Effectiveness of Problem-Based Learning Approach in Mathematics Subject Among Lower Secondary Students of SMK Usukan, Kota Belud, Sabah

Lasaraiya, S.*, Kiram, J. J., Juhan, N & Daud, M. A.

Preparatory Centre for Science and Technology PPST,
Universiti Malaysia Sabah UMS, Jalan UMS,
88400 Kota Kinabalu, Sabah.
*corresponding author: suriana@ums.edu.my
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Abstract
Problem-based learning (PBL) methods are being used widely amongst teachers and lecturers to educate students in Science, Technology, Engineering and Mathematics (STEM) related programs in higher secondary and tertiary levels. This project was done as an effort to redeem STEM education due to the declining number of students in STEM related subjects in higher secondary schools as well as in university levels. Thus, a total of 74 students from Form 1 and Form 2 in SMK Usukan, Kota Belud have participated in this study. A structured questionnaire focusing on learning, teaching and communication skills was given to the students and the results were analyzed. Based on the questionnaire, the mean value range of 5.30 - 5.73 and standard deviation value range of 0.50 – 0.76 was obtained respectively. It shows that this pre-experimental project suggested that the learning approach using problem-based learning was effective in terms of students understanding in learning, teaching, and promoting good social skills (communication, and teamwork skills) among the students.

Keywords: Mathematics, Problem-based learning, STEM, Sabah, Da Vinci Code Module

Introduction

It has been a huge concern to the government as the number of students who decide to go for STEM related subjects has declined since few years back. At an average, there is a decrease of about 6000 students per year in Malaysia (Malik, 2019). One of the efforts being done was the announcement of the campaign “STEM4ALL” with the aim to cultivate science culture amongst students. According to the statistics in 2019, only 19% of the students, coming from a total of 447,000 chose science stream (Idris, 2019). The percentage itself shows a relatively small number of students in Malaysia have the awareness on the importance of STEM related subjects.

Due to the fretful decline in numbers of pupils in STEM, various agencies intensified their efforts in order to create awareness of STEM related subjects, beginning with the lower secondary levels. Amongst these efforts are the initiatives introduced by the Ministry of Education, to strengthen Science, Technology, Engineering and Mathematics (STEM) education in the Malaysian Education Development plan (PPPM) 2013-2025 to produce STEM literate students through

integrated learning that applies in real life context with hands-on approach and open exploration (Ministry of Education, 2013). The aim of the STEM education initiative is to prepare students with the skill to meet the science and technology challenges and to ensure Malaysia have sufficient numbers of qualified STEM graduates in future.

STEM as a teaching and learning (STEM T&L) is one of the approaches taken to involve students in STEM related subjects. This allows students to apply STEM within their daily life, environment and society (Bahagian Pembangunan Kurikulum, 2016). This approach will be able to train the students physically and mentally in engaging problem solving related to real life context. There are seven initiatives should be included: (1) to raise students awareness towards real-life problems; (2) promote students in productive team work; (3) students involvement in open question scenario; (4) help the students in the STEM application knowledge; (5) give opportunities to students to improve their suggested solution; (6) students involvement on design skill; and (7) students justification to their proposed solutions (Bahagian Pembangunan Kurikulum, 2016).

On the other hand, educators, such as teachers and lecturers, play an important role too. Educators must encourage the students to participate persistently in their class. In this era, it is no longer 'chalk and talk' teaching method, but the educators must be creative in their teaching lessons. However, some of the teachers are still in their exam-oriented approaches (old style teaching, more to memorizing solutions) rather than teaching techniques that emphasize critical thinking skills and creativity among students (Meyer & Eley, 2006; Phang *et al*., 2012).

