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Effectiveness of PBL-STEM Module in Physics on Students' Interest: A Preliminary Finding of Implementation Amongst Students in Rural Areas of Sabah, Malaysia

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ABSTRACT The significant drop of the students' interest in Science, Technology, Engineering, and Mathematics (STEM)-related programs in higher secondary and tertiary levels have drawn concerns by many, and it needs to be addressed before it leads to further technical dependency on foreign workers due to insufficient STEM graduates. Problem-Based Learning (PBL) offers an effective solution to boost students' interest in science by providing them with opportunities to solve real-life problems using science concepts. As a result, they are interested in learning science subjects and motivated to pursue science at the tertiary level. Thus, this study mainly investigates the preliminary effects of the PBL-STEM module in physics (i.e., electricity, magnetism) on the students' interests. This study adopted the pre-experimental one-group post-test design, with a supplemental questionnaire as its instrument to measure the dependent variable. The results show that the implementation of this module improves the students' self-learning, communication skills, interest in learning science (i.e., physics), and teamwork skills. As this is only an early stage of its implementation, more positive results may be seen if it is more frequently implemented with a longer duration and broader topics of physics being covered.

KEYWORDS: Problem-based learning (PBL); STEM; physics; high school students; lower secondary school students in Sabah

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INTRODUCTION

The declining trend of the students' enrolment in STEM-related programs has been a heated topic in the Malaysian educational scene, with policy-makers and educators outlining strategies through various initiatives to enhance science teaching and learning. The Ministry of Education (MOE) revealed a significant decline in students' enrolment in the STEM stream, with only 44% in 2018 compared to 48% recorded in 2012 (Ibrahim, 2019). According to statistics published by the MOE from 2018 and 2019, the percentage of secondary school students participating in the science stream showed a decrease of 1.56% (Ministry of Education Malaysia, 2019; Ministry of Education Malaysia, 2018).

To date, the declining interest in STEM has received considerable critical attention from various parties such as lecturers, MOE (through Education Planning and Research Division), postgraduate students of education, and international agencies to identify factors that may contribute to low level of interest in venturing into science fields. Among the contributing factors are mainly related to students' perceptions and concerns about low achievement and difficulty in mastering science and mathematical concepts, which are commonly related to teaching and learning methods and practices in these two subjects; strict assessment of science subjects; difficulty in achieving excellent results in science and mathematics subjects etc. (Phang *et al*., 2012).

Other than that, a considerable amount of literature highlights that conventional teaching approaches are still being implemented in the classrooms despite ongoing efforts, measures, and improvement approaches initiated by the MOE. Teacher-centred teaching, 'chalk and talk' teaching, teaching that does not impart pure values to students, and exam-oriented teaching are still being practised in 21st-century classrooms. Teachers are still inclined to teach students with examination-oriented approaches (especially behaviourism approaches and drill and memorization exercises) rather than teaching that emphasizes thinking skills (Meyer & Eley, 2006; Phang *et al*., 2012).

It is widely accepted that physics is basic physical science. Physics plays an important role in all of the natural sciences, and it is a study to understand the world around, inside, and beyond us, such as why gravity on Earth is higher compared to the other planets, how a rainbow is formed, how does a light bulb work or how does a ceiling fan rotate to cool our bodies and more. During the introduction stage of science disciplines in physics, the students are exposed to the logic and correlation between what is happening in their surroundings and why it is happening. However, physics does not escape the preconceived notion of being the most challenging subject to understand because of its rather abstract and complicated concepts. Traditional physics teaching, such as teacher-centred teaching, has been commonly reported to be ineffective in helping students develop more scientific knowledge and conceptual understanding of physics (Mulhall & Gunstone, 2012).

Engaging in an interactive and fun learning environment for physics is crucial for the students to develop their scientific knowledge as scientists. Therefore, without memorizing the concepts, students can still learn and enjoy the learning process. In this 21st century, Problem-Based Learning (PBL) is considered as one of the most popular approaches to enhance students' conceptual knowledge, problem-solving skills, and motivation in learning physics (Argaw *et al.*, 2017; Sahin, 2010). PBL is an instructional method that emphasizes student-centred learning. This view is supported by Argaw *et al.* (2017), as he points out that PBL is an effective teaching method to improve students' achievement. Furthermore, PBL serves as an effective approach to develop students' conceptual understanding of physics and their knowledge of learning physics through their own experience (Tasoglu & Bakac, 2014).

