The Effectiveness of Project Based Learning Students Worksheet on Students' Achievements in Two Variables Linear Equations System

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ABSTRACT

Students' mathematics achievement in Indonesia has been reported experiencing a 'mathematical emergency' due to their scores below the Indonesian mathematics assessment standard as well as in international assessment, the Third International Mathematics and Science Study (TIMSS). This study aimed to determine the effectiveness of Project Based Learning (PjBL) student worksheet on student's achievements in Two Variables Linear Equations System (TVLES). This study was conducted by employing a quasi-experimental design with 30 Form Two students in one of the Indonesian schools in Malaysia as the participants of the study. The experimental group used the PjBL worksheet while the control group used the conventional learning material. The data for this study were collected from the pre-test and post-test for TVLES topics and analyzed using t-test. The findings showed that those in the experimental group significantly outperformed those in the control group. In conclusion, the PjBL worksheet is effective in improving the achievement of Form Two students in TVLES. The findings of this study have an implication for mathematics education in which PjBL oriented activities and materials should be integrated into the teaching and learning process to enhance students' learning and achievements. Furthermore, this study is beneficial in guiding and cultivating the development and use of potential strategies and materials in line with the 21st century learning.

Keywords: Project Based Learning, Student Worksheet, Two Variable Linear Equation System, Quasi-experimental design.

INTRODUCTION

Quality education is the key to producing human capital who is capable to compete with challenges of the Revolution Industry 4.0. However, efforts to possibly improve the quality of education in Indonesia was discouraged and the problem remains unaddressed. Mathematics is one of the subjects that is the focus of education following the latest report stating that Indonesia is experiencing turmoil due to 'Mathematical emergency' (Pratiwi, 2019). The situation is happening because the scores of secondary school pupils is below the average score, namely 70 for the standard assessment of mathematics in Indonesia which are 56.4, 49.84, 50.34, 44.08, 46.56 for five consecutive years of 2015, 2016, 2017, 2018, 2019, respectively (Arikunto, 2019).The issue of the low ability of students in mathematics in Indonesia is not new as it is the same situation at the international level. The report in the Third International Mathematics and Science Study (TIMSS) for the years 1999, 2003, 2007,

2011, 2015 showed that Indonesia was at the lower rank and average scores in compare to the neighbouring countries such as Singapore and Malaysia.

There are many factors contributing to the problems in the Education of Mathematics in Indonesia, namely negative attitudes towards Mathematics (Purnomo, 2016), low motivation (Wahyuni, 2019), less effective of teaching models by teachers (Endang, 2019) and the lack of learning through media which unable to attract students interests (Suryani & Lestari, 2019). In addition, there are some learning media used but were less innovative, interesting and do not provide any platform for students to build their mathematical ideas so that they are bored, thus reduce learning activities (Arindiono & Ramadhani, 2013). The use of appropriate learning media in learning is to increase understanding, interest and motivation of students in learning (Sulfemi, 2019). Thus, media need to be tailored to the needs of students, so they can achieve the expected objectives of the study.

One of the potential learning media to assist in achieving this goal is the Student Worksheet. The Student Worksheet used should have model steps, strategies or approaches that guide students to be active and direct students to build their own understanding. Wahyuni (2019) reported that the Student Worksheets with a realistic mathematical approach is effective in improving students' achievements in the topic of linear equations in one variable. Student Worksheets based on Science, Technology, Engineering, and Mathematics (STEM) are able to help students understand the topic of mathematics (Nurdin et al., 2019; Hains et al., 2020) A similar study was also carried out by Wirnalis and Hasanuddin (2019) and they reported that a student worksheet with project-based learning was able to improve students' mathematical connection skills. These past studies showed that Student Worksheets learning media have a positive effect on students' mathematical learning.

To meet the demands of the 21st century, learning media used must have the 4C features: Communication, Collaboration, Critical Thinking and problem solving, Creative and Innovative (Pandingan et al., 2017). One of the learning models that involves critical, communication and involvement of students is active Project Based Learning (PjBL). According to Gerhana et al. (2017) and Mahsan and Ibrahim (2017), PjBL are student-centered learning and gives students the opportunity to make in-depth investigations on topics in solving problems. This model aims to help students who can use High Order Thinking Skills (HOTS). It is also known as a higher learning model than conventional teaching models to improve problem-solving activities and thinking skills as well as involving students in their learning.

Two Variables Linear Equations System (TVLES) is one of the topics that should be given attention to in Mathematics Education not only in Indonesia, but also at international level. This is due to the fact that it is not only fundamental from algebra to advanced level, but it is also used in topics related to geometry and calculus. However, the average test nationwide for topics TVLES is very low and is experiencing a decline for the last 5 years as illustrated in Table 1.

