The Impact of the Near-Peer Mentoring Approach to Nurture Scientific Enquiry Skills: A Case Study in Kuala Selangor's School

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Abstract
Declining interest in science, mathematics, engineering, and technology (STEM) globally has also affected the students in Malaysia. Only 42% of middle school students in Malaysia chose to do science, including technical and vocational programs at high school as the course always been associated with difficult subjects, textbook-based fields and lack of job opportunities. Hence, it is important to tackle this issue promptly. A STEM Mentor-Mentee program was conducted to explore secondary school students' interest towards STEM for three months at Sekolah Menengah Kebangsaan Rantau Panjang and Sekolah Menengah Kebangsaan Tiram Jaya in the district of Kuala Selangor, Selangor, Malaysia. The main aim of the program was to boost the scientific inquiry skill using a near-peer mentoring approach. Participants consisted of 60 mentees from both schools and 12 mentors. Four STEM skills namely critical thinking skills, creativity, problem solving and decision-making were assessed through five modules. These skills are vital to developing scientific inquiry skill among participants. The mean value for all skills post study has increased and shows significant differences (p-value 0.000) after the mentees participated in the module session under mentors' observation. The program was also able to polish mentoring skills among mentors including creativity, problem solving, motivational and leadership skills with the school teachers favouring the mentoring approach. The result suggested that the relationships formed between mentor and mentee could have a positive effect on STEM education.

Keywords: Mentor, STEM module, Critical Thinking, Creativity, Problem solving, Decision making

Introduction

There is a declining trend among the students pursuing Science, Technology, Engineering and Mathematics (STEM) streams in schools although the growth of digitalizing is escalating particularly during the COVID19 pandemic which limited and challenged the face-to-face interactions. Even though STEM-related positions being among the top emerging jobs, the talent pool continues to shrink which is alarming. The STAR online reported that an average reduction of around 6000 students each year was observed which translated to only 44 % of Malaysian students in the STEM stream in 2018 compared to that of 48 % in 2012 (Chin, 2019). In addition, reaching the ratio of 60:40, the science to non-science student ratio proved to be challenging since a steady declining interest in engineering was observed in the past two years (since 2016) (Nurul Asyikin & Suhaila, 2018). Moreover, it was reported that the enrolment of form 5 STEM students in the year 2016 was just at 48.6 % and only 19.8 % of students pursued STEM courses in the year 2017 based on the enrolment of 424,128 forms 3 students in the year 2016 which further confirmed that the 60:40 Ratio Policy target was still unachievable (Chua & Choong, 2019).

The decrease in students' interest level in STEM education may be attributed to several factors. STEM education being monotonous, and abstract is one of the most cited motives for the lack of STEM students in Malaysia (Halim & Meerah, 2016). Students are exposed to examination-oriented teaching which is ultimately designed towards passing the national public examinations. In addition, the students are mostly frustrated due to unsuccessful teaching of abstract topics which led to the failure to discover the right conception of the abstract (Ramli & Talib, 2017). Besides, the students lack interest and engagement in scientific inquiry due to poor exposure to practical and experimental activities in addition to an almost nonexistence of equipment and maintenance of supplies such as computers and science laboratories in rural environments especially (Halim & Meerah, 2016). Due to this, students are losing curiosity and becoming discouraged to explore or experiment scientifically and mathematically. The students are also convinced that only certain people with 'special ability' are allowed and capable of pursuing STEM education (Halim & Meerah, 2016). Some students are indecisive to study STEM due to unwelcoming career prospects associated with STEM education. Moreover, most students face the challenge of not getting enough parental support when pursuing STEM-related careers (Halim & Meerah, 2016).

