STEM Outreach Program: An evaluation on students’ perspective towards STEM engagement via school-university mentoring partnership

H H Azman1,2,*, M N Maniyam1,3, N S Yaacob1,3, N N A Samah1,3, R Alias1,3, K B Hassan1, H H Kamaruddin1, R M Khalid1, N M Sout1, M F1, H Abdullah2, N A Suliman2, M M Moid4, Y M Yunus5, L A Latib6, N Idris7

1 Centre for Foundation and General Studies, Universiti Selangor, MALAYSIA
2 Faculty of Engineering and Life Sciences, Universiti Selangor, MALAYSIA
3 Selangor BioIT Institute, Universiti Selangor, MALAYSIA
4 Faculty of Business and Accountancy, Universiti Selangor, MALAYSIA
5 Faculty of Health Science, Universiti Selangor, MALAYSIA
6 Faculty of Communication, Visual Art and Computing, Universiti Selangor, MALAYSIA
7 Universiti Malaya STEM Centre, Universiti Malaya, MALAYSIA

*hazeeq87@unisel.edu.my

Abstract. The number of students pursuing science and engineering is reducing drastically over the years which is of great concern to the country. Hence, in 2011, the Malaysia Education Blueprint was initiated emphasizing on the role of STEM for establishing a scientific and innovative society. The National STEM Movement has taken the step forward to make the blueprint a reality by initiating the STEM Mentor-Mentee program in schools facilitated by universities. Universiti Selangor (Unisel) contributed actively through the participation of lecturers as facilitators and students as mentors. Fondly known as the Unisel Fun with STEM program, the team has shared their modules with seven schools in Selangor. This particular study is focusing on one of the schools, SMK Sungai Burong involving 60 students and 3 teachers, assessing the effectiveness of the module and the impact of mentoring approach. A five Likert scale survey was conducted at the end of the program with each of the four domains received positive feedback. The program itself was well-executed with the mean score of 4.24. The response towards the mentoring approach was very favourable, resulting in the mean score of 4.61. This outreach program is considered effective as students demonstrated positive attitude towards the module and STEM field.

1. Introduction

STEM is the abbreviation of Science, Technology, Engineering and Mathematics, which is an interdisciplinary field that incorporates the knowledge of science and mathematics to engineer the technologies for the benefits of human beings. The main goal for STEM education is to equip the younger generation with STEM skills; capable of solving problems with logical thinking, technological savvy, creativity and innovation, via an integrated learning with real world context as well as an interactive approach through hands-on inquiry and open-ended exploration [1].

The increased number of STEM research published in the journal in the past decade [2], even in the context of ASEAN countries [3], is a sign of concern on STEM education among academia. Some
emerging factors that could contribute to such phenomenon include higher demand in the latest innovations in industry, the urge in tackling global issues like climate change, and the lack of qualified STEM professionals that is essential to steer a nation towards modernization [4].

The number of students pursuing a STEM stream in Malaysia is dropping annually. This causes the talent pool to shrink, despite high skilled-STEM related positions being among the top emerging jobs. Last year, only 44% of Malaysian students were in the STEM stream as compared to 48% in 2012. This represents an average reduction of around 6,000 students each year [5]. Meanwhile, the National Council for Scientific Research and Development estimates that Malaysia requires approximately a 494,000 STEM workforce by 2020 in order to support Malaysia’s New Economic Model (NEM), while the Ministry of Science, Technology and Innovation (MOSTI) projected a shortfall of STEM professionals with the current trend [6].

This worrying scenario is a threat to the national agenda. The National STEM Movement has taken a step forward to support the Malaysia Education Blueprint in strengthening STEM education [7] by initiating the STEM Outreach program in schools, facilitated by universities through the mentoring approach. This STEM Mentor Mentee program aims to raise student interest through an interactive fun learning approach, assisting and guiding teachers while building public and student awareness.

Universiti Selangor (Unisel), as one of the universities involved in this program, has designed a ‘Unisel Fun with STEM’ module which was implemented in the program. This study is assessing the effectiveness of this module in engaging STEM interest among students. On top of that, the systematic mentoring approach is applied in the program and its impact is also evaluated.

2. Methodology

2.1. Sample of study

This study was conducted with 60 students of lower secondary level in SMK Sungai Burong in rural area of northern Selangor, Malaysia under the supervision of three teachers. 24 students of Universiti Selangor (Unisel) played roles as mentors in this STEM Mentor Mentee program as part of the STEM outreach program coordinated by the Malaysian National STEM Movement. 12 lecturers of Unisel acted as the facilitators of this program to train the mentor prior to the outreach program at school and in turn, coordinating the program.

2.2. Unisel Fun with STEM module

The module was designed to consist of four different submodules, which were chemistry, microbiology, DNA technology and plant biotechnology. Every submodule contains three activities set in different stations, each started with a simple activity which integrated the fundamental knowledge of that particular discipline. This was followed by the second activity which was scaffolded from the knowledge gained in the first activity. The final activity demonstrated the application of the discipline in daily life and current technology.

