in arts (Bahrum et al, 2017). This 60:40 policy is further supported by The Malaysia Education Blueprint 2013-2025 that aims at improving the teaching and learning process of science and mathematics related subject to increase the number of students in science streams, including engineering. (Shahali, Ismail & Hashim, 2017).

The development of STEM education is closely related to the development of the national education system (Ismail, Salleh & Nasir, 2019). Science education can produce students who possess scientific skills that can be applied in the work field later on. In order to implement and maintain the development projects in Malaysia, it is very crucial to attract more STEM students as otherwise the progress of the country will be delayed. In Malaysia, while the government is expecting 60% of students to enroll in science stream, the statistics in 2014 shows that only 21% of the upper secondary students are choosing science subjects. This worrying trend will further cause a shortage of science graduates in coming years, especially in engineering.

Many researchers found that students refused to opt for the science stream due to factors such as lack of interest in STEM subjects (Ugras, 2017), lack of mentoring and guidance from adults who are knowledgeable and involved in the field of science-related careers and lack of role models (mentors) in the field of science (Mayasari et al, 2016). Students also face psychological restraints whereby students believe that the field of science is difficult. They have negative perception towards STEM (Chittum et al, 2017), and the assumption that science is an uncreative endeavor.

Due to the significant decline in the numbers of students studying in the science stream and to revive student interest toward science and to address the negative perception toward science, respective stakeholders need to take necessary actions and play their roles within their authority. Although some effective STEM interventions were found in the literature, there is still a dire need for research to investigate into the effectiveness of those programmes, especially with regard to programme preventing talented and initially motivated STEM students to drop out of STEM education. Therefore, this research explores the results of STEM-related interventions in which its effectiveness is assessed.

Statement of The Problem

The challenges and issues faced in the STEM education are manifold. Among others, they involve students' low interest in science (Zaniewski & Reinholz, 2016), negative perception on STEM related subject and the lack of awareness to STEM education. Studies repeatedly warn of students' low interest in school science subjects as their interest in science declines during secondary schools (Fortus & Vedder-Weiss, 2014). A factor that relates to the low interest in school science subjects is the negative perception towards STEM which is worrying. Students and parents have negative perceptions on STEM related subjects where they usually assume that it is difficult to achieve good grades as compared to Social Science subjects.

Effective mentoring is a key component of academic and career success that contributes to overall measures of productivity including in the successful of STEM learning. Proper mentoring help students in their studies and become more familiar with STEM related activities at school and outside the school. Though mentoring play significant in recruiting and retaining students from groups underrepresented in STEM fields, many STEM entrants end-up switching their majors to non-STEM fields, perform poorly relative to their peers in other programs, and/or drop out of college without earning any academic qualification (Ali et. al, 2018).

One of the issues faced by STEM education is the lack of soft skills (Fortus & Vedder-Weiss, 2014). Soft skills are important components of both industry and organizations. STEM education today is not about teaching the subject disciplines but rather how to harness knowledge in the STEM subjects to provide solutions to real-life problems. STEM subject is also about how to connect the knowledge learnt in the disciplines concerned to provide creative and innovative solutions to real life problems.

Research Objectives

The objectives of this research are:

1. To examine the effect of participation in Mentor-Mentee STEM module on the mentees attitudes towards science,
2. To examine the effect of participation in Mentor-Mentee STEM module on the mentee's attitudes in Mathematics,
3. To examine the effect of participation in Mentor-Mentee STEM module on mentees perception towards STEM,
4. To examine the effect of participation in Mentor-Mentee STEM module on mentors soft-skills.

Research Questions

This study builds upon previous research which indicates that STEM module may enhance the students attitude towards Science and Mathematics subjects and increase mentees perception towards STEM education by forming the following questions

1. What effect does participation in Mentor-Mentee STEM module have on the mentees' attitudes towards science subject?
2. What effect does participation in Mentor-Mentee STEM module have on the mentees' attitudes towards Mathematics subject?
3. What effect does participation in Mentor-Mentee STEM module have on the mentees' perception on STEM' subjects?
4.What effect does participation in Mentor-Mentee STEM module have on the mentor soft-skills?

LITERATURE REVIEW

Current research studies regarding hands on learning experience have shown improvement in student learning and achievement in STEM subjects (Naizer, Hawthorne & Henley, 2014). Edy Hafizan Mohd Shahali et al (2018) study on students' interest towards STEM revealed that, 2 years after leaving a mentor-mentor programme, the levels of interest towards STEM careers were sustained. In a related matter, DeCoito (2016) study on the effects of a STEM intervention on elementary students' science knowledge and skill revealed a statistically significant gain in science process skills, science concepts, and science-content knowledge by general education students in the experimental group when compared with students in the comparison group. Their study also found that teacher participation in the STEM program had a statistically significant impact on students' variability in post test scores.