As for the Mathematics subject, standard learning process in Mathematics consists of five content, and the students themselves must own it. It consist of (1) Problem Solving, (2) Reasoning and Proof, (3) Communication, (4) Connections, and lastly (5) Representations. Effective learning is a learning technique that affects the student mathematical skills, one of which is problem-solving abilities (Msuhlihuddin *et al*., 2018). This module is one of the efforts made by the Preparatory Centre for Science and Technology, Universiti Malaysia Sabah, a public university, in order to increase the awareness in STEM related subjects during a student's lower secondary school, specifically for SMK Usukan, a school situated in the rural area of Sabah. This problem-based learning (PBL) module is an effective way to attract the student's interest in STEM subjects. This is also a medium for the STEM related activity as it can provide the students with real-world context (Wei & Chen, 2020), and gives the opportunity to the students to be more creative and innovative (Bunyamin, 2017). Therefore in our study, we investigate the preliminary effect of the PBL-STEM module on the student's interest in learning STEM subject.

Methodology

Module and Procedure

To make it sound interesting to these young pupils, the module was called the Da Vinci Code, and it was conducted in a school at rural part of Kota Belud district. This programme was conducted for main subject areas in science; Physics, Chemistry, Biology and Mathematics. The module was designed by Mathematics lecturers in the Preparatory Centre for Science and Technology (PPST), Universiti Malaysia Sabah

(UMS). This module is based on one of the topics taught in Form 1 Mathematics syllabus, "*Number Patterns"*.

Regardless of basic operations in Mathematics (addition, subtraction, multiplication and division), this module brings students to the miracle in numbers, known as the Fibonacci Sequences and The Golden Ratio. This basic knowledge of Fibonacci Sequences and Golden Ratio is then shown how to be applied in everyday life, focusing mainly in Engineering.

A total of 74 students (Form 1 and Form 2) from Sekolah Menengah Kebangsaan (SMK) Usukan, Kota Belud, Sabah participated in this module. According to the school's STEM coordinator, Madam Salikah Omar, the students involved are equipped with basic knowledge on general science and mathematics as they have been exposed to these topics since primary school. The students are then divided into 6 groups with 9-10 students in a group (Figure 1 & Figure 2). Facilitators whom are lecturers of PPST, UMS, facilitated each group. To create a fighting spirit for these students, these facilitators are called "STEM warriors" and each module represents a different theme.

Figure 1: A small group of students consist of 9-10 students, facilitated by a "STEM warrior" (facilitator)