2.2.1. Chemistry module. The chemistry module began with an explanation on the use of purple cabbage as a natural pH indicator due to the presence of anthocyanin-based dye. The anthocyanin extracted from purple cabbage can vary their colour depending on the pH of the surrounding environment. In the first station, the students were guided to extract the purple cabbage solution. This solution was then used as a pH indicator to determine the pH of several household items such as detergent, baking soda, salt, bleach, carbonated drinks and vinegar in the second station. In the third station, the application of pH in daily life was demonstrated through simulation using magnesia milk to relieve heart burn. Magnesia milk, an alkaline solution is often taken to neutralize excessive acid in the stomach.

2.2.2. Microbiology module. In this module, the first activity provided opportunities for students to view the morphology of microorganisms by using a microscope. Students were taught how to use a
microscope to view slides containing microorganisms. The second station enabled the students to experience the streaking method used to grow and isolate microorganisms. The final activity involved the traditional fermentation in which the students observed the enlargement of a balloon resulted from the gas released by the yeast during the fermentation process.

2.2.3. **DNA technology module.** This module started with the craft activity known as DNA beads. Each bead represents each nucleotide in the DNA model. Then, students were exposed to the application of DNA technology in forensics in the second and third stations, respectively. The students identified different blood groups (A, B, AB and O) and learnt how to collect and identify the shape of unique fingerprints. Students were also exposed to the concept of DNA fingerprinting while undergoing the last activity.

2.2.4. **Plant biotechnology module.** The first station in tissue culture was seed identification. Students examined each seed under the microscope to observe the structure and texture of the seeds. They were introduced to the concept of biodiversity. This was then followed by the water transportation activity by using Chinese cabbage. The white Chinese cabbage will change colour after a few minutes of being submerged in dyed water. The concept of phytoremediation was also introduced during this activity. The last station was a carrot tissue culture where students learnt the basic technique in tissue culture while discovering the importance of sterile environment during the tissue culture process. A sampled callus was also exhibited to students in order to capture their imagination on the product of a tissue culture process.

2.3. **Data collection**

A five-Likert scale survey was conducted at the end of the program with four main domains including the management of the program, the perception on the mentoring approach, the view on STEM and the interest in the module. The survey ranges from score 1 for the strongly disagree option to score 5 for the strongly agree option. Each domain consists of four to five questions. The survey questions tackled the research objectives of this study. The survey was analysed with Statistical Package for the Social Sciences (SPSS) analysis with the tabulated data was grouped into each domain and presented in a table. In addition, observation and interviews with students and teachers were used as part of the data collection tools.

3. **Results and Discussion**

From the conducted survey, the STEM outreach program, specifically known as STEM Mentor Mentee program, received positive feedback with each domain score between 4.2 – 4.6 mean as shown in table 1. This can be translated as most of the students agreed on the effectiveness of this outreach program. A previous study had reported the efficacy of the STEM outreach program with hands-on activities [8] while a review study highlighted the importance of integrated strategies including mentoring, research experience and workshop in promoting STEM to a diversified target [9].

As shown in Table 1, the majority of students (83.6%) found the program was well-executed with the mean score of 4.24. Based on the comments received, students found that the program was systematic with the flow between stations was easily comprehended. The duration of two hours for the program was sufficient and the materials provided were adequate. The teachers also gave a positive remark on the program with the intention to repeat the program with a different group of students.

It is interesting to note that the mentoring approach was well-received by the students with the total of 95.7% either strongly favour (65.5%) or favour (30.2%) the approach, resulting in a 4.61 mean score. The concept of mentoring involves the students as mentee while the university students acted as mentor. The effectiveness of this near peer mentoring approach has been acknowledged by previous studies [10]. The mentoring approach has been recommended in influencing student attraction, persistence and retention in the STEM program [11].

Table 1. Survey on Mentor Mentee Program

| Domain                      | Percentage of respondents, % (n = 60) |
|-----------------------------|----------------------------------------|
|                             | Strongly disagree | Disagree | Neutral | Agree | Strongly agree | Mean |
| Program management          | 1.7                 | 3.4       | 11.2    | 35.3  | 48.3          | 4.24 |
| Mentoring approach          | 0.0                 | 0.0       | 4.3     | 30.2  | 65.5          | 4.61 |
| STEM attitude               | 0.0                 | 0.0       | 12.6    | 34.5  | 52.9          | 4.40 |
| Interest on module          | 1.1                 | 2.3       | 9.2     | 25.9  | 61.5          | 4.44 |

This approach benefits both mentor and mentee as a previous study suggested that being a mentor developed leadership skills and the ability to handle stress [12]. It has also been observed that undergraduate students that were involved as mentors were independent and self-efficient in research [13]. On top of that, mentoring relationships provide mentees with both academic and personal support [14] while strengthening their STEM identity development, which contributed to persistence in the STEM field as they tend to pursue their future study and career in a STEM pipeline [15].