Therefore, corrective measures must be taken immediately to overcome these issues since currently 11000 places are available in various STEM-related fields that could not be filled. This will be a huge challenge to Malaysia to face Industrial Revolution 4.0. The Malaysian Government has described STEM as one of the catalysts for transforming the nation into a developing country by 2020. To satisfy the need for human capital educated in STEM, the value chain of the education sector must be in line with STEM-related human capital, services, and technology as the required foundations in this initiative. Malaysia has painstakingly incorporated STEM growth into many of its policies and has developed unique STEM policies to achieve its goal. The Malaysia Higher Education Planning Committee then developed a Science/Technical: Arts strategy (60:40) in 1967 and began enforcing it in 1970. Currently, 42 % of upper secondary school students are following the STEM stream (Nur Amelia & Lilia, 2019). While the 60:40 goal has not been reached, MOE continues to follow this strategy, with the focus on STEM education was further highlighted in the Malaysian Education Blueprint 2013-2025.

As part of this plan, Universiti Selangor as part of the National STEM Movement has conducted the STEM Mentor-Mentee program. This program was organized to boost the STEM identity by building critical thinking, creativity, and self-related skills of mentee towards scientific inquiry. It is an effort to enforce STEM education to increase science persistence by using the near-peer mentoring approach. Hopefully, the program will benefit mentees by overcoming some of the limitations imposed by the lack of universally accessible and sometimes poor scientific experiences. Besides, the near-peer mentoring approach amplified efforts to increase diversity and retention in STEM for both mentee and mentor.

Methodology

Data sampling

This study's population was the lower secondary schools in *Selangor* with the sample consisted of two rural schools in *Kuala Selangor* district, *SMK Rantau Panjang* and *SMK Tiram Jaya*. There were 65 students selected to be part of the study, 30 students from *SMK Rantau Panjang* and 35 students from *SMK Tiram Jaya*. Meanwhile, 12 mentors from University Selangor (students) were selected and divided equally to both schools with each mentor monitoring five to six students. The control group was the students from schools and universities with similar knowledge levels at the beginning of the study without the intervention phase being performed to this group. Besides, there are three teachers from each school, with the total of six, involved in this study in order to get their view on the impact of this approach to their students.

Modules

The modules introduced in this study is applied-based STEM module as it has been recommended to have positive feedback with students (Nawawi *et al*., 2021; Nguyen *et al*., 2021). The five modules used in this program were: (1) Outdoor Lab, (2) Fun with STEM, (3) MicroWorld, (4) Electronic Kit and (5) Forensic Science. The Outdoor lab introduced simple experiments that can be carried out outside the lab and linked with science knowledge and concepts. This ice-breaking module was developed to make students acknowledge that science is not limited to the lab and exists in the surrounding and is applied in daily life routine.

The second module, which is Unisel Fun with Stem was conducted with four different activities (sub-module) comprising tissue culture (Moid *et al*., 2021), microbiology, recreational mathematics (Hassan *et al*., 2021) and ICT for society and each module was divided into three substations, respectively. The third module, the Micro World module was introduced to expose mentee to the tiny world. The student was introduced with the microscope as a magnifying device in the second module.

The Electronic Kit module (Module 4) was implemented into this project as a part of engineering in STEM education. Finally in Module 5, which is the forensic module (Azman *et al*., 2019), was developed based on a detective role-play setup where the mentees were divided into a group of 6 with the aim of solving a crime.

Data collection
A mixed-mode survey was used in this study with questionnaires, observation, interview, and video recording as instruments for data collection. Both quantitative and qualitative modes were used to assess the sample. Prior to the module intervention, pre-survey was used to determine the baseline of STEM skills among participants including the control group. Meanwhile, in the intervention stage, only sample group follow the modules design by STEM UNISEL facilitators, and they were given a questionnaire and interview to know their interest and curiosity towards the activities.

The questionnaires for the mentee were given again at the end of module intervention session to assess mentors approach and to monitor the mentees progress of their performance (Deshler, Muller & Darrah, 2019). The questionnaire was a validated questionnaire adopted from (Karaahmetoglu & Korkmaz, 2019) that contained of 5 questions for each section. Every section was assessing different STEM skills; critical thinking, creativity, problem solving and decision making. The questionnaire used a 5-point Likert scale with 1 represent strongly disagree and 5 represent strongly agree. Similar 5-point Likert scale questionnaire was also distributed to six teachers involved in the program, consisting of 10 questions to assess their perception on the mentor and mentoring approach.

