INNOVATIVE: Journal Of Social Science Research
Volume 3 Nomor 3 Tahun 2023 Page 3111-3121
E-ISSN 2807-4238 and P-ISSN 2807-4246
Website: https://j-innovative.org/index.php/Innovative

Application of the Project Based Learning Model in Pythagorean Theorem Learning

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Abstrak

Penelitian ini bertujuan untuk mengetahui perbedaan hasil belajar matematika siswa kelas VIII MTs Negeri 1 Bitung pada materi teorema phytagoras. Metode yang digunakan adalah eksperimen semu. Rancangan penelitian yang digunakan adalah pre-test and post-test one group design. Subjek penelitian yaitu 20 orang siswa kelas VIII.A yang diajarkan menggunakan model PjBL dan 20 orang siswa kelas VIII.C yang diajarkan menggunakan model DI. Penelitian ini menggunakan rancangan penelitian berbentuk pretest-posttest control group design. Dari penelitian ini diperoleh hasil pretest-posttest kemudian dilakukan uji normalitas dan uji homogenitas sebelum dilakukan uji hipotesis. Hasil uji normalitas diperoleh L_{hitung} = 0,1238 < L_{tabel} = 0,1920 berarti data skor pretest-posttest kelas eksperimen berdistribusi normal, sedangkan hasil uji normalitas kelas kontrol diperoleh L_{hitung} = 0,1863< L_{tabel} = 0,1920 yang berarti data skor pretest-posttest kelas kontrol berdistribusi normal. Hasil uji homogenitas diperoleh F_{hitung} = 1,250082 < F_{tabel} = 2,168252 sehingga terima H_0. Jadiivarians dari kedua kelas, yaitu kelas eksperimen dan kelas kontrol adalah homogen. Hasil uji hipotesis dengan taraf nyata α=0,05 diperoleh t_{hitung} = 7,148892 > t_{tabel} = 1,685954. Dengan demikian dapat disimpulkan bahwa rata-rata hasil belajar siswa yang diajarkan menggunakan model PjBL lebih tinggi daripada rata-rata hasil belajar siswa yang diajarkan menggunakan model DI.

Kata Kunci: *Pembelajaran Matematika, Model PjBL, Teorema Pythagoras*

Abstract

This study aims to determine differences in mathematics learning outcomes for MTs Negeri 1 Bitung classs VIII students on the Pythagorean theorem material. The method used is quasi-experimental. The research design used was a pre-test and post-test one-group design. The research subjects were 20 students in class VIIIA who were taught using the PjBL model and 20 in class VIII.C who were taught using the DI model. This study used a research design in the form of a pretest-posttest control group design. This study obtained the pretest-posttest results. Then the normality and homogeneity tests were carried out before testing the hypothesis. The normality test results obtained $L_{count} = 0.1238 < L_{table} = 0.1920$, meaning that the pretest-posttest score data for the experimental class was normally distributed, while the normality test results for the control class obtained $L_{count} = 0.1863 < L_{table} = 0.1920$ which means the pretest-posttest normally distributed control class. The results of the homogeneity test obtained $F_{count} = 1.250082 < F_{table} = 2.168252$, so accept H_0. So, the variances of the two classes, namely the experimental and control classes, are homogeneous. The hypothesis test results with a significant level of $\alpha = 0.05$ obtained $t_{count} = 7.148892 > t_{table} = 1.685954$. Thus, it can be concluded that the average learning outcomes of students who are taught using the PjBL model are higher than those of students who are taught using the DI model.
Keywords: *Mathematics Learning, PjBL Model, Pythagorean Theorem*

INTRODUCTION

Learning and learning are activities that are inseparable in human life. By learning, humans can develop their potential; learning is carried out throughout life (Aris, 2014). With learning, humans may be able to meet their needs. All daily activities require knowledge that can only be obtained by studying. The process of learning is characterized by alterations in the learner (Fachri, 2014). Knowledge, understanding, attitudes and behavior, skills, abilities, habits, and other aspects of individuals who learn can change as a consequence of the learning process (Fikri, 2014). Learning is an active endeavor. Individuals acquire knowledge by responding to all encircling situations (Hendiana & Soemarno, 2014). When we speak of learning, we are referring to the process of altering a person's or an individual's behavior through exposure to a variety of experiences (Indrawati et al., 2017).

Student behavior that turns into learning outcomes is influenced by learning factors; one of the factors in question is using learning models. The learning model's purpose is to increase student learning outcomes (Jamil, 2011). Therefore, the educator must be able to select and implement active learning concepts in accordance with the 2013 curriculum. Formal, informal, and non-formal education contributes to the learning process (Made, 2012). For formal education conducted in schools, students must take all subjects to meet competency and graduation standards, and one of the subjects taught in schools is mathematics (Mashudi, 2013).