In examining the effectiveness of STEM intervention, Nurul Asyikin Mohamed Radzi & Suhaila Sulaiman (2017) proved that STEM intervention has higher success rate in students with low perceptions of STEM connections. In light with the effectiveness of STEM intervention, the role of good mentoring is one of the biggest factors for the student (mentee) to progress in STEM areas which eventually will help to shape their career as in Ali et.al. (2018) study proved that there is a correlation between academic success and degree of acceptance from positive mentoring experience. Both mentors and mentees involved in this research had positive values toward science and mathematics. Further research investigating the importance of mentoring in STEM education is seen in Stoeger et. al. (2013) who successfully highlights online mentoring for promoting girls' interests in STEM. A similar study by Holmes et. al. (2012) was sought to correlate middle school girls' overall confidence in science and mathematics with a year-long, after school mentoring program led by female engineering students from University of Oklahoma. The results demonstrated

that there was a significant correlation between the quality of the mentoring relationship and the girls' confidence in mathematics.

Zaniewski and Reinholzm in their 2016 study provided mentees with both psychosocial and academic support. Similarly, Sithole et. al. (2017) conducted a study to improve the interest of college students towards Science and Mathematics subjects. The study was initiated due to many STEM entrants end-up switching their majors to non-STEM fields, perform poorly relative to their peers in other programs, and/or drop out of college without earning any academic qualification. Steven et. al. (2016) introduced a culturally driven STEM programme aimed at increasing engagement in STEM learning among Native American 3rd-8th grade students.

RESEARCH METHODOLOGY

The main purpose of this study was to understand mentees' attitudes towards science, and mathematics and their perception towards STEM through the Mentor-mentee STEM program. This study experimented with a short-term Mentor-Mentee STEM module. Specifically, this experiment was designed using five activities that were run within five weeks. The goal for the Mentor-Mentee STEM module of producing the vehicle in this study provided an opportunity for the participating mentees and mentors to learn through group effort, group discussion and continuous activities. It also facilitated application and integration of soft skills and STEM knowledge in the mentors and mentees to enhance their abilities of communication skills, teamwork, problem solving and knowledge integration.

The mentor in this study consists of 10 undergraduates' students from Universiti Sains Islam Malaysia from two faculties. Their role is to help and assist the mentees during the intervention sessions and to ensure different dynamic in engaging with the mentees apart from typical chalk and boards concept done by the schools. The mentors were also evaluated using another set of pretest and post-test to study the impact of soft skill after engaging with the mentees. The questionnaires revolve around communication, problem solving, professionalism, teamwork, social responsibilities and life-long learning set of skills.

Twenty (20) form 3 students were chosen as mentees in this study. To complete all the modules, the mentees had to actively apply their STEM knowledge, communication skills, problem solving skills and to collaborative using teamwork. They had to undergo a five modules programme. They had to answer a set of questionnaires before and after the module was implemented. The location of the research is at Putrajaya for School A.

Instruments

A set of questionnaires was used to measure the mentee attitude towards Science Subject (8 items) and mentees 'attitude towards Mathematics (8 items) and mentees perceptions on STEM Education (10 items). A questionnaire on the Mentors Soft skills was also administered. A five-point Likert type scale was used ranging from 1 (strongly disagree) to 3 (neutral), 5 (strongly agree**.** The overall reliability of the confidence coefficient Cronbach's alpha value questionnaire is high (Cronbach's α = .72 and the dimensions of interest toward science subject Cronbach's α = .67, interest toward Mathematics subject Cronbach's α =.78 perception towards Science 68. and mentors; soft skills Cronbach's α = .72. Meanwhile a set of questionnaires was administered to 10 mentors for School A.

Mentor-Mentee STEM Intervention

The five activities in the Mentor-Mentee STEM Modules are Activity 1 (paper plane, and balloon). This activity was to test the communication and problem-solving skills of the mentees. The goal of the activities in the module provided an opportunity for the participating mentees to learn group effort, group discussion. It also facilitates application and integration of STEM knowledge abilities of communication skills, problems solving and knowledge applications. Activity 2 is on the topic of "Reactivity Metals". The mentees were taught the different kinds of metal and the topic was suggested by the school teacher. Here, the mentees explored the experiments and perform risk assessment on the experiment. The third activity is: Build Your Own Molecules. This activity requires mentees to use 3D molecules set printed from 3D printer.