Universiti Kebangsaan Malaysia (UKM), which conducted the same Mentor Mentee program with a different module, revealed a significant impact of this program on STEM interest, as compared to the group that did not follow the program [16]. This is consistent with our finding; the total of 87.4% gave positive attitude towards the STEM post program with the mean score of 4.40. It is noteworthy to highlight the suggestion of UKM on the need of framework development for the STEM mentoring program with the implementation of blended Mentor Mentee programs for further study in order to get substantial evidence.

In this present study, the effectiveness of the designed Unisel Fun with STEM module was also evaluated with the result of 61.5%, and 25.9% of students opted for strongly agree or agree feedback respectively. On the other hand, a total of 3.4% of students gave a negative response while 9.2% remained neutral for this domain. Further investigation is required in order to understand the reason behind these responses. Thus, students were instructed to specify their interest towards each module accordingly. The result is featured in Table 2.

Table 2. Rank of interest for Unisel Fun with STEM module

| Rank | Module                  | Total percentage of positive feedback, % |
|------|-------------------------|------------------------------------------|
| 1    | Chemistry               | 73                                       |
| 2    | DNA technology          | 70                                       |
| 3    | Plant biotechnology     | 63                                       |
| 4    | Microbiology            | 55                                       |

Among the four stations, the chemistry module was most favoured (73%), followed by DNA technology (70%) and plant biotechnology (63%). The microbiology module was least favoured resulting in a 55% response and therefore needs further improvement. This might be due to limited facilities, especially the quality of microscopes at the school and the nature of microorganisms that cannot be seen with the naked eye. Thus, it is harder to grasp student’s attention and relate with their experience. In addition, the students perhaps could not foresee the real application of microbiology. This
is not an isolated finding as another microbiology-based STEM module received similar feedback with no significant increase on attitude towards microbiology observed post study [17]. Additional activities to increase the interest of students in microbiology was also proposed, based on the output received from the teachers and students. This included arts and crafts using plasticine to construct microorganisms such as HIV virus for better understanding of the morphology of microorganisms, instead of solely relying on microscope observation. Bread dough and other samples of microbiological products should be provided in the future to demonstrate the real application of microorganisms.

The high interest in chemistry modules could be due to the subject being introduced in school syllabuses, and the practicality of the activities in this module with daily life, as the application of pH has been experienced by students before without prior knowledge. One study mentioned positive attitudes towards chemistry after undertaking the research-inspired STEM module [18]. The same paper suggested that simply relating the syllabus-based experiment in class with actual research was not sufficient. The integration of actual research in the form of real world context is more interesting as demonstrated in present study. The mechanism of magnesium milk in treating gastric patients in this module caught the students’ interest in chemistry.

DNA technology as the second ranked module suggested the willingness of students to learn something beyond their curriculum syllabus. Previous study reported that a similar biotechnology-based module was able to foster students’ interest in learning biotechnology [19]. A DNA technology module in the present study is relevant to the field of forensic science. Several published studies have demonstrated the significant interest in forensic science among school students [10,20] with one possible influence being the fictional forensic programs aired on television [21].

The implementation of the plant biotechnology module, ranked third, has received a fairly positive response (63%). As pointed out by one of the recent studies, hands-on and fun-learning tools assisted student to better understand plant biotechnology [22]. This is further supported by a study which reported that practical teaching led to a higher understanding of basic plant tissue culture among students than the one only taught with theory[23].

While participating in the program, students were instructed to wear lab coats and role-played as scientists. This will promote experiential learning while exposing students to the STEM career. The aforementioned study revealed that STEM programs could indirectly motivate students to pursue a STEM career [24], while another extensive study illustrated that STEM programs create awareness of the available job opportunities in STEM, but not necessarily influence them to pursue STEM careers [1]. Thus, further intervention is required at the university level in order to retain students in the STEM pipeline.

4. Conclusion
Students benefit from seeing new context that might be used as an inspiration in regular science courses. From the knowledge gained through the module, the possibilities within the STEM-based world might refine and update their point of view in STEM. It can be concluded that the present module was able to attract students’ interest on STEM while creating positive awareness and attitude towards a STEM field. Furthermore, this study portrayed that the mentoring approach was well-received by students, which offers a lot of benefits for both mentors from the university and mentees in school. To sweeten the study, this Unisel Fun with STEM module was recognised with a Special Award: Most Innovative Project during National Mentor Mentee STEM Award competition. Nevertheless, further research is needed before generalising these results with the investigation of possible relationships between mentoring approach and persistence of mentee in STEM pipeline, is of interest.

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