Table 1: Average National Test for TVLES Topics

Year	Average TVLES
2015	68.20
2016	55.16
2017	47.85
2018	35.21
2019	34.90

Source: *Indonesian Education Assessment Center*

A review by Ismail et al. (2017) in Indonesia discovered that a student experiencing difficulties in TVLES topics such as changing the general shape of TVLES and understands the problem. Subsequently, Wati and Fitriany (2018) stated that students had difficulty in creating a chart and writes it in mathematical models of TVLES. Meanwhile, a study by Samuel et al. (2016) in Zambia discovered that the difficulty of students in TVLES was due to the lack of knowledge of concepts as well as strategies and skills required to solve TVLES and also inappropriate approaches and models used in the teaching of TVLES. Based on the problems described, the question whether there is a problem or not also applies to Indonesian students in foreign countries who are studying in schools with Indonesian curriculum. Observations made by researcher at one of the Indonesian School in Malaysia, discovered that students in that school need a learning media that can motivate them to be active, to be guided to build their understanding and reasoning in Mathematics.

Accordingly, the main purpose of this study is to determine the effectiveness of PjBL worksheet in improving the achievement level of Form Two students in one of the Indonesian School in Malaysia for the topic of TVLES.

LITERATURE REVIEW

Project Based Learning

Project based learning (PjBL) is an active student-centred form of instruction which is characterised by students' autonomy, constructive investigations, goal-setting, collaboration, communication and reflection within real-world practices (Kokotsaki et al., 2016). Gapor et al. (2012) and Kemendikbud (2014) stated that PjBL is a learning method that uses the project as a medium, where the project is planned and produced. It is also the main teaching method that guides students to learn and as a guide to the direction of their own learning process. The process begins with questions that support an understanding of the core concepts and principles of the lesson. This greatly helps students to master the topic as well as be able to achieve learning outcomes as required by the syllabus. This statement is supported by Aiedah and Lee (2012) who stating that PjBL is a complex task based on questions or problems which challenge students in design, problem solving, decision making or investigation activities. It gives students the opportunity to work autonomously over an extended period of time and the culmination of realistic products and presentations. Similarly, teaching is not only an activity to transfer knowledge from teachers to students, but also an activity that allows students to build their own knowledge (Munter & Wilhelm, 2020). This is in line with PjBL which emphasizes more on students doing and finding. The role of educators or teachers in PjBL is as facilitators, coaches, advisors and intermediaries to obtain optimal results in accordance with the imagination, invention and innovation of students.

Numerous previous studies have shown the effectiveness of PjBL, among them is able to increase students' creativity, critical thinking, mathematics learning outcomes, the ability to connect mathematical concepts and motivates teaching (Susanto et al., 2020; Harun, 2020; Astuti, 2019; Mustopo, 2019; Fathonah et al., 2019; Hapsari, 2019).

Student Worksheet

Nasrullah et al. (2018) indicated that Student Worksheet is an easy teaching material developed by educators in printed form. It can be understood that Student Worksheet is a printed teaching material in the form of sheets of paper containing materials, summaries and instructions for the implementation of learning tasks that must be completed by students referring to the basic competencies which need to be achieved (Darvina & Sari, 2020; Annisa, 2017; Prastowo, 2013). The same opinion has been stated by Trianto (2009) that Student Worksheet is a student guide used to carry out the investigation or problem solving activities.

Apart from that, the Student Worksheet is also an initiative that can make students active in a student-centered learning. According to Barlenti et al., 2017 & Tam et al., 2017, the use of Student Worksheets can support the teaching and learning (TnL) process and as can hone reading skills because Student Worksheets create an interesting and systematic way and help students to learn more actively and independently in groups. Furthermore, student worksheets can also improve critical thinking skills (Tanjung & Nababan, 2018), metacognitive skills (Amir & Kusuma, 2018), problem solving skills (Septina et al., 2018), as well as students' mathematical understanding and achievement (Putra et al. 2018).

Two Variables Linear Equations System

The system of linear equations is a topic from the field of algebra. Observing and examining what happens in our daily lives is closely related to the system of linear equations, especially in the fields of science, industry and even economic problems. Such problems can be summarized in a form of a system of linear equations containing one or more variables. However, students find it is difficult to learn Two Variables Linear Equations System (TVLES) due to not understand the variables used (Irfan et al., 2019). TVLES is one of the topics contained in the 2013 Indonesian curriculum for Form 2 mathematics which is an extension of the One-variable linear equation system topic, for Form One student (Kemendikbud, 2018). This topic is necessary because it is a basic concept to learn before going to the next topic which is the linear equation system of three variables in Form 4 of upper secondary school.