The mentees have to build molecule as basic as as water and as complicated as ascorbic acid (Vitamin C). Activity 4 is Arduin where the programming and coding electronic circuit were conducted. The mentees task was exploring MIT Apps Inventor to build their own apps. In this activity, the students were given specific theme for them to develop their own apps. In the final activity, activity 5 is ": Gases Around Us". The activity involves lecture demonstration: Gases Around Us! Students experience various gases molecules around them including creating Hydrogen Fireball.Nitrogen gas being introduced from liquid nitrogen at -196°C.

Data Collection Procedure

A paired-sample t-test was used to understand the changes of student's attitudes to Science and Mathematics and their perception towards STEM before and after the Mentor-Mentee STEM modules. In order to gain a deeper understanding of the activities and a rich narrative descriptions of student experiences to provide insight into their experiences of science, a semi-structured interview was conducted after the project. All the interviews were tape recorded and then transcribed. A uniform set of

rules were applied to transcribed coding. For instance, S5: 46-49 meant that the data was from line 46-49 in the transcript of Subject 5. Quantitative and Qualitative analysis had been employed in this study. It involves collecting data from a school (school A) in Putrajaya.

In regards to mentees interest/attitude towards science, the quantitative data revealed that mentees' attitude were positive and significant at both pre-test (M-=13.70, SD=1.916, t=32.432,p< 0.05) and post-test (M=18.300, SD=2.536, t= 27.43, p < 0.05). Similar results can be found in the interview showing that mentees' attitudes towards science are positive. Mentees indicate that "*they are more willing to learn science after attending the STEM Mentee-Mentor programme*". (S1:015). They also indicated "*they liked to learn Science and Mathematics more from practical experiments such as the activities conducted in this study*" (S2:06). In addition, a few mentees mentioned that "*Science and Mathematics are beneficial and can be generally applied in everyday life"* (S3:07). They further suggested that "*the activities produced high-order thinking skills for example (s)he can think how to make a proper plane*" (S4:07).

Table 1: Analysis of one sample t-test regarding mentees attitudes towards Science, mathematics and perception towards STEM.

Participant	Number	Subject	Pre-test		Post-Test			
			Mean	SD	t	Mean	SD	t
Mentee	20	Mentee attitude towards Science	13.700	1.9166	32.432*	17.700	2.885	27.432*
		Mentee attitude towards Mathematics	11.350	1.980	25.625*	13.00	1.891	30.731*
		Mentee perception Towards STEM subject	14.600	2.233	29.231*	16.550	4.957	29.231*

* p < 0.05

As for the mentees' attitudes toward Mathematics,the results revealed that mentees' attitude towards Mathematics were positive and significant at pre-test (M-=11.35, SD=1.980 ,t=25.625, p< 0.05) and post-test (M=13.00, SD=1.89, t= 30.731, p < 0.05). From the interview, similar results were shown that students were positive in their attitude towards Mathematics. They mentioned "*Mathematics is helpful in our daily life. It can solve many calculations problem. For example, when purchasing things*" (S3:09). A few mentees indicated in the interviews that "*they dislike Mathematics due to its difficulty in understanding, but they know the importance of it and will still learn it*" (S4:05, S7:09).

Finally, in relation to the mentee's perception towards STEM, the quantitative data revealed that it was positive and significant at both pre-test (M-=14.60, SD=2.23, t=29.231, p< 0.05) and post-test (M=16.55, SD=4.957, t= 29.231, p < 0.05). Similar results can be found in the interview showing that mentees perception towards STEM are positive. They indicated that *"STEM subjects are very important in the lives of people.* Another mentee mentioned that *"Science can open up many opportunities in the career field such as scientist, astronaut, or doctor"* (S4:06). *"Show that science is able to solve various problems in life such as boiling water, washing clothes, rearing fish and a cat"* (S5: 011).

In regard to mentor communication skills, the quantitative data revealed that it was positive and significant at both pre-test and significant at both pretest (M= 2.500, SD= 5270, t= 15.00, p < 0.05) and post-test (M= 4.700, SD=488.05, t= 30.769, p < 0.05). The data findings proved that mentors 'problem-solving was positive and significant at both pre-test and post-test as pre-test (M= 3.000, SD= .666, t=14.23, p < 0.05) and post-test (M= 4.700, SD= .483, t= 30.769, p < 0.05).