Random interviews and observations on the mentor and mentee behaviours were also held and recorded among participants and teachers as part of the mixed-mode survey. There were six teachers, with three from both *SMK Rantau Panjang* and *SMK Tiram Jaya* respectively, who took part in the teacher's survey. They were given a questionnaire during the last session to study their perceptions towards the mentors. All data collected through the three phases were analysed using Statistical Package for the Social Sciences (SPSS) software, to produce the conclusion of this study. Data was analysed by using quantitative research method or specifically descriptive statistics to measure the central tendency (mean) and variation (standard deviation) for dataset.

Results and Discussion

Improvement on STEM Skills for Mentees
In this study, STEM modules were designed to allow the students as mentees to apply their scientific enquiry skills including critical thinking, creativity, problem solving and decision making, which are part of STEM skills. The result from the conducted survey was portrayed in Table 1.

Based on table 1, the mean value for all skills has increased after the mentees took part in the module session which was not observed with the control group. The p-value is less than 0.05 which means that there are significant differences on the mentees' skills after the intervention of STEM modules.

The two main elements of critical thinking skill that were assessed via the survey were the ability of students to identify problems and questions relevant to the situation and the ability of students to evaluate conclusions, implications and consequences. In general, critical thinking require mentees to think whether they can includes the process of identifying purposes, raise up questions, use information, utilizes concepts, make inferences, make assumptions, generate implications and embody a point of view about a certain issue or a problem.

Table 1: The result of conducted pre-and post-survey on STEM skills among mentees

	Question	Pre Assessment		Post Assessment		*p*-value	Difference of average mean (post – pre)
		Mean	SD	Mean	SD		
Critical Thinking	1	2.38	1.07	3.31	1.36	<0.05	0.388
	2	2.36	1.15	3.28	1.34		
	3	2.39	1.19	3.37	1.45		
	4	2.41	1.13	3.34	1.41		
	5	2.40	1.09	3.28	1.42		
Creativity	6	2.42	1.12	3.52	3.50	<0.05	0.394
	7	2.44	1.19	3.34	1.36		
	8	2.40	1.15	3.30	1.40		
	9	2.37	1.11	3.32	1.37		
	10	2.40	1.09	3.29	1.37		
Problem Solving	11	2.51	1.11	3.37	1.34	<0.05	0.364
	12	2.37	1.12	3.27	1.34		
	13	2.35	1.15	3.26	1.37		
	14	2.35	1.14	3.19	1.39		
	15	2.37	1.12	3.21	1.39		
Decision Making	16	2.37	1.09	3.28	1.33	<0.05	0.345
	17	2.29	1.13	3.07	1.40		
	18	2.49	1.15	3.16	1.36		
	19	2.37	1.12	3.26	1.37		
	20	2.28	1.08	3.10	1.42		

In this study, the increase of 38.8% average mean score of critical thinking skill was observed among the mentees on the post survey. Previous study has reported the ability of project-based STEM module in fostering critical thinking with the average mean score of 2.82 (Mutakinati *et al*., 2018). This is consistent with the present study in which the average mean score of 2.38 and 3.32 were recorded for pre and post survey respectively. Similar impact of STEM module in improving critical thinking was also reported in other studies (Gencer & Dogan, 2020; Retnowati, Riyadi & Subanti, 2020). Interestingly, a recent study suggested that the near-peer mentoring approach in STEM education is effective in promoting critical thinking among mentees (Nelson *et al*., 2018).

Apart from critical thinking, creativity is another essential scientific enquiry skill. The module was designed to allow room for exploration with flexible outcome. For example, the outdoor lab activities provide various instruments which enable the mentees to use various methods in order to achieve the result. Table 1 shown that the average mean score for creativity increased by 39.4% post survey. This result is consistent with aforementioned study in which STEM project-based cooperative learning approach, similar to the module conducted in present study, was able to benefit the scientific creativity of participated students (Siew & Ambo, 2020). A different paper demonstrated the positive impact of effective STEM mentoring on productivity and creativity (Hund *et al*., 2018).

