Developing Interest in STEM through Mentor Mentee Program

Marlina Ali[1#] & Corrienna Abdul Talib[1]

[1]School of Education, Faculty of Social Science and Humanities,
Universiti Teknologi Malaysia, Johor Bahru, Johor, MALAYSIA

[#]corresponding author <p-marlina@utm.my>

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Abstract

The Johor Young Innovators Challenge Programme is one of the programmes in Malaysia to help youth to develop technical and life skills in areas which consist of system, problem solving, innovation and entrepreneurship through workshops, competitions and boot camp. The programme consists of three phases that are capable of producing a generation with enhanced interest in science and technology. The roadshows and boot camp were aimed at creating awareness and as a platform for the organizing committee to work with teacher in-charge in identifying talented individuals for the Young Innovators Team Challenge. This paper describes how this programme was able to affect the participants' interest especially in science and technology by using questionnaire method to measure the level of interest of participants. Using purposive sampling technique, the survey instrument consisting 30 items and 3 constructs was distributed to 27 respondents who were inspired by the items being analysed under three constructs, i.e. mentor competency, career and interest. The method called as Young Innovate STEM questionnaire (YISTEM) A was implement to identify the level of interest of respondents towards Science, Technology, Engineering and Mathematics (STEM) after joining the programme. The data obtained from the questionnaire which were analyzed by using Rasch Model revealed that The Young Innovators Challenge program appears to have been successful in boosting undergraduate students' interest in STEM.

Keywords: STEM mentor mentee; STEM; Young Innovators Challenge; Interest towards STEM; Training the Trainers (TTT)

Introduction

Background and Overview

Science, Technology, Engineering and Mathematics (STEM) Education has become an important topic for researchers because of its vital role in the country's economic growth and nation building. The STEM approach has been widely implemented in many countries especially in developed countries such as USA, Singapore and UK. Its curriculum idea is based on the four specific disciplines, i.e. Science, Technology, Engineering and Mathematics using the multidisciplinary and application based approaches. STEM education is responsible to develop students to become better problem solvers, more innovative, inventive, and self-reliant. They are logical thinkers who are also technologically literate (Morrison, 2006). However, international benchmarks of mathematics/science achievement such as TIMSS and PISA have shown that Malaysian students do not perform well in mathematics and science (Educational Planning and Research Division, 2016). This due to the fact, mathematics and science subjects need student to have critical thinking to solve the problem. In addition, according to Ministry of Education (MOE) (2013) there was a decrease in graduation rates in STEM fields. Those who were trained for STEM-related careers were not sufficient to meet the country's needs (Ministry of Science Technology and Innovation (MOSTI), 2012).

A national study that was conducted, namely Science and Technology (S&T) Human Capital: A Strategic Planning Towards 2020 Ministry of Science Technology and Innovation (Ministry of Science Technology and Innovation (MOSTI), 2012) confirmed that Malaysia needs at least 1.0 million S&T human capital by 2020 based on a 6% annual economic growth and the emergence of Entry Point Projects (EPPs) under the National Key Economic Areas (NKEAs) as well as the emergence of new technology-driven sectors. High skilled workers are among the 50% of this number. However, it would only comprise 3% (or 500, 000) of our expected total workforce of 15 million in 2020. All these data shows that more efforts need to be done to prepare more students to enter STEM fields. According to the National STEM Movement (2016), STEM is referred to disciplines of knowledge consisting of Science (physics, chemistry and biology) and mathematics with the integration of various technologies and engineering. STEM incorporates all the technologies that engage science and mathematics. Sahin (2013) also stated by carrying out various activities such as science fairs, after school activities, engaging students with STEM related clubs can often develop positive attitudes towards STEM fields.