Project Based Learning student worksheets in Two Variables Linear Equations System

PjBL student worksheets in TVLES used in this study are designed in accordance with the components of the student worksheets that have been defined and are divided into several learning activities such as linking learning material with everyday life which are in accordance with the indicators of achieving mathematical competence. Each indicator is presented with problems that provoke students to explore learning experiences and arouse students' memories related to learning TVLES topics to create a project that will be presented in certain columns contained in student worksheets. There is one material for PjBL student worksheets in TVLES that comprise of HOTS element that requires reasoning, namely the critical thinking skills.

METHODS/METHODOLOGY

Research design

This study uses a quantitative approach with quasi-experimental design with the equivalent control group. Following Chua (2012), this study consisted of two groups of participants: a control group and an experimental group. Both groups were given a pre-test to determine the level of early achievements in the topic of TVLES. This was then followed by a number of treatments which are 2 times a week for 4 weeks on a TnL using PjBL worksheet for the experimental group whereas for the control group, a TnL using conventional material was implemented. Finally, both groups were given a post test to determine the final level of their achievements in the TVLES topic after the treatments were completed. Figure 1 describes the process of data collection for the control group and experimental group.
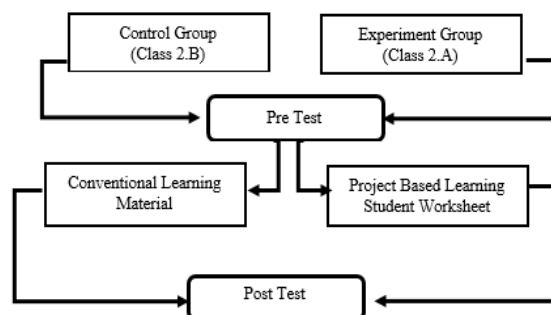
Figure 1: Data Collection Procedure

Population and Sample

This study was conducted in one of the Indonesian School in Malaysia. A total of 30 Form Two students from two classes were involved as the participants in this study. There are only two Form Two classes available at the school and each of the class consists of 15 students. Hence, the experimental group consists of students from class 2A while the control group consists of students from class 2B. The number of participants for both groups is acceptable and can be justified by Gall et al. (1996) and Cohen et al. (2007) who stated that there should be at least 15 participants in control and experimental group for comparison. Table 2 shows the details of both group in which their early performance is equivalent.

Table 2. Participants of Study

Group	Gender		Number of Respondents	Mean Score of Maths Exam
	Male	Female		
Experiment	5	10	15	36.38
Control	6	9	15	36.32
Total			30	

Research Instruments

The research instruments used in this study were the pre-test and post-test to measure the level of achievement of students in TVLES topic. Both tests have the same set of questions. These instruments were developed by Annisa (2017) which based on Indonesian Curriculum 2013 and consisted of 6 items in a form of mathematical problems. Table 3 shows the Test Specification that were constructed for both tests. These tests had received experts' validity and reliability with the percentage of experts' validity consent of 93.63% and Cronbach Alpha of 0.538, respectively. According to Hinton et al. (2004), a Cronbach Alpha coefficient of 0.5-0.75 is a moderate but acceptable reliability. Lestari (2015) categorized Cronbach Alpha coefficient of 0.4-0.7 as adequate. Subsequently, Taber (2018) listed several literatures that describe Cronbach Alpha of 0.45-0.98 and 0.45-0.96 as acceptable and sufficient, respectively.

The second research instrument was PjBL worksheet for topic of TVLES that used Indonesian language were given to the student in the experimental group during a TnL implemented. It has gained expert validation of 90.44% and reliability with a Cronbach Alpha coefficient of 0.62 (Annisa, 2017).

Table 3. Test Specifications for Pre and Post Tests

Level	Domain	Question number						Frequency and Percentage
		1	2	3	4	5	6	
LOTS	Remember		✓	✓	✓		✓	4 (22.22%)
	Understand	✓	✓				✓	3 (16.67%)
	Apply	✓			✓	✓		3 (16.67%)
HOTS	Analyze	✓		✓	✓	✓	✓	5 (30.55%)
	Assessment	✓				✓		2 (11.11%)
	Build/Create						✓	1 (5.56%)
Number of Domain Items		4	2	2	3	3	4	18

Data Analysis Procedure

The data obtained from the pre-test and post-test were analysed using Statistical Packages for Social Science (SPSS) version 20 software. The levels of achievements for pre-test and post-test were measured based on the criteria as shown in Table 4.