Mathematics is a subject that can foster logical, systematic, critical, and rational thinking. Mathematics is also used as a basis for studying other sciences (Muhibbin, 2010). However, only some learn to understand the material the teacher teaches entirely. Different difficulty levels require different treatment for students (Mulyadi, 2015). Through measurement, mathematics helps develop the ability to count, measure, derive formulas, and apply mathematical formulas essential in everyday life. (Ni'matul, 2016). The difficulty of learning mathematics makes responsible teachers have to make several efforts, one of which is using effective and efficient learning models (Noviayana, 2017).

The use of learning models can provide many benefits for students and teachers. Benefits for students and easily understandable material can also improve student learning outcomes (Octafiona, 2018). While the benefits for teachers make it easier to transfer material to students, so students can easily understand the material being thrown (Rosmaini & Situmorang, 2010). The school has made many ways and efforts, especially by mathematics teachers, to improve student learning outcomes, but they still need to be optimal (Rusman, 2017). This is because students consider mathematics subjects problematic, causing students to need more understanding of mathematical concepts.

What happened at MTs Negeri 1 Bitung, located in Bitung City, North Sulawesi Province, is based on preliminary observations made by researchers. The results of learning mathematics on the Pythagorean Theorem material for students at these schools still need to be higher. This can be seen from the average student learning outcomes, which are proven according to the proportion of classical teaching and learning, namely that around 32% of students have completed it. In comparison, 68% of students still need to complete it.

The results of interviews with Mathematics teachers who prohibited Pythagorean Theorem material obtained information that: (1) The learning model used for rakes was not effective and efficient and did not attract students' interest in learning because it was considered boring for students. (2) Teachers still use a lot of direct learning models. They are rarely developed, so teachers dominate learning more than students, students rely more on and depend on teachers without wanting to think for themselves, and students become not independent because their understanding of the material still needs to be improved. (3) Inaccuracy in using mathematics learning models can hinder the desire to learn mathematics.

Other factors that cause low student mathematics learning outcomes are: (1) there are still many students who are noisy and pay less attention to the material because it is considered tedious (2) The teacher must repeatedly provide the same material; this is because students still experience difficulties in applying the Pythagorean theorem, students consider this material to be complex, students experience difficulties when solving questions, and students lack understanding of the material. (3) The teacher lacks control over the class, making learning uncomfortable. These things impact students' mathematics learning outcomes that could be more optimal.

The process and learning objectives, in this case, learning mathematics, will run smoothly if teachers and students are both actively involved in learning. The influencing learning factors must be interrelated; many factors influence external factors, such as the school environment, and internal factors, such as students' interest and motivation to learn (Slameto, 2015). Mathematics learning can be successful if the learning method or model used by the teacher can run effectively and efficiently where teachers and students support each other and are actively involved; teachers must be able to stimulate and develop students' knowledge, so they want to think critically (Sugiyono, 2015).

When starting a math lesson, the teacher should open it first, not yet getting to the core of the problem but explaining it step by step, starting from the learning objectives and introducing problems and solutions. Students are guided to understand all mathematical concepts related to the studied material (Sugiyono, 2012). Projects that students will complete should be in everyday life to make students easier to understand (Suyono & Harianto, 2014).

With this problem, researchers need to use an exciting learning model to encourage activeness and improve student learning outcomes. The learning model that is thought to improve student learning outcomes is the Project Based Learning model. The goal is that teachers can see student participation directly. Students must investigate, evaluate, interpret, and synthesize information to generate diverse learning outcomes (Purwanto, 2011; Zanah, 2020).

PBL is a learning model that focuses on learning experiences that are regulated to include investigation and problem-solving, particularly problems related to ordinary life, such as math. Applying the PjBL model in learning Mathematics can improve student learning outcomes. Several previous studies on applying the PjBL model in learning Mathematics showed increased student learning outcomes (Wardani et al., 2019). Research conducted by Noviyana, H. (2017) concluded that there is a Project Based Learning Model that can improve student learning outcomes as well as research conducted by Wardani, D. K., Suyitno, S., & Wijayanti, A. (2019) concluded that this model learning Project Based Learning is effective on learning outcomes of mathematics.

Some problems in the real world, namely about mathematics Pythagorean theorem material such as right triangles, are very close to real life. Many events that we encounter every day use right triangles. For example, building constructions that use right triangles, measuring street distances in the form of right triangles, etc., apply the Pythagorean Theorem. Thus, the

PjBL model can be assumed to be used in Pythagorean Theorem learning material.