Therefore, the main purpose of this study is to develop a module based on the PBL approach, where the students were exposed to hands-on activities in solving real-life problems. In addition, this study aims to investigate the effectiveness of this module in enhancing the students' interest in learning STEM, particularly in physics, and to improve their communication skills.

METHODOLOGY

Experimental Design

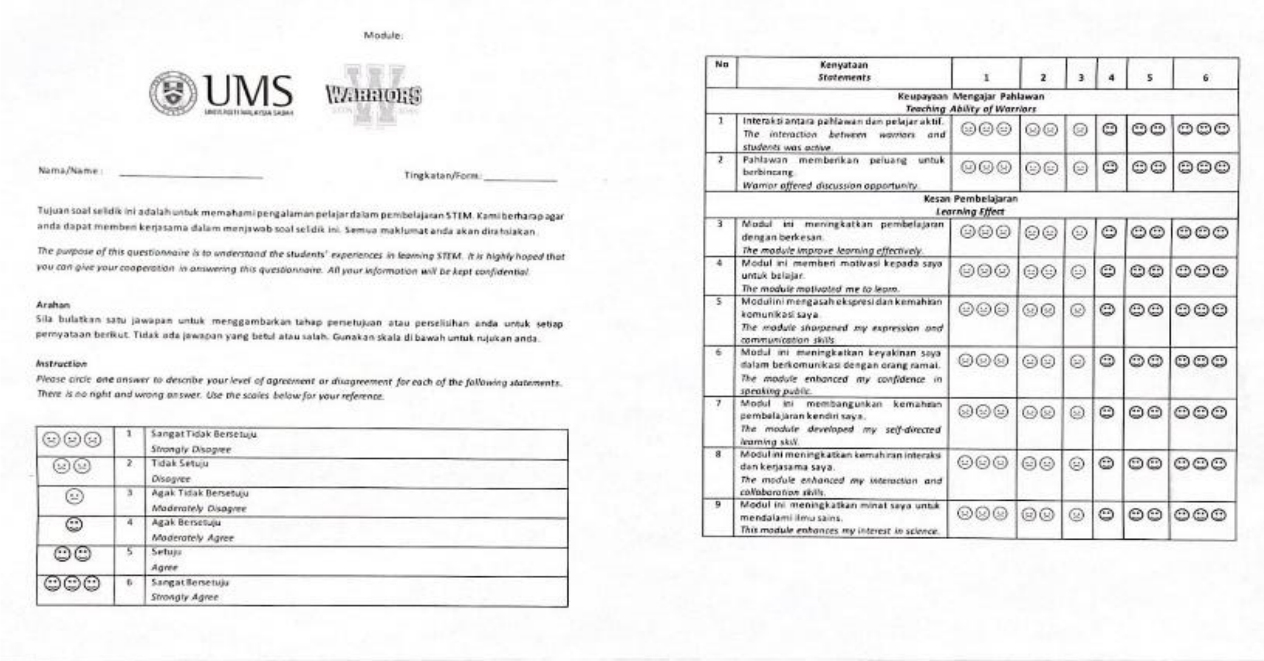
This study adopted a quantitative approach with the pre-experimental one-group post-test research design. The main objective of this study is to develop a PBL-STEM Module (physics), which was integrated into the learning process of lower secondary school students in Kota Belud, Sabah. This research followed the 7-steps of Maastricht, which were to clarify, define, analyze, review, identify learning objectives, report, and synthesis to implement the PBL learning approach.

Participants

A total of 62 lower secondary school students (i.e., Form 1, Form 2) from Sekolah Menengah Kebangsaan (SMK) Usukan, Kota Belud, Sabah, Malaysia participated in this study. These students have had prior knowledge of general science and mathematics as they have been exposed to these subjects during their primary school level. Before implementing this module, these students were randomly divided into 6 groups and each of these groups was assisted by an experienced facilitator.

