The effectiveness of STEM mentor-mentee programme: Recreational Mathematics among secondary school students

K B Hassan¹, H H Kamaruddin¹, R Md. Khalid¹, H H Azman¹ and C M M Kasim²

¹Centre for Foundation and General Studies, Universiti Selangor, Malaysia
²Faculty of Engineering & Life Sciences, Universiti Selangor, Malaysia

E-mail: khbariyyah@unisel.edu.my

Abstract. In effort to engage secondary school students’ awareness towards Science, Technology, Engineering and Mathematics (STEM), the Recreational Mathematics programme is designed. The main objective of this programme is to promote secondary school students’ interest towards Mathematics subject. The participants were grade 5 students from Sekolah Menengah Kebangsaan Sungai Burong, Kuala Selangor, Malaysia. This programme contained 7 Mathematics activities involved basic concept of algebra. For each activity, they were guided by Universiti Selangor’s facilitators and mentors. The effectiveness of Recreational Mathematics programme was assessed through these activities. Data on a total of 91 students was collected and it was found that 75% students agreed on the success of the programme management. More than half of the students were interested with the method guided by the facilitators and mentors. They enjoyed studying this subject through mathematical games and activities. Nevertheless, there is a challenge to be encountered while conducting this programme. It was found that 96% of the students were not aware on the importance of STEM and more specifically the significance of mathematical subject. These findings show that STEM activities should be continuously run especially to the students in the rural area.

1. Introduction

Recent reports indicate that United States students exhibit a low level of performance in mathematics and science [1]. Hence, individuals trained for STEM related professions have become insufficient in terms of quantity and quality to meet the country’s demand [2]. In most of the schools in Malaysia, the number of students pursuing science subjects is less than 40% compared to arts students. At the tertiary level, a study also showed that the percentage of science graduates produced by universities is only 32.4 of the targeted 60% [3].

The government through the Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC) has introduced a STEM Mentor-Mentee programme with the aim to strengthen the STEM learning process at the school level. This program involves the facilitators from the selected universities such as Universiti of Malaya (UM), Universiti Tun Hussien Onn Malaysia (UTHM) and Universiti of Selangor (UNISEL) as the mentors whereas students from the selected schools in Selangor as the mentees. According to the research done involving students of UTM in the same mentor-mentee programme with their selected school, 87% of total respondents agree that students’ interest has an important role in attaining good performance for mathematics and statistics subjects. This important factor certainly develops excitement in learning and solving the mathematics and statistics problems [4]. To nurture students’ interest in STEM, many researchers suggest combining after-school activities with
supplementary schooling experience [5]. In this study, the Recreational Mathematics programme with the main objective to promote secondary school students’ interest in the field of mathematics has been done. The effectiveness of the program in terms of the awareness, knowledge, and interest of students towards STEM before and after the program was measured. By organizing this STEM related programme at a small-scale school, it is hoped that students’ engagement in hands on activities will enhance their attentiveness in mathematics subject particularly.

2. Methodology

There are 91 participants of form 5 students joined the Recreational Mathematics programme. Throughout the Recreational Mathematics programme, participants are divided into 10 groups and each group was given the route card stated the substations. Those substations provide the mathematical games listed as follows.

- Station 1: Math’s Wheel
- Station 2: Lighting Race
- Station 3: Fraction Race
- Station 4: Decimal Board Games
- Station 5: Matchstick
- Station 6: Ken-ken Puzzle 3 x 3
- Station 7: Ken-ken Puzzle 4 x 4
- Station 8: Ken-ken Puzzle 5 x 5
- Station 9: Math’s Checkers 1
- Station 10: Math’s Checkers 2

*MATH’S WHEEL* activities aimed to increase students’ achievement in mathematics by answering the SPM standard questions in a fun way. Sijil Pelajaran Malaysia (SPM) or Malaysian Certificate of Education is a national examination taken by all form five students in Malaysia. Since SPM examination provides the opportunity for Malaysians to continue their studies to pre universities level, it is important for all parties to ensure that the students strive their best in this examination. In order to achieve the objective, participants work in a group to discuss the solution while recall the lesson that they learnt in class. Before solving a question, a player must spin the eponymous wheel to determine which card should be selected at random. A player can continue taking turns after each solution has been made.

Some of the groups were tested on their skills of answering fraction and decimal questions at *FRACTION RACE* substations and *DECIMAL BOARD GAMES* substations separately. Meanwhile, players for *LIGHTING RACE* board game are tested with addition and subtraction of number. This certainly aimed to increase the capability of solving basic arithmetic questions without depending on calculator. Each participant in a group played among themselves and no participant was excluded. Like ladder and snake board games, player needs to throw a dice and make a move according to the number of spaces shown on the dice. Each box contains of question to be answered by the player. If the counter lands at certain of the lucky box, the player of the games can make an extra move according to the stated space in the box. The first player to get the ‘End’ box will declared as a winner.

