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Effect of Project-Based Learning and Communication Skills On Students' Reasoning Ability

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Abstract
This study aims to investigate the impact of communication skills and the project-based learning (PBL) model on the reasoning skills of eighth-grade students at SMP Islam Nurul Huda. This study used a two-group experimental design, with one experimental group using the PjBL model and the other group using traditional techniques. A two-way MANOVA approach was used in analysing the data. The results showed that the PjBL model significantly improved students' abilities in mathematical reasoning and problem solving compared to the traditional approach. The learning model and communication ability interacted to affect reasoning ability, but there was no difference in ability based on students' communication ability level.

Keywords: Communication Skills, Project-Based Learning, Reasoning Ability

Abstrak
Penelitian ini bertujuan untuk melihat dampak keterampilan komunikasi dan model pembelajaran berbasis proyek (PjBL) terhadap keterampilan penalaran siswa kelas delapan di SMP Islam Nurul Huda. Penelitian ini menggunakan desain eksperimen dua kelompok, dengan satu kelompok eksperimen menggunakan model PjBL dan kelompok lainnya menggunakan teknik tradisional. Pendekatan MANOVA dua arah digunakan dalam menganalisis data. Hasil penelitian menunjukkan bahwa model PjBL secara signifikan meningkatkan kemampuan siswa dalam penalaran matematika dan pemecahan masalah dibandingkan dengan pendekatan tradisional. Model pembelajaran dan kemampuan komunikasi berinteraksi untuk mempengaruhi kemampuan penalaran, namun tidak ada perbedaan kemampuan berdasarkan tingkat kemampuan komunikasi siswa.

Kata Kunci: Keterampilan Komunikasi, Kemampuan Penalaran, Pembelajaran Berbasis Proyek

Introduction

Learning is an interactive and systemic process or activity involving teachers and students, learning resources, and the environment, creating a conducive atmosphere for conducting learning activities (Zainal, 2009). In other words, learning is a process that facilitates interaction among students and enables them to communicate various matters to others. Teacher communication in the classroom determines the learning interactions that occur, whether between students and teachers, among students, or with learning resources (Inah Ety Nur, 2015). Teacher communication also influences the learning interaction models that take place in the classroom (Zayyadi et al., 2020).

This research involves a project-based learning model. One of the paradigms that applies constructivism is project-based learning (Hidayati et al., 2017). Several studies have shown that cooperative learning yields superior learning outcomes compared to traditional learning (Alex & Olubusuyi, 2013; Kızkapan & Bektaş, 2017; Zayyadi et al., 2020). For instance, Yuni Pantiwati's dissertation, titled *The Effect of Biology Assessment Types in TPS (Think Pair Share) Cooperative Learning on Cognitive Abilities, Critical Thinking, Creative Thinking, and Metacognitive Awareness of High School Students in Malang City* (Pantiwati, 2012). Similarly, research by Husna et al. (2012) Their article revealed that, in terms of overall student performance and mathematical reasoning skills, students participating in the Think-Pair-Share cooperative learning paradigm showed greater improvement in their mathematical reasoning skills compared to those in traditional learning.

The study also found that the use of authentic assessment had a significantly superior and different effect on creative thinking abilities compared to conventional assessment. By fostering a fairer learning environment, project-based learning also helps children achieve academic success, as noted in Oktay's research. Among the constructivist learning methods gaining popularity in science education is project-based learning (PjBL) (Frank & Barzilai, 2004). PBL allows students to actively participate in problem-solving (Doppelt, 2003; Kızkapan & Bektaş, 2017; Krajcik et al., 1994). When a researcher measures problem-solving abilities, they go through a reasoning process. Reasoning is a structured way of thinking that produces conclusions and statements to solve problems; it does not rely entirely on formal logic and is therefore not limited to the use of evidence (Ginting, Paham dan

Situmorang, 2008). Students often struggle with solving mathematical problems due to their low level of mathematical knowledge and reasoning skills.