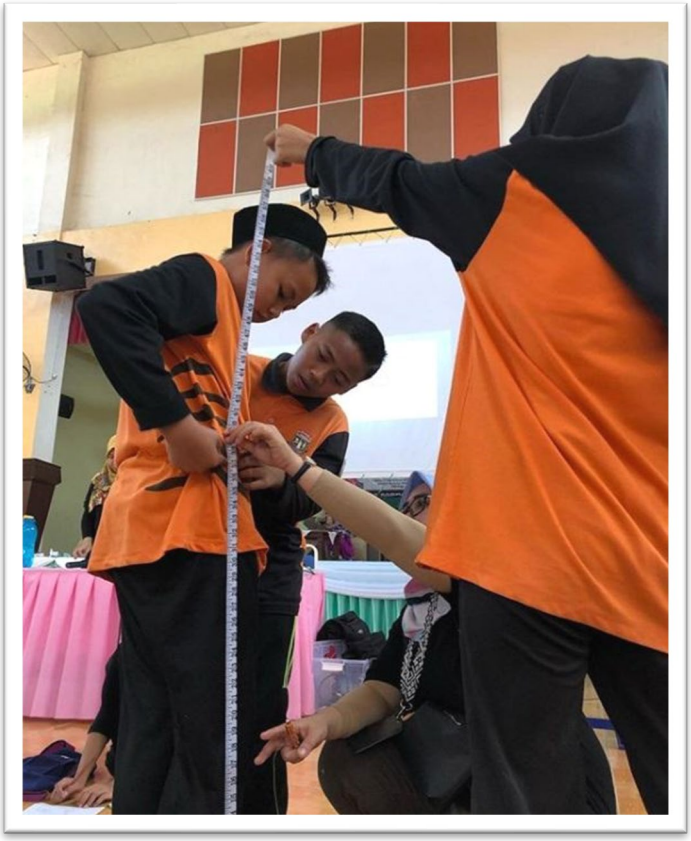

Figure 2: The activity of Golden Ratio during the programme

In general, the module can be summarized as shown in Figure 3. In each session, the students were evaluated based on their performance within teamwork activity. At the end of the module, a special badge will be given to the group with the highest marks, throughout the activities. This is to encourage their full participation. Random pop quizzes were also administered, focusing on individuals instead. Those who participated, despite giving the right or wrong answer, were given small rewards such as a decorated pen.

At the end of the sessions, a copy of the questionnaire will be given to the participant in order to get their response and feedback on the effectiveness of problems-based learning modules of Mathematics.

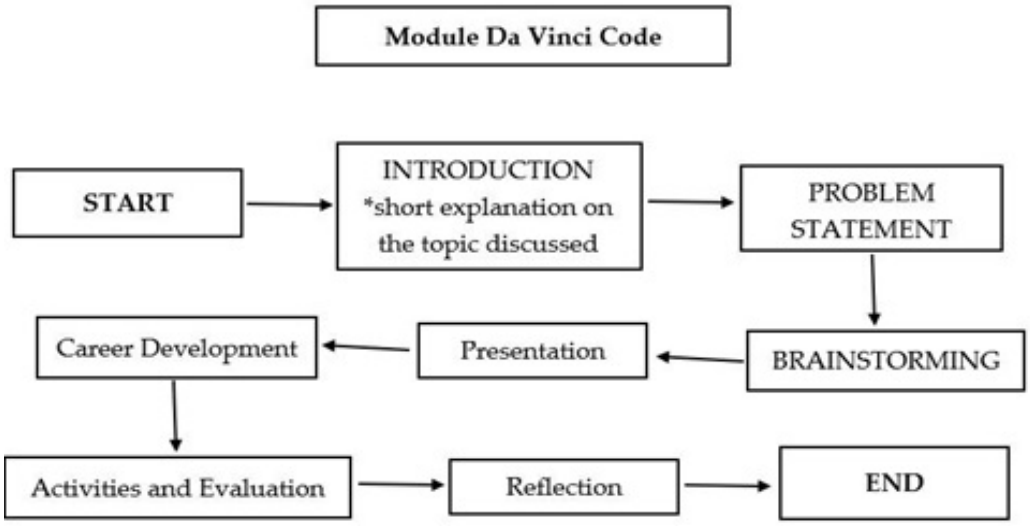

Figure 3: Flow chart of the module

Data Collection Instrument

In order to investigate the effectiveness of PBL-STEM Module for Mathematics subject in the three main objectives, a constructed questionnaire was given to the students composed of 9 questions altogether. Each question consists of 1 - 6 self-rating scales, that is Strongly Disagree (SD), Disagree (D), Moderately Disagree (MD), Moderately Agree (MA), Agree (A) and Strongly Agree (SA). The questionnaire is basically adapted from a six-point Likert scale (Luo et al., 2017). This research instrument was developed and validated by a team of English coordinators before it was being given to the participated students.

At the end of the activities, students were given a copy of a questionnaire to get their responses related to the effectiveness of the module among students. The question units are as shown in Table 1.

Table 1: Questionnaire (Luo *et al*., 2017)

No.	Questions	(SD)	(D)	(MD)	(MA)	(A)	(SA)
1.	Q1. The interaction between warriors and students was active.						
2.	Q2. The warrior offered a discussion opportunity.						
3.	Q3. This module improves my learning effectively						
4.	Q4. This module motivated me to learn						
5.	Q5. This module sharpens my expression and communication skills						

6.	Q6. This module enhanced my confidence in speaking public
7.	Q7. This module developed my self-directed learning skill
8.	Q8. This module enhanced interaction and collaboration skills
9.	Q9. This module increases my interest on science knowledge

Results and Discussion

The result of the study was obtained by analyzing the data collected from the questionnaires answered by the students. Statistical Package for Social Science (SPSS) Version 24.0 was used for analysing purposes. The results of the effectiveness can be seen in three different aspects, that is effectiveness of teaching, effectiveness of learning and effectiveness of communications and social skills.