Rationale, Objective and Research Questions

"Young Innovate" program and later was called as Johor Young Innovators Challenge Program is an innovation competition among secondary school students (DreamCather, 2016). This competition was introduced in 2013 and had attracted participants from many schools as well as universities in Malaysia. The objective of Johor Young Innovators Challenge is to reach out and create awareness and interest in STEM education among secondary school students. The role of the mentor is to guide and provide mentoring for student groups from secondary schools to

innovate using technology and to solve real-life challenges. It also has purposes to encourage volunteerism and leadership growth among the students in Universiti Teknologi Malaysia (UTM). Johor Young Innovators Challenge 2017 started with the ongoing road shows and boot camps to the selected schools between February to April. Road show and boot camp were delivered in the schools for groups of between 20-40 students. The roadshow and boot camp were aimed at creating awareness and as a platform for the organizing committee to work with teacher in-charge to identify talented individuals for the Young Innovators team challenge. The UTM mentors had to go through a compulsory mentor training. The training covered not only the technical aspect of the competition but was largely focused on mentoring and leadership skills as well as the application of Design Thinking in project development.

UTM undergraduate mentors gained insights into effective mentoring, communication skills, pitching skills, critical and creative thinking, and most importantly gained the know-how to mentor project using Design Thinking. With training completed, mentor were assigned to the schools and had the responsibility of mentoring the schools' teams in their project according to the selected theme and completion of prototype before the competition. The themes of the product include such as agriculture & marine, automotive, manufacturing, and tourism. Each team comprises of 3 to 4 members. The mentors had to commit from the start of the program in March through July and for winning teams, the commitment is expected to last till September. Mentors contributed time, energy and resources such as money, project and components. Mentors are also required to support other mentors in ensuring unresolved problems are looked into as a group and in ensuring there is no mentor fall out in the group. The mentors were 100% committed and many went out their way to ensure their schools teams were able to complete the race and be at the showcase. After an average of 8 mentoring meets ups (both face to face and virtually) with school teams, the school teams completed their prototype and participated in Johor Young Innovators Challenge which took place at UTM, Johor Bahru. UTM joined this mentoring programme since 2016. The objective of this program was to inspire passion in STEM and it is hoped the program is able to boost student's interest in STEM fields and cultivate STEM literacy. Johor Young Innovators Challenge (JYIC) participated by 386 school students (mentee) from Johor, 32 schools in Johor and 30 mentors (UTM) in 2016. In 2017, Johor Young Innovators Challenge was participated by 199 students from 22 schools in Johor district. There were 67 teams that entered the JYIC 2017 competition.

John (2013) reported one study led by researcher Sharon Straus at St. Michael's Hospital, in Toronto. The Academic Medicine found that good mentors were honest, trustworthy, and active listeners (Bethany (2014). Mentorship program helps expand students' ideas about possible careers in STEM fields. Guidance from the right person can trigger a passion for STEM. As previous studies highlighted the benefits of mentorship program, this study is proposed to identify the interest in science after completing Johor Young Innovators Challenge.

The purpose of this study is to identify mentor's interest in science after completing the Young Innovators Challenge Program. It addresses the following research question:

> What are the mentor's interest in science after completing the Young Innovators Challenge Program?

Literature Review

Decreasing enrollment and poor performance in Science and Mathematics

Despite substantial investment in science, technology, engineering and mathematics (STEM) education, there has been a decrease on students' interest in STEM (Ministry of Education (MOE), 2013). The statistics in Table 1 shows that Malaysia were not able to reach the targetted ratio of 60:40 between students of science and non-science streams in secondary school since 1980s up to 2017. The problem became serious in recent years as many students still showed poor performance in science and mathematics in Malaysian national examination i.e UPSR and PT3 (refer Figure 1 and Figure 2 respectively).

Table 1

Enrolment of Students in Form 4 and Form 5 in Government Schools

	STEM (%)	**Non-STEM (%)**
Target	60.00	40.00
1986	31.00	69.00
1993	20.00	80.00
2001	29.00	71.00
2004	36.00	64.00
2011	44.00	56.00
2013	46.96	53.04
2014	46.33	53.67
2016	47.82	52.18
2017	45.74	54.26

*data for year 2015 is incomplete
(Ministry of Education Malaysia (MOE), 2017)