Data Collection Instrument

To determine the effectiveness of the PBL- STEM module (physics) in enhancing learning and communication skills among the students, a six-point Likert scale questionnaire was distributed to the participants at the end of this module, as shown in Figure 1. This questionnaire was structured with nine close-ended questions, each with 1 to 6 self-rating scales: (1) Strongly disagree; (2) Disagree; (3) Moderately disagree; (4) Moderately agree; (5) Agree; (6) Strongly agree. The questionnaire is bilingual (i.e., English, Bahasa Melayu), and each scale is represented by an emoticon for the students to answer the questionnaire items effectively. This research instrument was developed and validated by a team of English instructors before it was being administered to the students.



Module:

Nama/Name : ____________ Tingkatan/Form: ____________

Tujuan soal selidik ini adalah untuk memahami pengalaman pelajar dalam pembelajaran STEM. Kami berharap agar anda dapat memberi kerjasama dalam menjawab soal selidik ini. Semua maklumat anda akan dirahsiakan.

The purpose of this questionnaire is to understand the students' experiences in learning STEM. It is highly hoped that you can give your cooperation in answering this questionnaire. All your information will be kept confidential.

Arahan

Sila bulatkan satu jawapan untuk menggambarkan tahap persetujuan atau perselisihan anda untuk setiap pernyataan berikut. Tidak ada jawapan yang betul atau salah. Gunakan skala di bawah untuk rujukan anda.

Instruction

Please circle ***one*** *answer to describe your level of agreement or disagreement for each of the following statements. There is no right and wrong answer. Use the scales below for your reference.*

	1	Sangat Tidak Bersetuju *Strongly Disagree*
	2	Tidak Setuju *Disagree*
	3	Agak Tidak Bersetuju *Moderately Disagree*
	4	Agak Bersetuju *Moderately Agree*
	5	Setuju *Agree*
	6	Sangat Bersetuju *Strongly Agree*

No	Kenyataan *Statements*	1	2	3	4	5	6
	Keupayaan Mengajar Pahlawan ***Teaching Ability of Warriors***						
1	Interaksi antara pahlawan dan pelajar aktif. *The interaction between warriors and students was active.*						
2	Pahlawan memberikan peluang untuk berbincang. *Warrior offered discussion opportunity.*						
	Kesan Pembelajaran ***Learning Effect***						
3	Modul ini meningkatkan pembelajaran dengan berkesan. *The module improve learning effectively.*						
4	Modul ini memberi motivasi kepada saya untuk belajar. *The module motivated me to learn.*						
5	Modul ini mengasah ekspresi dan kemahiran komunikasi saya. *The module sharpened my expression and communication skills.*						
6	Modul ini meningkatkan keyakinan saya dalam berkomunikasi dengan orang ramai. *The module enhanced my confidence in speaking public.*						
7	Modul ini membangunkan kemahiran pembelajaran kendiri saya. *The module developed my self-directed learning skill.*						
8	Modul ini meningkatkan kemahiran interaksi dan kerjasama saya. *The module enhanced my interaction and collaboration skills.*						
9	Modul ini meningkatkan minat saya untuk mendalami ilmu sains. *This module enhances my interest in science.*						

Figure 1. Questionnaire of study.

Procedures

Prior to the module implementation, 62 participating students were divided into 6 groups, with facilitators assigned to each group to facilitate the group activities and discussion. Facilitators were picked among the Preparatory Centre of Science and Technology lecturers, and they had attended meetings and training beforehand to ensure successful delivery of the module. For this study, the role of these facilitators was different from the conventional approach, as they were only required to assist the students without giving direct answers but to guide them on how to approach the problems.

In Problem-Based Learning (PBL), learners are being challenged with a problem, and through discussion with their team members, prior knowledge is activated to solve the problem actively. At the start of the implementation, the students were introduced to a real-life problem in the pre-recorded video (see Figure 2). The problem description was presented in Bahasa Melayu, so the students could apprehend the problem considering the ability to understand English among them was weak. Electricity, Magnetism, Energy, and Power were among the topics selected to be delivered in this module because of their less interesting nature and these topics are considered difficult amongst students.