*KEN-KEN* was invented in 2004 by the Japanese mathematics teacher Tetsuya Miyamoto [6]. KenKen grids are divided into heavily outlined groups of cells often called ‘cages’ and the numbers of each cage must produce a certain target number when combined using a specified mathematical operation (addition, subtraction, multiplication or division). For example, a three-cell cage specifying addition and a target number of 6 in a 4×4 puzzle might be satisfied with the digits 1, 2, and 3. Digits may be repeated within a cage if they are not in the same row or column. The target number and operation appear in the upper left-hand corner of the cage. In this Recreational Mathematics programme, participants are only tested with 3 x 3, 4 x 4 and 5 x 5 grids at different substations. Basically, Ken-ken is such a simple logic puzzle, but finding the solution is quite intricate especially for higher number of
grids. Therefore, it is included in this Recreational Mathematics programme with the main goal to improve students’ cognitive abilities and critical thinking skills. As the name derives from the Japanese word for cleverness, studies have shown that mental aerobics such as solving Ken-ken Puzzle and Sudoku can minimize the risk of developing Alzheimer's and other neurodegenerative diseases [7]. Thus, it is not only developed for students, but the games suitable for adults of all ages, nationalities, and abilities.

In MATH’S CHECKERS activities, the participants were instructed to answer simple multiplication questions or division for each step taken. Each group will only play at either station 9 (multiplication) or station 10 (division). Basic movement in this game is to move a checker one space diagonally forward and answer the question stated on box. If a jump is available for one of pieces, the player must take the action. This game certainly creates collaborative opportunities in the making process of correct moves and answers. Furthermore, the participants learn patience, determination and breaking complex problems into easily solvable solution at MATCHSTICK substation. A sense of accomplishment is achieved when the group solves the puzzle together. Hence, the activity helps to increase the confidence level of the students in their ability to solve the problems. As they were guided by 10 facilitators and 10 mentors, students enjoy completing the games with freedom and flexibility among the teammates.

Throughout the programmes, data were collected through observations and questionnaires. Mentors took field-notes about each group performance. It includes participants’ effort, feeling, cooperation and time of completing the puzzles or games. The way of understanding the instruction and solving the questions are also observed by the mentor of each group. In other hand, the ranking quality of facilitator and mentor also assessed in the questionnaire. On a scale of 1 to 5, the questionnaire examined the participants’ views, beliefs and experiences related to the management of this Recreational Mathematics programme. The responses then analyzed by using Statistical Package for the Social Science (SPSS). The evaluated criteria include feedback on what working well for the organizer to improve the programme such as activities material, the module quality, time management and venue suitability. Based on the finding, the study explored in what ways these activities can help the students to develop their mathematical skills. Furthermore, it will investigate the answer on how the students are encouraged to pursue career or studies in STEM field. The findings also were used to discuss the strength of these activities and recommend the area needed for improvement.

3. Result and Discussion

The effectiveness of Recreational Mathematics program was studied through this activity. Data on 91 students was collected. The following table 1, 2 and 3 shows the frequency of students’ gender, race and course. There were 20 male students and 71 female students. Gender significantly related because male and female have different view on this program. Meanwhile, this school has more percentage on Malay students involved and the rest is Indian. The most involved students were come from accounting course, followed by sport science, pure science and the least was from art and literature program.

| Table 1. Students gender frequency. |
|-----------------------------------|
| Gender | Frequency | Percentage |
| Male    | 20        | 22.0       |
| Female  | 71        | 78.0       |
| Total   | 91        | 100.0      |
Table 2. Students Race Frequency.

| Ethnicity | Frequency | Percentage |
|-----------|-----------|------------|
| Melayu    | 85        | 93.4       |
| India     | 6         | 6.6        |
| Total     | 91        | 100.0      |

Table 3. Students Course Frequency.

| Course of study  | Frequency | Percentage |
|------------------|-----------|------------|
| Pure Science     | 25        | 27.5       |
| Accounting       | 29        | 31.9       |
| Sport Science    | 26        | 28.6       |
| Art and literature | 11      | 12.1       |
| Total            | 91        | 100.0      |

Table 4 shows that in the range on good and very good, there are 74.8% students agreed on the success of the program management. It means the material used in this program are suitable, the program makes them feel interesting, time management were well organized and the place where the program held is also suitable. Nevertheless, gender is significantly related in giving their opinion throughout this program. There is significant difference in mean of systematic program management between male and female, with the p-value equal to 0.03 which less than 0.05. It shows that male and female have different view on the systematic program management.