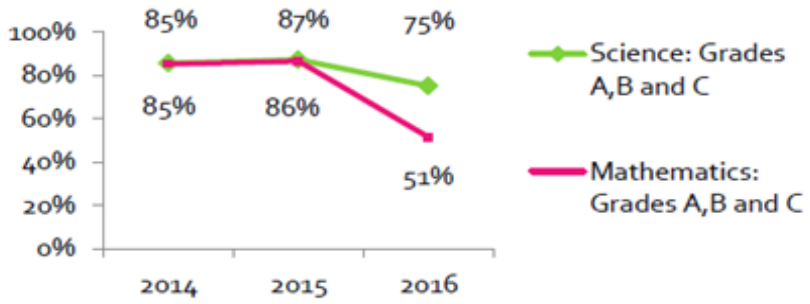

Figure 1. Percentage of students scoring grade A, B or C in UPSR science and mathematics. Source: (Ministry of Education Malaysia (MOE), 2017)

Figure 2. Percentage of students scoring grade A, B or C in PT3 science and mathematics (Ministry of Education Malaysia (MOE), 2017)

Lack of STEM Talents

Talent is unconditional, and most fundamental for a nation to pursue the vision and mission to become a developed country. Thus, while the nation continuously strives to build a high caliber and highly productive human capital base, enhancing knowledge of STEM remains a priority. It is an established view that the role and contribution of STEM is critical in addressing various economic, social and environmental issues as a result of human endeavors in promoting business, trade and industry. The projected STEM workforce is illustrated in the following Figure 3.

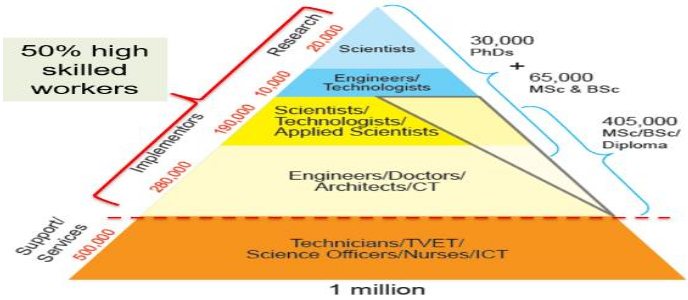

Figure 3. Projected STEM workforce (Academy of Sciences Malaysia (ASM), 2017).

Australia, US and many other countries also faced similar problems as Malaysia. According to Weaver et al. (2013) & Aydeniz and Kotowski (2014), statistics on the state of education in the United States indicated a decreasing trend in domestic students choosing to major in and successfully complete degrees in Science, Technology, Engineering and Mathematics (STEM) disciplines. In fact,(US National Science Foundation, 2010) reported only 16% of U.S. undergraduates are major in a STEM field compared to 47% in China and 38% in South Korea (Aydeniz & Kotowski, 2014). According to Dabney et al. (2012) student interest tends to decline as student school-level increases from upper elementary, to middle, to high school. This is an alarming situation and need a round table discussion among the countries' leaders.

Malaysia needs at least 1.0 million S&T human capital by 2020, out of which 50% are high skilled workers. A national study, *S&T Human Capital: A Strategic Planning Towards 2020* (Ministry of Science Technology and Innovation (MOSTI), 2012) confirms that Malaysia needs at least 1.0 million S&T human capital by 2020 based on a 6% annual economic growth and the emergence of 'Entry Point Projects' (EPPs) under the National Key Economic Areas (NKEAs) as well as the emergence of new technology-driven sectors such as nanotech. Currently, Malaysia was having only 29% high skilled workers. At the current rate of entry, there are shortage of 80% research scientists and engineers (RSEs) by 2020. Target of 500,000 high skilled workers by 2020 is only 3% of total workforce; other advanced countries more than 30% (Academy of Sciences Malaysia (ASM), 2017).

Talent are the heartbeat of a nation to ensure sustained economic progress and innovative solutions to societal problems (Academy of Sciences Malaysia (ASM), 2017). A Progressive Malaysia 2050 will depend on the ability of our talents to remain relevant in the future workforce, our ability to nurture, retain and attract such talent, at the same time ensure that our people are leveraging on technology and not being made irrelevant by it. As the world becomes more connected, current STEM talents need to continuously reskill themselves to adapt to the changes and exhibit the skills that will attract industries or be willing to even become job creators and break traditional boundaries (Academy of Sciences Malaysia (ASM), 2017).