Ampal dan Sumayah yang berumur 15 tahun adalah sahabat baik dan baru berkenalan di sekolah berasrama penuh yang terletak di Kota Kinabalu. Ampal berasal dari daerah Keningau dan perlu melalui perjalanan kawasan yang bergunung-ganang dan berbukit-bukau untuk menuju ke Kota Kinabalu. Rumah Ampal seringkali mengalami masalah terputus bekalan elektrik, yang mana kadang-kadang berlaku pada waktu tengah malam, pagi dan juga petang. Kejadian terputus bekalan elektrik biasanya mengambil masa selama 10 hingga 30 minit, malahan sampai berjam-jam dan pernah mengambil masa sehari. Sumayah pula tinggal di kawasan Kota Kinabalu iaitu merupakan kawasan rata dan berhampiran dengan kawasan laut. Rumah Sumayah jarang mengalami kejadian terputus bekalan elektrik, kemungkinan sekali atau dua kali dalam tempoh sebulan atau dalam tempoh yang tidak lama. Kejadian terhadap perbezaan bekalan elektrik pada kedua-dua kawasan ini membuatkan Ampal dan Sumayah tertanya-tanya antara satu sama lain.

Anda adalah seorang guru yang baru sahaja mula berkerja di sekolah ini. Anda diminta untuk membandingkan sumber bekalan elektrik pada kedua-dua kawasan yang berbeza. Huraikan perbezaan tersebut dari sudut rintangan pada wayar elektrik serta mengaitkannya dengan bentuk muka bumi kawasan yang diberikan. Anda harus memberikan perbandingan yang mudah difahami oleh Ampal dan Sumayah agar mereka tidak tertanya-tanya lagi. Anda disarankan untuk membina model aliran elektrik bagi dua kawasan berbeza ini bagi memudahkan anda menerangkan kepada Ampal dan Sumayah.

Figure 2. Screenshot of video and problem statement of this module.

To encourage the student's participation in understanding the problem, the facilitators would pose questions like "*Why does this problem occur? Give your opinion.*" and "*What is the relationship between the type of conductor and resistance for each circuit?*" to them. This step was crucial as the facilitators needed to relate the problem with the students' prior knowledge in solving this issue.

Figure 3. Model of Grid System by students.

The module was carried out for two hours with three separate but continuous group activities. The first activity started with presenting a problem, and the students needed to address it by linking the problem with their existing knowledge. They should come out with the hypothesis 'the longer the wire (resistance), the weaker the light intensity produced by the light bulb.' They were then introduced to basic instruments (i.e., ohmmeter, voltmeter, ammeter) and their function in the second activity. They were provided with wires of different lengths, and the facilitators assisted them in observing the relationship between the length of wires and the intensity of light of each wire produced. The main purpose of this activity was to prove the hypothesis generated from the first activity. The final activity requires them to develop and build their own model of the Grid System circuit, and it needs to be similar to the actual grid system. The creativity in building the Grid System was also being considered. Figure 3 shows a few grid systems build by the students in this activity.

At the end of this activity, students were briefed on the job scopes of an electrical engineer. They understood the elements that could affect the resistance in an electrical circuit, which then interferes with the flow of electric current and at the same time relates the importance of learning the concept of electricity. The students were required to complete the questionnaire at the end of this module.

RESULT AND DISCUSSION

Statistical Package for Social Science (SPSS) version 24.0 was used to analyze the results of this study. To analyze the effectiveness of the PBL- STEM module (physics) in improving the students' learning and communication skills, both Frequency Distribution and Descriptive Statistics were evaluated. The results from the questionnaire are presented in Table 1, Table 2 and Table 3 with several students responding to each statement. In summary, this result indicates that the students view this learning approach positively in terms of their learning, motivation, interest, communication skills, and collaboration skills.

Table 1. Frequency distribution for effectiveness in learning towards PBL- STEM module (physics).