Effectiveness in Teaching

The effectiveness of teaching was measured based on the data collected according to Question 1 and Question 2, in the questionnaire. Short and attractive introduction at the beginning of the module is meant to manifest the feeling of curiosity amongst the students. This is good to drive the focus of the students throughout the module. The involvement of facilitators (PPST lecturers) within the group of students, stimulate their thinking process during the brainstorming session. On average, the ability of the facilitators to manifest the two-way interactions during the module was rated 5.55 out of 6. This shows positive feedback from the students. The calculated average for Question 2; 5.73 also suggests that the facilitators succeeded in giving space and opportunities to the students within their group to discuss the topic given. These results are shown in Table 2 below.

Table 2: The mean and standard deviation score on teaching effect (Q1 and Q2)

Effectiveness in Teaching	**Module Da Vinci Code**	
Questions	Mean	Standard deviation
Q1. The interaction between warriors and students was active.	5.55	0.74
Q2. The warrior offered a discussion opportunity.	5.73	0.50

Effectiveness in Learning

Meanwhile, the effectiveness in learning among the students was measured from responses in Question 3, Question 4, Question 7 and Question 9. Based on the results shown in Table 3, the value of standard deviation calculated was small, between 0.66 – 0.75. This directly indicates that the data area was concentrated around the mean line. From this value, we can say that the module has attracted the students to get to

know more in the topic discussed as well as motivated the students to discover mathematics in depth.

Table 3: The mean and standard deviation score on learning effect (Q3, Q4, Q7 and Q9)

Effectiveness in Learning	**Module Da Vinci Code**	
Questions	Mean	Standard deviation
Q3. This module improves my learning effectively	5.46	0.69
Q4. This module motivated me to learn	5.42	0.66
Q7. This module developed my self-directed learning skill	5.30	0.75
Q9. This module increases my interest on science knowledge	5.50	0.69

Effectiveness in communication and social skills

Based on the mean and standard deviation values in Table 4, it shows that the Da Vinci Code module gives good indications towards the communication and social skills among the students. The students were initially a bit reluctant and slow in response, but adaptation slowly took place very well within their group members and ultimately, the students completed all the activities given with significant commitment. They discussed and solved the problems together. Each group members was able to explain their findings and solutions during the presentation session with a good understanding of the topic.

Table 4: Mean and standard deviation score on communication and social skills (Q5, Q6 and Q8)

Effectiveness in communication and social skills	**Module Da Vinci Code**	
Questions	Mean	Standard deviation
Q5. This module sharpens my expression and communication skills	5.32	0.76
Q6. This module enhanced my confidence in speaking public	5.47	0.65
Q8. This module enhanced interaction and collaboration skills	5.45	0.74