The low ratio of enrolment in science indicates that the supply of human resources was not inclined towards Science and Technologies (S&T) human capital. In other words, Malaysia will face a serious shortage of human capital in science fields as the target for student enrolment in the stream is not being met annually at the school and tertiary levels. Table 2 shows existing ratio and production rate of S&T human capital versus target.

Table 2
Existing Ratio and Production Rate of S&T Human Capital Versus Target

Level	2012		2020	
	Ratio	Production rate (Quantity/ year)	Ratio	Production rate (Quantity/ year)
Science student in secondary school	30%	135, 000	70:100	315, 000
Science student in tertiary education	40%	40, 000	70:100	70,000

(Ministry of Science Technology and Innovation (MOSTI), 2012)

In spite of the substantial expenditure on education, there is a shortage of skilled labour in Malaysia. Labour force participation rates by education level show that the majority of workers only have at most, a secondary school education. In 2010, unskilled workers represented more than 75% of total workers employed; those with tertiary education and applicable skills made up only a quarter of the workforce. Only 28% of Malaysian skilled jobs are in the higher skilled bracket. Shortages in critical professions such as engineers, scientists as well as research and development (R&D) personnels are indeed limiting the evolution of current industries. Therefore, it is crucial for educational stakeholders to continuously develop and maintain the interest of students in STEM

in order to produce first class human capital who possess scientific minds (Academy of Sciences Malaysia, 2015).

Out-of-school activities and career choice

STEM competitions have become an increasingly popular out-of-school activity over the past century. According to Miller, Sonnert, and Sadler (2018), competitions are an effective way to foster career interest in specific domains within STEM, especially when students compete in competitions over several years of their high school periods. Competitions help students develop a better understanding of scientific concepts, processes and procedures, acquire scientific inquiry and reasoning skills as well as develop their communication skills. However, different competitions develop different interest. According to Miller et al. (2018), participation in an IT/computing competition predicts interest in computer science specifically. Participation in a robotics or engineering competition predicts interest in a career in engineering, and not in any other sub-discipline within STEM. Participation in science fair is predictive of interest in a career in science/mathematics, but not in engineering or computer science. Therefore this study intended to see how Young Innovators Challenges influence STEM career interest.

Methodology

This study incorporates a mixed method technique to examine the mentor's interest in science after completing the Young Innovators Challenge Programme. The instruments used in this study included questionnaire and interview questions. The questionnaire developed by the researchers is known as Young Innovate STEM questionnaire (YISTEM) A. There are 30 items listed which consists of 10 items for each construct. For YISTEM A, it is purposely to assess mentors on mentoring competency, career and interests. Seven experts were referred to assess the items. Some questions need a modification but some were good and accepted as it is. After modification, the instrument was given to one school teacher, one undergraduate student and one secondary school student to check the language to ensure that the item is easy to understand. There were 27 mentors, including four school teachers and 162 mentees who participated in this study. The school teachers were Teach For Malaysia (TFM) teachers. The selection of respondents was based on purposive sampling. There were 32 schools involved in state level of Young Innovate Program. The school were from Johor Bahru, Pontian dan Batu Pahat. During the competition, only 27 schools entered the competition. The rest withdrew from the competition. The instrument was distributed during the competition. Rasch Model was used to analyse the data. The data is analysed quantitatively. Based on Rasch model, value for item reliability is 0.51 and the items dimensionality is 40.7%.

Findings and Discussion

Background of Mentor

A total of 12 [42.9%] mentors are male and 16 [57.1%] mentors are female as displayed in Table 3.

Table 3
Gender Distribution of Mentor

Gender	Frequency	Percentage
	12	42.9
e	16	57.1
Total	28	100

Based on Table 4, most mentors are in the range of 20 to 24 years. About 10 [35.5%] mentors are 21 years old and 20 [21.4%] are 20 years old. Three (3) [10.7%] mentors are at the age of 22 and 24 respectively, while for mentors aged 31 and 40, each is [3.6%] only respectively. There was also a mentor who did not disclose his age [7.2%].