Table 4. Criteria of Achievements Levels in the Test

Score	Criteria
0 – 20	Very weak
22.5 – 40	Weak
42.5 – 60	Simple
62.5 – 80	Good
82.5 – 100	Excellent

Adapted from *Buku panduan pembinaan instrumen "anda dan kepenggunaan"* (Hamzah et al., 2013)

In addition, two statistical inference applications were conducted which were the paired sample t-test and independent sample t-test to determine if any changes had occurred after the treatment for each group and between the groups, respectively.

RESULTS AND DISCUSSIONS

This section discusses the data analysis and present the findings of the study conducted using the pre and post tests to both groups.

Analysis of Achievement Level of Pre Tests for The Treatment and Control Groups

Table 5 illustrates the mean scores of the pre-test achievement in TVLES Topic for the experimental group and the control group, which are 32.40 and 32.73, respectively. The results indicated that the level of students' achievements in TVLES topic is still weak.

Table 5. Mean Score of Pre-Test Achievement in TVLES Topic

Group	Test	Mean Score
Control	Pre	32.73
Experimental	Pre	32.40

This poor level of student achievement is certainly worrying because TVLES which is a topic in Algebra is an important topic and plays a role in the process of solving mathematical problems. The findings of this study are in line with the findings from a study by Yanto et al. (2014) who discovered that many students had difficulty solving algebraic problems and were still in the low category.

Analysis of the Difference in Pre-Test Mean Scores between Experimental and Control Groups

Table 5 and Table 6 clearly show that there is no significant difference in the mean scores of achievement in the pre-tests for the experimental and control groups ($t = 0.538$, $p = 0.595 > 0.05$, Df $= 28$). These findings indicated that the students in both groups had an equivalent level of achievement before TnL using PjBL Worksheet and conventional learning material, were implemented respectively.

Table 6. Independent Sample t-test of Pre-Test

	t-value	Df	Significant Value
Pre- Test	0.538	28	0.595

Analysis of the Difference in Pre-Test and Post-Test Mean Scores for the Control Group

Table 7 shows that the mean score of post-test (37.53) is slightly higher than the mean score of pre-test (32.73) for the control group. However, based on the analysis of paired t-test in Table 8, there is no significant difference between the mean scores of pre- and post-tests for the control group ($t = 1.490$, $p = 0.158 > 0.05$, Df $= 14$). The findings also indicated that there was no improvement in the level of students' achievement before and after the TnL using conventional learning material were conducted on the control group.

Table 7: Mean scores of pre-test and post-test for the control group

Group	Test	Mean Score
Control	Pre	32.73
	Post	37.53

Table 8: Paired t-test of pre-test and post-tests for the control group

Group	N	Mean	Standard Deviation	Sig (2 ends)	t-value
Control	15	4.8	11.478	0.158	1.490

Figure 2 and Figure 3 show the sample of responses from the students in both pre-test and post-test for TVLES topic. Figure 2 shows that the student had not mastered one of the components to achieve TVLES ability in finding patterns or ways of facts and develop them into sentences of mathematics to make a generalization. Meanwhile, Figure 3 shows a response from a student in an examination on the

question of 'whether' in which the students were not allowed to dominate the achievements of mathematics to make patterns of behaviour or problem in Mathematics competition to make generalizations.
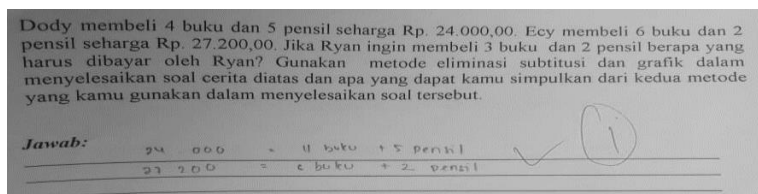

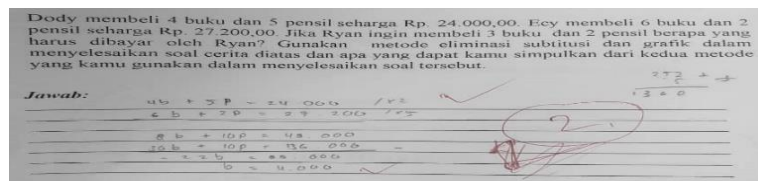**Figure 2:** Student's pre-test sample answer from the control group

Figure 3: Student's post-test sample answer from the control group

Based on the data obtained, it has proven the conventional TnL cannot assist in improving students' achievements in a short time. This finding is in line with Artobatama (2018) who stated that conventional TnL makes students passive; learning is mastered by teachers and does not get much feedback or tends to be one direction, and students do not understand materials presented by teachers. In presenting a particular topic, teachers typically use lecture methods where students simply sit, take notes, and listen to what the teacher has to say, and little opportunity is given to students to ask questions. Thus, a non-conducive learning environment in conventional TnL encourages students to be passive.