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	4.50 – 5.49	18	29.0	29.0	29.0
	5.50+	44	71.0	71.0	100.0
	Total	**62**	**100.0**	**100.0**	

Table 2. Frequency distribution for effectiveness in communication skills towards PBL- STEM module (physics).

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3.5 – 4.49	1	1.6	1.6	1.6
	4.50 – 5.49	16	25.8	25.8	27.4
	5.50+	45	72.6	72.6	100.0
	Total	**62**	**100.0**	**100.0**	

Table 3. Descriptive statistics for effectiveness in learning and communication skills towards PBL-STEM module (physics).

	N	Mean	Std. Deviation	Skewness		Kurtosis	
				Statistic	Std. Error	Statistic	Std. Error
Learning	62	5.6411	.41642	-.963	.304	.109	.599
Communication	62	5.6352	.42987	-1.239	.304	.848	.599
Valid N (listwise)	62						

Tables 1 and 2 show frequency distributions for the effectiveness in learning and communication skills towards PBL- STEM Module (Physics). 71.0% of students agreed that the module is very effective in improving learning and motivation. Meanwhile, 29.0% of students felt that the module is effective. As for communication and teamwork, 72.6% of the students answered that the program is very effective. 25.8% of the students felt that the program effectively improves communication and teamwork, while only 1.6% of the students claimed that the program is somewhat effective.

Table 3 shows the analysis data of descriptive statistics for the effectiveness in learning and communication skills towards PBL- STEM Module (Physics). The mean scores for the effectiveness in learning and communication for physics are both 5.64, rounded to 2 decimal places. The distribution for both attributes is negatively skewed, which indicates that both distributions tend to have outliers below the mean. Meanwhile, both distributions are leptokurtic. The difference in kurtosis is because only one person answers "somewhat agree" for the effectiveness in communication in contrast to the effectiveness in learning and tends to become an outlier. This contributes to larger positive kurtosis.

According to the results above, perhaps, due to the nature of this module which was different from the other conventional strategies they had (i.e., reading, searching for information, listening to class), the opportunity for the students to solve the problems practically boost this type of response from them. Due to this, the findings reveal that when PBL was integrated into the learning module, it was effective in instilling the interest of the lower secondary school students to learn science. It is also a good learning approach that heavily emphasizes working in a team. Hence, interaction and collaboration are another set of skills which the students should acquire (Noble *et al.*, 2020; Argaw *et al.*, 2017; Becerra-labra & Gras-martí, 2013). Other than that, these findings were further supported by Tasoglu & Bakac (2014), which claimed that the students' conceptual understandings were more successful when PBL is implemented in the learning process. This is in line with the recent findings by Djajadi & Rauf (2020) and Argaw *et al.* (2017), which show how hands-on experience in learning physics helps to improve the students' learning experience, motivation and enhance students' problem-solving skills. Thus, this module is hoped to attract students in becoming more interested to pursue their future study in STEM majors, particularly in physics.

Generally, for communication and teamwork, the implementation of the PBL- STEM Module (Physics) shows that this module has sharpened the students' communication skills and improved their confidence level in terms of public speaking. The result also shows that this module improves student's communication and teamwork skills. It is somewhat expected as PBL is known as a learning approach that can help students improve their communication skills as it involves much interaction (i.e., explaining and share information) between the members in groups and presentations (Saldo & Walag, 2020; Eldy & Sulaiman, 2019; Eldy *et al.*, 2019; Jatmiko *et al.*, 2018).

Application of PBL-STEM Module (Physics) to lower secondary school students was intended to introduce basic science to attract students' interest in pursuing their future study in STEM fields. It is a student-centred approach to learning that actively integrates STEM knowledge to engage in real-world and personally meaningful activities.

CONCLUSION

This study is an ongoing project with its main goal to enhance students' interest in pursuing their future study in STEM majors, particularly physics. Hence, this preliminary results from the early implementation of PBL in STEM learning give bright hopes as it does not only shape students' interest but the skills (i.e., motivation, communication, self-learning, collaboration, higher-order thinking) were also developed and enhanced to meet the demands in today's society. It is hoped that the implementation could be carried on a larger scale with a longer duration.

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