METHOD

This is comparative research employing a quasi-experimental methodology. This investigation contrasts the mathematical learning outcomes of two classes' Pythagorean Theorem content. The first class is called the Experiment Class, with the treatment being the Project Based Learning (PjBL) model, while the second class is called the Control Class, with the treatment being the Direct Instruction learning model. Both classes were given an initial test (pretest) to measure the initial ability of the material to be taught and a final test (posttest) after treatment to measure the final ability after the material was taught. Thus, the design of this study uses the Pretest-Posttest Control Group Design (Sugiyono, 2012) as follows:

Table 1 Pretest-Posttest Control Group Design

Class	Pre-test	Treatment	Post-test
Experiment (E)	O_{1E}	X	O_{2E}
Control (K)	O_{1K}	-	O_{2K}

Information:

E : Experiment Class

K : Control Class

X : Treatment in the Experimental Class, namely the application of the Project Based Learning model

O_{1E} : Initial observation or pretest value of Experimental Class

O_{1K} : Initial observation or pretest value of Control Class

O_{2E} : Final observation or posttest score of Experimental Class

O_{2K} : Final observation or posttest value of Control Class

$O_{1E} = O_{2E}$ and $O_{2E} = O_{2K}$ with $O_{1E} \equiv O_{2E} \equiv O_{2E} \equiv O_2$

This research will take place in eighth grade MTs Negeri 1 Bitung during the odd semester of the academic year 2022-2023. Class VIII MTs Negeri 1 Bitung consisted of eight classes, each containing twenty students, and comprised the entire population for this investigation. This study employed a random sampling method (simple random sampling) because every member of the population has an equal chance of being selected. In this study, the variables were the mathematics learning outcomes of the Pythagorean Theorem material for students taught using the Project Based Learning model and for students taught using the Direct Instruction model.

This research instrument was a set of test questions in the form of a description test totaling 5 numbers. Before being distributed to the research sample, the questions were tested on students in other classes or outside the sample class. The test questions are intended to test the validity and reliability of the test items. The researcher prepared this set of test questions. Research data was collected by giving tests to research samples. The test is in the form of questions in the form of a description test that has been tested for validity and reliability.

Data collected by administering tests to subjects were processed with the help of Microsoft Excel to describe the required statistical measures (sum of datum n, minimum datum x_min, maximum datum x_max, mean $\bar{x}$, standard deviation s, variance/variety s^2). Because the research design uses the Pretest-Posttest Control Group Design, the data that is processed is n-gain score data (the difference between the posttest and pretest = posttest – pretest). Furthermore, based on the research hypothesis, which is formulated as follows: The results of learning mathematics from the Pythagorean Theorem material are greater for students taught using the Project Based Learning model than for students taught using the Direct Instruction model.

RESULT AND DISCUSSION

Result

This research was conducted at MTs Negeri 1 Bitung using two randomly selected classes, namely class VIII A (Experimental class) and class VIII C (control class) for the 2022/2023 academic year. Each was numbering 20 people. This study used a Pretest-Postest Control Group Design. The data in this study were taken from student learning outcomes in the Pythagorean Theorem material after being given treatment or treatment. The data analysis from the pretest-posttest of the experimental and control classes can be seen in the following table.

Table 2. Summary of experimental class pretest-posttest data

No.	Statistics	Value
1.	Total	224
2.	Minimum Score	6
3.	Maximum Score	15
4.	Average	10,6667
5.	Variance	9,642080
6.	Standard Deviation	3,10517

Table 3. Summary of experimental class pretest-posttest data

No.	Statistics	Value
1.	Total	103
2.	Minimum Score	1
3.	Maximum Score	12
4.	Average	4,9048
5.	Variance	7,713156
6.	Standard Deviation	2,777257

Hypothesis Test Analysis

Before testing the hypothesis using the t-test, the normality test and homogeneity of variance were tested in the pretest-posttest data from the control and experimental classes. The normality, homogeneity, and data hypothesis tests are presented as follows.

1. Data Normality Test

   Hypothesis :

   - H_0 : Data is normally distributed
   - H_1 : The data is not normally distributed

   Decision criteria:

   - If the value of $L_{count} < L_{table}$ accepts H_0, then the data distribution is declared normal
   - If the value of $L_{count} > L_{table}$ rejects H_0, then the data distribution is not normal

Table 6 Results of the Normality Test for Pretest-Posttest Scores for the Experimental Class and the Control Class

Class	N	L_{count}	L_{table} ($\boldsymbol{\alpha = 0,05}$)	Note
Control	20	0,1863	0,1920	Normal
Experiment	20	0,1238	0,1920	Normal
Conclusion: Normal Distribution				

Based on the table above, data from the normality test results for pretest and posttest scores in the experimental and control classes come from normally distributed populations. (Calculation of Liliefors pretest and posttest scores).