Analysis of the Difference in Pre-Test and Post-Test Mean Scores for the Experimental Group

Table 9 shows that there is an improvement in pre-test mean score of 32.40 to post-test mean score of 79.93 for the experimental group. Table 10 shows that there is a significant difference of mean scores between the pre-test and post-test for the experimental group (t = 5.846, p = 0 < 0.05, Df = 14). The findings further indicated that the process of TnL using PjBL Worksheet is effective in improving achievement in TVLES.

Table 9. Mean scores for the pre-test and post-test for the treatment group

Group	Test	Mean Score
Treatment	Pre	32.40
	Post	79.93

Table 10. Paired t-test of pre- and post-tests for the treatment group

Group	N	Mean	Standard Deviation	Sig (2 ends)	t-value
Treatment	15	47.53	3.356	0.000	5.846

Figure 4 and Figure 5 show a student's sample answer of pre- and post-tests for the TVLES topic in the experimental group. Figure 4 shows that the student had not mastered one of the components in mathematical achievement. While Figure 5 shows a student's answers in the post-test had improved in

answering questions, in which the student already mastered the mathematical ability of reasoning component to organize evidence and give reasons for a question's solution.
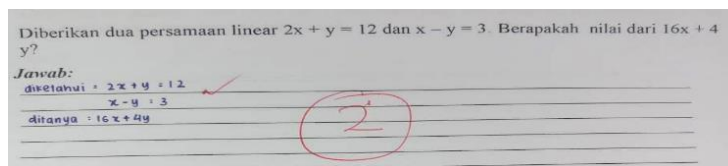

Figure 4. Example of a student's pre-test answers from the experimental group
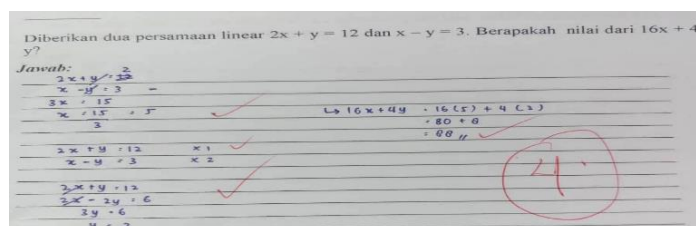

Figure 5. Example of a student's post-test answers from the experimental group

The findings of this study show that TnL using PjBL worksheet is effective to improve students' achievements rapidly in tests that were conducted in a short time compared to conventional TnL. The effectiveness of using a PjBL worksheet to improve students' achievements in a short time is also in line with the findings of Nurjailam (2017) study which discovered that one of the purpose of modular learning is to enable students to manage their learning process at their own pace.

Analysis of the Difference in Post-Test Mean Scores between Experimental and Control Groups

Table 11 shows that mean score of post-test (79.93) for the experimental group is higher than the mean score of post-test (37.53) for the control group. Table 12 further depicts that there is a significant difference in the mean scores of the post-test for the control and experimental groups (t = -12.63, p = 0 < 0.05, Df = 28). The findings show that the students in PjBL worksheet group performed better than students in the conventional learning material group.

Table 11. Mean scores of post-test achievement for TVLES topic

Group	Test	Mean Score
Control	Post	37.53
Experimental	Post	79.93

Table 12. Independent t-test of post-test

	t-value	Df	Significant Value	The difference Mean Score between Two Group
Post Test	-12.630	28	0 .000	42.40

Thus, it is evident that PjBL student worksheet is effective for improving the achievement of students in TVLES. This finding is consistent with the previous studies by Septina et al. (2018) and Putra et al. (2018) which highlighted that student worksheets can improve students' problem solving skills, mathematical understanding and achievement. According to Endang (2019), the use of language that is easy to understand among students is an important condition in students' worksheets. Thus, the use of Bahasa Indonesia, the mother tongue in the PjBL student worksheet can help students to better understand a concept even if they are abroad.

CONCLUSION

As a conclusion, this study shows that the Form Two students' achievement in TVLES in one of the Indonesian school in Malaysia is still weak. This is due to several factors, such as mathematics TnL techniques, which still use conventional method that causes students to become passive and lack of interest. In addition, the findings of this study clearly show that PjBL student worksheets are alternative sources for educators to carry out planned activities and further improve students' achievement. This proves that TnL strategies and creative TnL materials have become one of the main factors to improve students' mathematical achievement.

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