The indicators for mathematical reasoning ability are: 1) Verifying the truth of statements; 2) Making generalizations and analogies; 3) Drawing logical conclusions; 4) Following rules of inference (M Ario, 2016). It is evident that these mathematical indicators can be developed and are influenced by the learning model employed. In this study, the project-based learning model is central. Each phase of this project-based learning model begins with formulating fundamental questions designed to engage and enhance these reasoning indicators, guiding them toward improvement. This process continues through subsequent and final phases, which help to refresh and consolidate students' existing thinking. Students find it difficult to solve mathematical problems due to their low levels of mathematical knowledge and reasoning abilities. By assigning tasks in the form of problems that require activities or projects related to mathematical principles and concepts, students' mathematical problem-solving abilities are strengthened (Monti et al., 2003). This approach enables students to engage directly in problem-solving and ultimately produce a product.

Through project-based learning, students are given tasks in the form of real-world challenges that require activities or projects related to mathematical principles and concepts, thereby enhancing their problem-solving skills. This method allows students to be directly involved in problem-solving and produce tangible outcomes. Students gain extensive mathematical experience when frequently exposed to such tasks. They unknowingly apply mathematical thinking and problem-solving skills to various issues (Suriyani, Mulbar Usman, 2018). Based on the description above, project-based learning involves using projects or activities to teach students how to solve problems by presenting them with real-world challenges. Students can then use their problem-solving and mathematical reasoning abilities to produce papers or other works.

Method

This study aims to examine how communication skills and a project-based learning approach influence students' reasoning ability. The research employs two groups: an experimental group and a control group. A pre-test will be administered before the treatment begins, followed by the treatment itself, and a post-test at the end of the learning process.

This research is designed using a quasi-experimental plan (quasi-experimental design). Since the research subjects cannot be randomly selected and classroom conditions do not allow for modifications, a quasi-experimental approach is used (Setyosari, 2013). The population consists of students from SMP Islam Nurul Huda in Malang City. Several reasons underlie the selection of this population, including students' reasoning abilities that have not yet emerged in their academic performance, despite their problem-solving skills being evident in their work. A total of 67 students from classes VIIIa and VIIIb serve as the sample in this study.

The reasoning ability variable is measured using a test instrument. The instrument consists of non-routine questions in the form of real-life problems. The test instrument was developed by the researcher based on teacher textbooks. The test instrument includes two types: a pre-test and a post-test. The pre-test is administered before both groups receive the treatment to assess students' initial abilities. Meanwhile, the post-test is given after the treatment to measure students' abilities following the intervention (Sinaga, 2016).

Before conducting the research, the test questions will undergo a trial to evaluate their validity and reliability before being used for data collection (Afiyanti, 2018). The validity of the reasoning ability test instrument is determined through expert judgment, ensuring the questions align with learning objectives. The instrument's reliability is tested using Cronbach's Alpha formula to measure the internal consistency of the items (Sugiyono, 2017). The results of the validity and reliability calculations serve as the basis for revising or refining the instrument before the main research is conducted.

Two-way Multivariate Analysis of Variance (MANOVA) 2 x 2 is the method used in this study (Budiyono et al., 2015). Similar to other difference tests (t-test, z-test, ANOVA), MANOVA also requires prerequisite tests, including tests for data normality and variance homogeneity.

Results and Discussion

Results

This study employed three types of tests: hypothesis testing, data analysis prerequisite testing, and descriptive data analysis. The descriptive data analysis involved describing the implementation process in the experimental group using a project-based learning model. The prerequisite tests for data analysis included normality and homogeneity tests. Hypothesis testing was conducted using MANOVA statistical techniques with the aid of SPSS version 24.0, at a significance level of $\alpha = 0.05$.