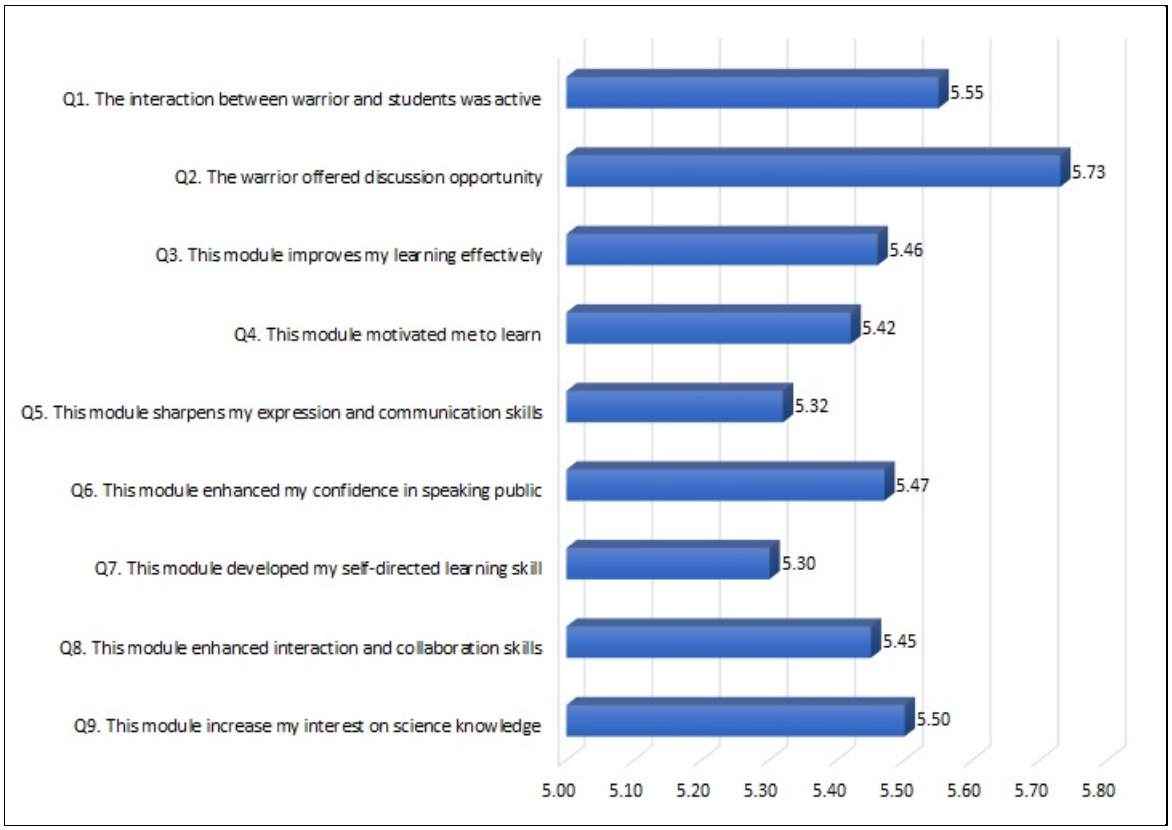

Figure 4: The mean score of Question 1 until Question 9

Figure 4 shows the overall results on the mean value for Question 1 until Question 9. It shows range of 5.30 – 5.73, which means that the learning approach using problem-based learning was effective in terms of students understanding in learning, teaching, and promoting good social skills (communication, and teamwork skills) among the students. Based on the module and the results obtained from the questionnaire, the module succeeded in the encouragement of thinking critically and creatively in handling tasks given in a group. This will directly enhance their knowledge of the discussed topic especially in STEM-subject.

The PBL module promotes self-confidence among students as well as exposure towards the possible application of mathematics in our daily lives instead of just seeing them as complicated problems. Competitive learning is another effective way of learning to increase the motivation and satisfaction among students (Hwang *et al*., 2012 ; Verdu *et al*., 2012). This is supported by Tasoglu & Bakac (2014), who claimed that students' understanding on the conceptual theory is deeper when PBL is integrated in the learning process. Besides that, PBL module also creates a positive mindset towards learning Mathematics in school, altogether motivating them to study smartly. Other than that, this module helps to enhance students' communication and problem solving skills, increase their motivation, as well as promoting teamwork.

Conclusion

This study concludes that the project's main goal was achieved successfully, which is to increase the student interest and exposure towards STEM related subjects as well as a motivation to the students to be more immersed in their studies. Ultimately, this project not only enhances their communication skills during presentations, but also the students' self-learning abilities, collaboration and teamwork skills.

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