2. Homogeneity Test

   The data used for the homogeneity test are pretest and posttest scores. Following are the steps for testing the homogeneity of the control and experimental classes.

1) The statistical hypothesis to be tested in both groups is:

$H_0 : \sigma_1^2 = \sigma_2^2$ (both variances are equal)

$H_1 : \sigma_1^2 \neq \sigma_2^2$ (the two variances are not the same)

2) Significant level: $\alpha = 0,05$

3) Test Statistics:

$F = \frac{largest\ sample\ variance}{smallest\ sample\ variance}$, if $S_1^2 > S_2^2$

4) Test Criteria:

If the value of $F_{count} > F_{table}$, then reject H_0

If the value of $F_{count} < F_{table}$, then accept H_0

Table 7 Data on Homogeneity Test Results for Pretest-Posttest Scores for the Control Class and the Experimental Class

Significant Level	0,05
F_{count}	1,250082
F_{table}	2,168252
$F_{count} < F_{table}$	Homogen

Based on the data above, the variances of the two classes, namely the control and experimental classes, are homogeneous.

3. Hypothesis Testing

Because the normality and homogeneity tests have been fulfilled, hypothesis testing using the t-test can be carried out. Testing the hypothesis is as follows

$H_0 : \mu_E = \mu_K$

$H_1 : \mu_E > \mu_K$

With:

μ_E = average student learning outcomes taught using the Project Based Learning model.

μ_K = average student learning outcomes taught without using the Project Based Learning model

Based on the hypothesis testing criteria, reject H_0 if the test statistic falls within the critical area. The results of testing the hypothesis with the t-test at the fundamental level (α) = 0.05, t_{count} = 7.148892, and t_{table} = 1.685954. So, t_{count} = 7.148892 > t_{table} = 1.685954, meaning the test statistic falls within the critical area. This shows that there is enough evidence to reject H_0. Therefore, it can be concluded that reject H_0. From testing the hypothesis, it can be stated that the average learning outcomes of students taught using the PjBL model are higher than those taught without using the PjBL model in Pythagorean theorem material.

Discussion

The average difference in pupil learning outcomes between the two classes is caused by differences in the learning process in the class where the PjBL learning model is implemented. In contrast, the control class is taught solely using the DI model, which, in its application, must be capable of enhancing students' mathematical comprehension, particularly in the Pythagorean theorem material. This is because the DI learning model focuses more on learning from the teacher, so the learning process becomes monotonous, resulting in a lack of student activity in the learning process. This is because students are required to pay more attention to the teacher's material explanations, which prevents them from exploring their own knowledge, leading to a lack of motivation and student learning interest. Consequently, students lose interest in learning mathematics in class, resulting in poor learning outcomes.

Contrary to the PjBL paradigm. This model can enhance student learning of Pythagorean Theorem material because, when applied, it can generate interest and motivation in mathematics students who are learning. This learning model can provide students with an engaging learning experience by presenting everyday problems that are directly related to the Pythagorean Theorem material, thereby stimulating students' reasoning to think critically when solving various mathematical problems related to the theorem. The existence of a process of exploration, assessment, interpretation, synthesis, and presentation of information in the learning process using the PjBL learning model enables students to acquire the knowledge necessary to comprehend the Pythagorean theorem itself with greater ease. This is what causes students to become more engaged in class, which has a positive effect on their learning of the Pythagorean theorem material. This also results in the PjBL model having a higher average learning result than the Direct Instruction model.

CONCLUSION

Based on research data that has been carried out at MTs Negeri 1 Bitung regarding the application of the project-based learning model in learning mathematics on Pythagorean theorem material, it is obtained that the average student learning outcomes taught using the project-based learning model are higher than the average student learning outcomes taught with the direct instruction learning model. Thus, learning by applying the PjBL model can increase the average student learning outcomes in Pythagorean theorem material.

Suggestions that can be given based on the results of this study are that students can develop the learning experiences that have been obtained through the application of the PBL model in each mathematics lesson in order to improve overall mathematics learning outcomes further. In addition, in the learning process, teachers and prospective teachers should choose a learning model that helps students more easily understand the material to be taught and makes students more active and involved in completing a product. Also, teachers must improve the quality of learning by applying the PjBL model in learning mathematics according to the material.

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