In regard to mentor knowledge application, the quantitative data showed that findings were significant and positive as in pretest (M= 2.9000, SD=.3162, t= 4.800, p < .005) and post-test (M=4.800, SD= 4216, t= 36.00, p < 0.05). Finally, in relations to teamwork, the data indicated that it was positive and significant at pretest (M= 2.900, SD= .567, t= 16.15, p <.005) and post-test (M= 4.800, SD= .4216, t = 36.00, p < 0.05). Similar results can be found in the interview showing that mentors soft skills increased after the intervention.

Table 2: Analysis of one sample t-test of mentors' softskills

Participant	Number	Subject	Pre-test			Post-Test		
		Soft/Skills	Mean	SD	t	Mean	SD	t
Mentor	10	Communication	2.500	.5270	15.00*	4.700	488.05	30.769*
		Problem Solving	3.000	.666	14.23*	4.700	.483	30.769*
		Knowledge application	2.9000	.3162	29.00*	4.800	.4216	36.00*
		Teamwork	2.900	.567	16.15*	4.800	.4216	36.00*

* p < 0.05

Figure 1. Mentor-Mentee STEM activities

A mentor indicated that *"implementation of STEM-based activities contributed to the development of my STEM skills"* (S1:04) Another mentor mentioned that "*since STEM education leads to production of communication skills, problem-solving, we all as university students will benefit"* (S2: 011) and *"due to the introduction of different activities that could provide solutions to the same problem, creativity of the mentees will develop as a result of thinking different"* (S2: 013) Some mentor indicated that their self-confident has improved."*I notice that my self-confidence in communicating my ideas has improved"* (S5:07). The result showed that use of STEM education would have various contributions to the mentors and mentees. The activities conducted is a form of active learning. It encourages students to fully engage in the learning process. By allowing students to explore topics, make their own connections, and ask questions, they are able to learn more effectively in STEM's activities.

DISCUSSION

This study found that the STEM module has been able to increase mentees' interest of science and Mathematics. Interviews were conducted to determine the views of mentees' of the effectiveness of the Mentor-Mentee programs. It was found that mentees had positive views on the intervention. The related research findings were consistent with the results of the previous studies (Uğraş (2017), Bahrum, Wahid & Ibrahim (2017) & Cotabish et. Al, 2013). All these research stated that STEM education intervention improved students' scientific process skills and allowed them to better understand scientific concepts and content.

Chen, Wei, & Li (2016) and Denson et. (2015) stated that STEM activities were entertaining, allow students to develop psychomotor skills, encourage collaborative learning, provide social interaction and thus, provide effective and permanent learning. Sánchez, Robles, & Pons, (2017) stressed that STEM education improved the creativity, communication and cooperation skills that students require for lifelong learning. Ing, Aschbacher & Tsai (2014) stated that students, who are open to innovations with scientific curiosity, could conduct research and could question, could be trained with STEM education.

One of the very obvious advantages and effectiveness of the treatment of the STEM module in this study is the increase of communication skills of mentors and mentees. This supports the idea that across many different countries, science educators and organizations have explicitly identified communication skills as a requisite competency for scientific literacy in the twenty-first century. The ability to listen effectively so as to understand the main points being made by others and to utilize different modes of communication as appropriate for specific purposes (e.g. persuading, arguing, or providing appropriate information)

One of the findings in this study is the importance of teamwork in STEM education. The mentors and mentees in this study stated that the STEM module that they have undergone have improved their team skills. The best STEM classes feature collaboration and teamwork 21st-century skills all students need, no matter what their career paths; therefore, preparing kids to work together. STEM teams should foster a sense of purpose, creativity, accomplishment, and a spirit that team members need one another to solve problems.

The importance of thinking skills as shown in the study is as we move into the era of globalization and the digital age, thinking skills become crucial in order for the educated person to cope in the rapidly changing world The subjects in this study (mentors and mentees) need thinking skills in order to make good choices. In the current job market there is a need for thinking skills to ensure job employability. Therefore, today's education must emphasize on creative and critical thinking. As proven, the STEM module activities in this study have attempted to transform the typical teacher-centred classroom by encouraging a curriculum that is driven by problem-solving, discovery, exploratory learning, and requires students to actively engage a situation in order to find its solution. It is also in in line with the the Shared Prosperity Vision (SPV) which, among eight focus points is the TVET, which is to increase skilled workforce, a consistent learning society and outcome-based education.

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