The research was conducted at SMP Nurul Huda in January 2020 over five sessions. Based on the research findings, a project-based geometry learning approach was used in the experimental class. In this context, cooperative learning was the traditional instructional approach applied in the control group, where inquiry-based learning was one type of cooperative learning strategy. The intervention in the experimental class involved the implementation of the project-based geometry learning model, consisting of several main stages: problem presentation, project planning, scheduling, group project implementation, continuous monitoring and evaluation, presentation, and reflection.

In the experimental class, the stages of geometry learning focused on project-based activities. In the first phase, the teacher posed questions that guided students to undertake a project activity. In the second phase, students and the teacher jointly planned the agreed project, which included selecting activities to answer the question from the first phase, choosing the tools and materials needed for project completion, and setting project implementation guidelines. Scheduling the tasks to complete the project was the third phase. Here, both the teacher and students agreed on the start and end dates for completing the project. When students came up with new ideas unrelated to the project, the teacher helped guide them accordingly.

While working on the project, students were arranged in groups, which helped them communicate effectively and facilitated the execution of the project steps. This process is documented in the worksheets (LKPD 1 to 4) on pages 89–90.

During the fourth phase, the instructor monitored student progress by assisting them through each task step. The fifth phase involved evaluating results, which helped the teacher measure students' level of understanding and provide feedback regarding their competency achievements. In the sixth phase, both teacher and students reviewed the activities and project outcomes, marking the end of the learning process. While working on the project, students shared their thoughts and feelings and engaged in discussions to improve group performance. Eventually, a new question emerged, aimed at solving the original problem introduced in the first learning stage.

The normality test was conducted to ensure that the research data were distributed according to the normal curve principle. This analysis used the Kolmogorov-Smirnov Test, where the criterion is: $p > 0.05$ indicates normal distribution, whereas $p < 0.05$ indicates non-normal distribution. The analysis results showed that both pretest and posttest data from the control and experimental classes, including the questionnaire data, were normally distributed according to the Ebbinghaus Gaussian curve, indicating that the data met the assumption of normality.

Table 1. Normality Test of Pre-test Data for the Experimental and Control Classes

One-Sample Kolmogorov-Smirnov Test

		Unstandardized Residual
N		33
Normal Parameters[a.b]	Mean	,0000000
Std. Deviation		23,27911109
Most Extreme Differences	Absolute	,147
Positive		,086
Negative		-,147
Test Statistic		,147
Asymp.Sig. (2-tailed)		,066[c]

a. Test distribution is Normal
b. Calculated from data
c. Lilliefors Significance Correction

From the table above, the normality test result for the pretest data was 0.066, where $p > 0.05$. This result indicates that the data were normally distributed. Table 2 below shows that the post-test results were also normally distributed.

Table 2. Normality Test of Post-test Data for the Experimental and Control Classes

One-Sample Kolmogorov-Smirnov Test

		Unstandardized Residual
N		33
Normal Parameters[a,b]	Mean	,0000000
	Std. Deviation	11,65095336
Most Extreme Differences	Absolute	,123
	Positive	,123
	Negative	-,080
Test Statistic		,123
Asymp. Sig. (2-tailed)		,200[c,d]

a. Test distribution is Normal.
b. Calculated from data.
c. Lilliefors Significance Correction.
d. This is a lower bound of the true significance.

From the table above, the normality test result for the posttest data was 0.200, where p > 0.05, indicating that the data were normally distributed. The first hypothesis of this study was that there would be a difference in reasoning ability outcomes between students with high communication skills and those with low communication skills, in groups taught using a project-based learning model versus a conventional model in mathematics. To test this hypothesis, the Test of Between-Subject Effects was used, and the results are presented in the following table.