Table 4. Systematic Program Management.

| Rating     | Frequency | Percentage | Cumulative Percentage |
|------------|-----------|------------|-----------------------|
| Medium     | 23        | 25.3       | 25.3                  |
| Good       | 36        | 39.6       | 64.8                  |
| Very good  | 32        | 35.2       | 100.0                 |
| Total      | 91        | 100.0      |                       |

Moreover, 93% students rated this programme were good. Throughout this program, this hands-on module designed involved basic algebra to encourage the students to feel that mathematics is fun and interesting. Table 5 shows that more than half of the students were interested with the method guided by the facilitators and mentors. They were interested with the delivery method and the module contents also suitable. It means that this 54% of the students agreed that the facilitators and mentors are knowledgeable in conducted this programme. Throughout the programme, all the activities were recorded, and they were enjoyed all the mathematical games and activities.
Table 5. Effectiveness of Guidance Method.

| Rating | Frequency | Percentage | Cumulative Percentage |
|--------|-----------|------------|-----------------------|
| Low    | 5         | 5.5        | 5.5                   |
| Medium | 37        | 40.7       | 46.2                  |
| Good   | 49        | 53.8       | 100.0                 |
| Total  | 91        | 100.0      |                       |

Nevertheless, there is a challenge to be encountered while conducting this programme. The study shows that 95.6% of the students were not aware on the importance of STEM and more specifically the significance of mathematics subject. However, there are three students did not answer the STEM awareness question. From the survey, found that the main factor is the school location was in the rural area whereby they had less exposed on STEM awareness. On the other hand, the students gave a positive feedback whereby they want these programme to be done regularly. These findings show that STEM activities should be continuously run especially to the students in the rural area since they were less information about the important of STEM’s subject but teachers in rural school more competent in organizing STEM activities by collaborating with local university [8].

4. Conclusion
The study reported in this paper is one of efforts to support National STEM Movement to nurture greater interest and understanding in mathematics subject among students in schools and higher learning institution. In summary, this Recreational Mathematics programme is well received by the students and their teachers. They hope that this programme will continue and done annually towards encouraging student’s interest in STEM subject especially in mathematics. All parties including students, teachers, parents, minister of education and the government need to take on their respective roles and support the efforts to increase the number of students who take science stream class as these young generation are the future innovators and inventors in order to make our country as a productive country.

Acknowledgement
The authors gratefully acknowledge support from Centre for Foundation and General Studies (CFGS), Universiti Selangor and Counseling Unit, Sekolah Menengah Kebangsaan Sungai Burong, Kuala Selangor. Special thanks to each member of this Recreational Mathematics team and UNISEL’s students who have involved from the beginning until the success of the programme.

References
[1] Sahin A 2014 STEM Related After-School Program Activities and Associated Outcomes on Student Learning 14 309–322 (https://doi.org/10.12738/estp.2014.1.1876)
[2] National Research Council 2011 Successful K-12 STEM Education: Identifying effective approaches in science, technology, engineering, and mathematics (Washington DC: NAP)
[3] Utusan Malaysia 2009 Dasar 40:60 pelajar sastera sains belum tercapai. (http://ww1.utusan.com.my/utusan/info.asp?y=2009&dt=0327&pub=Utusan_Malaysia&sec=Dalam_Negeri&pg=dn_07.htm) Retrieved on 20 June 2018
[4] Mohd Razali S N A, Sufahani S F and Arbin N 2015 Pencapaian Kursus Matematik dan Statistik di kalangan Pelajar UTHM: Faktor Mempengaruhi dan Teknik Pengajaran dan Pembelajaran yang Lebih Diminati J. Techno Soc. 7 40-50
[5] Bell P, Leweinstein B, Shouse A W and Feder M A 2009 Learning science in informal environments: People, places, and pursuits (Washington DC: The National Academic Press)
[6] Olivia J, Samuel L and Kie V I S 2012 Solving and Modeling Ken-ken Puzzle by Using Hybrid Genetics Algorithm. *Indonesia: The First International Conference on Engineering and Technology Development (ICETD)*

[7] National Council of Teachers of Mathematics 2013 Experts Show How Nextoy's KenKen Puzzle is A Powerful Math Learning Tool and is Revolutionizing Math Learning

[8] Khairani A Z 2017 Assessing urban and rural teachers’ competencies in STEM integrated education in Malaysia. *In MATEC Web of Conferences* (EDP Science) *87* p 04004