Table 4
Age Distribution of Mentor

Age	Frequency	Percentage
20	6	21.4
21	10	35.5
22	3	10.7
23	2	7.1
24	3	10.7
31	1	3.6
40	1	3.6
isclosed	2	7.2
Total	28	100

It was found that majority [96.4%] of the mentors are from the science field, while only one mentor [3.6%] was from the arts field as shown in Table 5.

Table 5
Field Distribution of Mentor

Field	Frequency	Percentage
	1	3.6
:e	27	96.4
Total	28	100

Referring to Table 6, a total of 17 [60.7%] mentors were Malay, while a total of [21.4%] mentors were Chinese. For Indians and others, their number is about the same, which is 2 [7.1%] and 3 [10.7%] respectively.

Table 6
Race Distribution of Mentor

Field	Frequency	Percentage
	17	60.7
se	6	21.4
	2	7.1
s	3	10.7
Total	28	100.0

Mentor's Interests

As mentioned earlier, the main purposes of this paper is to identify mentor's interest in science after completing the Young Innovators Challenge Program. Based on the questionnaires given, there were 17 mentors that have a good interest which was above the value of the average logit. From the total of 17 people, seven of the mentors were males and 10 of the mentors were females. Their ages ranged from 20 to 31 years old.

There were also six mentors that were on the average scale. Four of them were males as well as the rest were females and they were between 22 and 40 years old. Meanwhile, for the mentors who have interests below the average logit or that can be categorized as less interested, there were only one male and three females making them a total of four people. Their age range from 20 to 21 years old. One of them did not inform his or her age.

As shown in Figure 4, majority of the mentors admitted that when they produced an innovative product in this program, their interest toward STEM had increased. Subsequently, they also agreed that this Young Innovators Challenge Program had played a role in making them more interested in STEM.