Table 3. Results of the Test of Between-Subject Effects

Variabel	df1	df2	F_{count}	F_{tble}	Significant	
Posttest results of problem-solving ability	1	57	0,051	4,010	0,821	H_0 accepted

Source: Research data analysis, 2020

The F-test result for the posttest of students' reasoning ability between those with high and low communication skills yielded an F-value of 0.396 and a significance value of 0.532, while the F-table value for df 1:1 and df 2:57 at a 95% confidence level was 4.010. Therefore, since the calculated F-value < F-table (0.396 < 4.010) and the significance value 0.532 > 0.05, H_1 is rejected and H_0 is accepted. This means that there is no significant difference in the posttest reasoning ability scores between students with high and low communication skills in the mathematics class. The MANOVA analysis results above show that there is no significant difference between the two variable groups under investigation.

The second hypothesis of this study was that the traditional model and the project-based learning model are related, and communication skills affect students' reasoning in mathematics. To test this hypothesis, the Test of Between-Subject Effects was used, and the results are presented in the table below.

Table 4. Results of Test of Between-Subjects Effects

Variabel	df1	df2	Fhitung	Ftabel	Signifikan	Keterangan
Posttest results of problem-solving ability	1	57	5,191	4,010	0,026	H0 accepted

Source: Research data analysis, 2016

The F-test result for the relationship between the project-based learning model and the conventional model, and communication skills with students' reasoning ability in mathematics for the posttest group, showed an F-value of 5.191 and a significance value of 0.026, while the F-table value for df 1:1 and df 2:57 at a 95% confidence level was 4.010. Therefore, since the calculated F-value > F-table (5.191 > 4.010) and the significance value 0.026 < 0.05, H_1 is accepted and H_0 is rejected. This indicates that there is a relationship between the project-based learning model and the traditional model, as well as the impact of communication skills on students' ability to solve problems in mathematics in the posttest group.

Discussion

Project-Based Learning (PjBL) has been proven to have a positive impact on students' reasoning abilities, especially in the context of mathematics learning, when compared to conventional approaches. According to this study, students' problem-solving abilities significantly improved when they applied the PjBL paradigm. This is due to the constructivist approach inherent in PjBL, which encourages critical thinking, decision-making, and the completion of tasks both independently and collaboratively. As a result, this model creates a more active and interactive learning environment, allowing students to understand mathematical concepts in greater depth.

However, the findings also indicate that communication skills do not directly influence students' reasoning abilities. Although good communication can support discussion and collaboration in project-based learning, no significant difference was found between students with high and low communication skills in terms of mathematical reasoning. On the other hand, the relationship between the learning model and communication skills shows that students with better communication tend to adapt more quickly to PjBL and make better use of discussions to strengthen their understanding.

Moreover, the statistical test using MANOVA confirms that project-based learning is consistently more effective than conventional methods in enhancing students' thinking abilities. A key factor contributing to the effectiveness of PjBL is the presence of real-world challenges in the form of projects, which prompt students to apply the concepts they have learned. Thus, this study affirms that a combination of innovative learning strategies and an environment that fosters interaction and problem-solving can significantly enhance learning outcomes.

Conclusion and Suggestions

According to the findings of this study, compared to conventional approaches, the project-based learning (PjBL) model significantly improves students' mathematical reasoning and problem-solving abilities. Although students' communication skills do not have a direct impact on reasoning ability, the relationship between the learning model and communication skills shows that students with stronger communication skills more easily adapt to PjBL. Therefore, teachers can implement PjBL as an alternative instructional strategy to enhance students' capacity for critical analysis and problem-solving. To implement it effectively, teachers need to integrate PjBL into the curriculum, guide students through each phase of the project, encourage group discussion and collaboration, and utilize media and supporting technologies to make learning more engaging and effective.

For future research, several aspects can be further developed. One possibility is to examine the long-term impact of PjBL on students' cognitive development to determine whether the benefits are sustained over time. In addition, a more flexible PjBL model could be developed so that this method can be applied to various subjects and educational levels. Further research may also explore the role of communication skills in project-based learning, particularly how verbal and non-verbal communication can aid student understanding in completing projects. Lastly, future studies could adopt a broader approach by including factors such as learning motivation and collaborative skills as variables that influence the effectiveness of PjBL.

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