Besides, STEM skill on problem solving has increased by 36.4% as revealed in table 1. The result indicated that the modules were able to enhance the ability of mentees to solve a problem efficiently that involved steps such as defining the problem, generating alternatives, evaluating and selecting the best alternative and implementing a solution. If the learning environments based on problem solving are carried out successfully and efficiently, problem solving skills and achievements improve significantly (Keratas & Baki, 2017). While, Shieh & Chang (2014) has mentioned that realistic, trial and error experience learning has not only strengthened students' innovative skills and problem solving abilities but has also led to their realisation of the importance of teamwork. A different study suggested that students engagement via problem-solving approach could promotes their transferable skills, essential for employability (Maegala *et al*., 2021).

This study also revealed that decision making skill has increased by 34.5%. This result indicated that the assessed group of mentees can increased their ability to make decisions efficiently which involve steps such as defining the problem, identifying the limiting factors, developing and analysing the alternatives, selecting the best alternative and implementing the decision. Previous study reported that team activities as applied in present study assisted the development of decision making skill. Collaborative facilitation which involved the creation of common ground between group members, tasks that benefit from multiple perspectives, and shared task-relevant information resulted in which the individuals within groups go beyond their predicted potential as compared to the isolated individual (Zhang *et al*., 2016).

Roles of Near-Peer Mentoring

Near peer mentoring approach offers significant benefits for both the mentee and mentor where it incorporates established principles of mentoring and offers novel opportunities for integrating research and teaching in STEM disciplines as well as enhances the learning experience of all participants (Tenenbaum *et al*., 2014). The significant improvement on STEM skills among the mentees as illustrated in Table 1 could be influenced by the role of mentor. This is consistent with recent study, which suggested the involvement of underrepresented students in STEM field, in the case of present study is the mentees from rural background, could be prompted through mentorship (Kricorian *et al*., 2020).

In this particular study, mentors experience challenges while carrying out their roles and work their way to solve them. Among the responses by mentors were *"We need to know how to give instruction clearly and in a creative way so that mentees can do the task smoothly"* and *"It is really tough to explain to young children because students lack of knowledge about STEM"*. When handling audience who are new to STEM learning, mentors can opt to creatively diversify their approach by using simpler terms when explaining tasks and encouraging students to ask questions throughout the activities.

The core of STEM learning is studying real-world problems and solving them through project-based learning. While problem solving is an integral part of the study, some mentees were reluctant to give effort in finding the solutions for the task. A response collected stated *“The difficult part is when I have to give ideas to my mentees how to solve certain problem because they don’t want to think at all. So, I gave an example to them how to solve other similar problem.”.* Innovative mentors would use similar problems and scenarios, suggesting ways to solve them and let the mentee utilise the new information in their given task. This encourage mentees to link the dots, and mentees could propose their solution. It has been suggested by recent study focusing on Asian students that combining learning approach, which is the core of STEM education, will result in improved learning outcomes (Wahono, Lin & Chang, 2020).

Since the mentees are still young, they lack confidence and due to it, some were less cooperative than others. This was recorded from mentors’ responses, stating *“The challenge that I face during the program is communication. Most of my mentees are too shy and not confident to give their opinion.”* and *“Some of the mentees were not well cooperative during the activities especially ones that need to be done in a group.”.* As mentors, the key step to improve confidence amongst mentee is by giving encouragement. This is done via recognition and sincere positive verbal feedback, which enhanced the mentor’s motivational skill.

Sharing information about their learning experience or excitement of their work as well as demonstrating passion in STEM is beneficial for mentees. By showing curiosity and enthusiasm towards the STEM activity of interest, mentors will encourage mentees’ participation (Stelter *et al*., 2020). Persistence is key to any successful experiment since failure is a common component of any true STEM work. Hence, apart from mentors listening attentively and giving encouragements, mentees’ tolerance for failure can be instilled by being their role model and demonstrating a positive attitude about failure in both STEM activities or pursuits, as well as failure outside of STEM. (Stelter *et al*., 2020). All of these traits contributed to a great leadership skill. Similar study has demonstrated that near-peer mentoring approach could increase the positive attitude among students/mentees towards STEM activity. (Azman *et al*., 2021)

Teachers’ perspective on Mentor

The survey for the teachers consists of ten questions in form of statements that related to the perceptions of teachers towards the mentor involved in this program. These statements include teachers’ opinion on the mentors’ attitude and their readiness during the program. Summary of the findings on mean and standard deviation for this part are presented in Table 2.