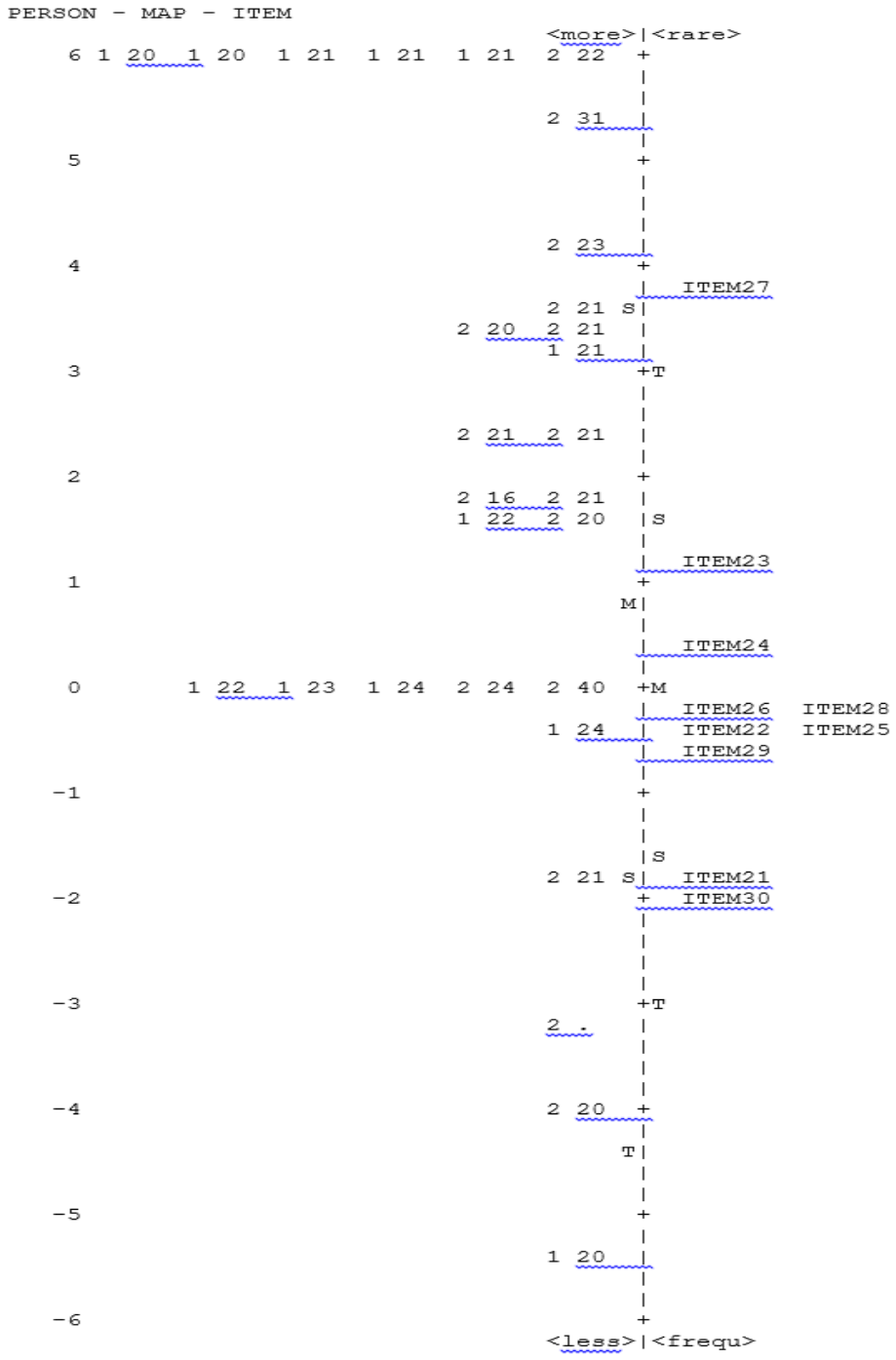

Figure 4. Map item-person for mentor interest.

Next, on a medium level, they agreed that this program has influenced them to learn more about STEM in the near future. Also on a medium level, they agreed that this program make them more

curious about STEM. They mentioned that the exhibition's product is very entertaining since it was related to everyday's life.

However, there were three aspects that were not agreed upon by the mentors. They did not agree that this program cause them to be interested in creating innovations that were related to STEM. They also did not agree that this program makes them feel passionate to find STEM resources. Finally, the last aspect was that the mentors did not agree that through this program, they would make an effort to find information without being instructed.

Conclusion

This study has benefited in many ways. Apart from achieving the primary objectives, it has also encouraged volunteerism and leadership growth among the undergraduate students. Over the past several decades, a number of strategies have been offered for encouraging undergraduate students toward STEM career pathways.

In this program we have employed STEM competition called Young Innovator Challenge. It is a nationwide event bringing together universities, local communities and technology pillars to celebrate the creativity and inventiveness of secondary school students in Malaysia. The Young Innovators Challenge program appears to have been successful in boosting undergraduate students' interest in STEM. The assignment given in the programme increases their curiosity towards STEM. There were no mentor fall-out in this year's program. They supported each other and all mentors persevered even the commitment from some of their school teams were questionable. In the final debriefing, most mentors shared how they were humbled by the experience of mentoring and realised that they gained more that they gave. They were also in admiration of the commitment of some of the students' teams and their teachers.

One implication from this study would be to encourage undergraduate students to participate in similar programs to Young Innovators Challenge because engaging students with this program facilitate students in developing positive attitudes towards STEM fields and cultivates STEM interest in students. These trained mentors benefitted from the training and mentoring experience. Mentors contributed time, energy and resources such as money, and project components. Mentors were also required to support other mentors in ensuring that unresolved problems were looked into as a group also in ensuring that there was no mentor fall out in the group. The mentors were 100% committed and many went out of their way to ensure their school teams were able to complete the race and be at the showcase. There were no mentor fall-out in the program as they supported each other and all mentors persevered even the commitment from some of their school teams were questionable. In the final debriefing, most mentors shared how they were humbled by the experience of mentoring and realized that they gained more that they gave. They were also in admiration of the commitment of some of the student teams and their teachers.

Another implication from this study would be to encourage undergraduate students to participate in similar programs to Young Innovators Challenge because engaging students with this program facilitate students in developing positive attitudes towards STEM fields and cultivates STEM interest in students.

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