It is shown that statement number 4, 7 and 9 has a mean value of 5 and the rest of the statement has the mean value above 4. This result illustrated that every teacher have the same perspective towards mentor where the responses are “Agree” or “Totally Agree” with the given statement. As the standard deviation for question 4, 7 and 9 equal to zero, it is also shown that all teachers reached an agreement that mentors involved constantly monitoring mentee and always encouraged them to participate while carrying out the activities. In addition, the result also indicated that no hesitation from the teachers about mentors’ attitude who are friendly and liked by the students.

Table 2: Descriptive Statistic of Teacher's Perception towards Mentors

	Mean	Std. Deviation
1. Mentor showed a positive attitude throughout the program.	4.83	0.41
2. Mentor was motivated while conducting the activities.	4.50	0.55
3. Mentor seemed well-prepared in ensuring the activities ran smoothly.	4.83	0.41
4. Mentor always encouraged mentees to participate in the activities.	5.00	0.00
5. Mentor provided clear thoughts, examples and ideas to the mentees.	4.67	0.52
6. Mentor always encouraged mentees to solve the problems and facilitated them whenever necessary.	4.67	0.52
7. Mentor was friendly and warm towards mentees.	5.00	0.00
8. Mentor was actively communicating with the mentees.	4.83	0.41
9. Mentor was always present throughout the activities.	5.00	0.00
10. Mentor was rational and open-minded with the mentees.	4.83	0.41

Research from Sithole (2017) mentioned that peer mentor may challenge mentee with new ideas, and encourage mentee to move beyond the things that are most comfortable. Furthermore, a mentor will instill the desire to share their love and knowledge of science with mentees (Anderson et. al., 2019). This academic and psychological support certainly comes from mentor with positive attitude. Since mentors from Universiti Selangor are selected based on certain criteria such as students' confidence, reliability, independence and strong academic standing, they also serve as positive role models to their mentees. Consequently, these findings showed that mentors successfully provided encouragement, advice and friendship to the mentees. These values not only appreciated by the students, but also being recognized by the teachers involved in the programme.

Conclusion

Five modules were used to execute the STEM Mentor Mentee program and all the modules were able to benefit all the students involved, both mentee in school and mentor from the university. In conclusion, exposure to STEM education through this near-peer mentoring approach program could nurture students' scientific enquiry skills and stimulate their competency to solve problems and challenges. The conducted study was successfully demonstrated a positive impact on mentees' level of critical thinking, creativity, problem solving and decision making while polishing mentoring skills among mentors including creativity, problem solving, motivational and leadership skill.

In view of these outcomes, it can be inferred that such program was able to improve the interest of students in studying STEM-related subjects at secondary school, as the near-peer mentoring program has been shown to enrich their learning experiences. Students gained considerable scientific enquiry skills in this program through hands-on experiments, and they had the ability to discuss current emerging science topics. Mentees were also exposed in STEM-related fields to different job opportunities. The result also suggested that the relationships formed between mentor and mentee could have a positive effect on STEM education.

Due to the essence of the study, this research was primarily focused on qualitative research techniques. Several limitations have been identified which interfered the data collection. The study should be a time-consuming research but has been done in a short time which causing the exposure of students to the STEM have a lesser profound effect than intended. In the meantime, getting a pure participant in a specific group also becomes a challenge as some mentees were absent from school on the day of scheduled program.

Future research should examine the impact of long-term STEM training programs on different student groups, for example, towards the high or low achievers, high motivation or low motivation students attitudes toward STEM education and STEM career. The continuous study and initiatives in promoting STEM education will hopefully lead to the increase of STEM workforce, which will steer the nation towards a developed country.

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