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Effect of Project-Based Learning Model on Students' Higher-Order Thinking Skills

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Abstrak

Masalah dalam penelitian ini berfokus pada rendahnya kemampuan berpikir tingkat tinggi siswa di sekolah menengah atas, yang menjadi perhatian utama dalam peningkatan kualitas pembelajaran. Penelitian ini bertujuan untuk mengetahui perbedaan pengaruh model project based learning (PjBL) terhadap kemampuan berpikir tingkat tinggi siswa kelas X di salah satu sekolah di Tilamuta, kabupaten Boalemo. Metode penelitian ini adalah eksperimen dengan desain penelitian One Group Pretest-Posttest Design. Subjek penelitian terdiri dari 3 kelas eksperimen (E1, E2, E3). Teknik pengumpulan data dilakukan melalui tes kemampuan berpikir tingkat tinggi berbentuk esai. Analisis inferensial menunjukkan bahwa H0 ditolak, yang berarti terdapat perbedaan signifikan dalam pengaruh model project based learning (PjBL) terhadap kemampuan berpikir tingkat tinggi siswa di ketiga kelas tersebut.
Kata Kunci: Kemampuan Berpikir Tingkat Tinggi; Project Based Learning; Sistem Persamaan Linier Tiga Variabel

Abstract

The problem in this study focuses on the low level of students' higher order thinking skills in senior high school, which is a major concern in improving the quality of learning. This study aims to determine the difference in the effect of project-based learning (PjBL) model on the high-level thinking ability of grade X students in one of the schools in Tilamuta, Boalemo district. This research method is an experiment with One Group Pretest-Posttest Design research design. The research subjects consisted of 3 experimental classes (E1, E2, E3). The data collection technique was done through an essay-shaped higher order thinking ability test. Inferential analysis showed that H0 was rejected, which means there is a significant difference in the effect of the project-based learning (PjBL) model on students' higher-order thinking skills in the three classes.
Keywords: Higher Order Thinking Skill; Project Based Learning; Systems of Linear Equations in Three Variables

I. INTRODUCTION

Education plays an important role in improving the quality of students in school to compete in the 21st century (Kane et al., 2016). Education's quality is not only determined by the plan and development of education but also by the quality of its implementation (Retnawati et al., 2018). Learning and teaching are also two conditions that have a strong relationship or correlation and cannot be separated from educational activities. In learning, there are components consisting of educators, students, and learning resources that run in a learning environment. Learning and teaching must consider students' skills in addition to memorization and recall (Wowiling et al., 2013). 21st-century learning should ensure students have 21st-century skills, including skills, work habits, and characters that are considered essential to succeeding in life (Anazifa & Djukri, 2017).

Studying mathematics will hone human thinking skills, especially higher-order thinking skills that include analysis, creativity, and evaluation. Because mathematics may help people think clearly and logically and solve problems on a daily basis, everyone should learn it (Abbas & Zakaria, 2018). As explained, by learning mathematics, one can develop skills and ways of thinking that align with the advancement of science in the 21st century. It is because a lot of problems in daily life may be solved by mathematics, such as determining the price of an item, profit, loss, etc (Rusdi et al., 2020). The existence of a systematic learning concept in mathematics learning means that consistency in each concept becomes a demand in mathematics learning and has an inseparable relationship. It requires students to take advantage of their higher-order thinking skills. This skill can be triggered by solving problems, complex questions, uncertainties, or difficult situations that require a person to choose. It helps students argue well, know a problem clearly, solve problems, provide hypotheses, and understand complex things clearly. Higher-order skills related to logical and creative competencies are also assessed based on the presented details of the cross-thematic linkages and logical progression of the steps (Tularam & Hulsman, 2013; Susanti et al., 2023).

HOTS is also a skill needed in math learning. It is asserted by the statement that HOTS is essential for learning math (Arnellis et al., 2021). But in reality, classroom learning shows that some students didn't like mathematics; they thought that math was quite hard to solve. An example of this is when students find difficulty solving contextual problems in the material on the three-variable linear equation system. According to the teachers' interpretation of the analyses' findings (Abbas et al., 2021) the student's abilities were above average. However, they had not engaged in adequate research, problem-solving, opinion-expressing, or question-asking. This can

happen because solving the problem requires understanding the concept, precise calculations, high analysis, and evaluation. It causes students' high-order thinking skills to be relatively low because they are poorly trained and developed.

During the learning process, students are less responsive to complex and simple questions given and lack the willingness to find out or ask questions about poorly understood material. They have difficulty analyzing and making mathematical models of the given problems. Additionally, interviews with mathematics teachers at a school in Tilamuta and observations from the learning process indicate that the HOTS of tenth graders are relatively low. Similarly, PISA results in mathematics show that Indonesia ranked 39 out of 41 countries in mathematics (Putri & Zulkardi, 2018; Rohmawati & Afriansyah, 2022).

Due to the difficulties in learning mathematics, teachers must be creative when creating classes and selecting the methods and media to be used (Riskawati et al., 2021). Teachers have been getting used to traditional teaching for many years. They were used to explaining all the materials to the students. In such a method, the teacher usually only asks the students yes-or-no questions (Putri & Dolk, Maarten Zulkardi, 2015). To apply the learning process in mathematics, the teacher must be able to select the proper learning model based on the characteristics of the mathematical subject that allow the growth of the student's abilities (Hulukati et al., 2018).

The interview results also showed that the learning model used in the research area is an expository learning model that impacts the classroom's learning process, which is only teacher-centered, makes students less active, and only receives the material. Because what happens inside the classroom is crucial for students' learning and career expectations (KICE, 2015). knowledge in each individual in the learning environment. The teacher is no longer the only source of expertise in the classroom when project-based learning is used, as students obtain knowledge from a number of sources, such as the Internet, the library, or email interaction with a working professional (Mathematics, 2016).

Research supports the effectiveness of PjBL in enhancing students' understanding of mathematical concepts and developing HOTS (Nurhikmayati & Sunendar, 2020; Effendi, Ummah, & Cahyono, 2023; Kartikasari, Rahman, & Ahyan, 2023). For instance, a study conducted at SMP Negeri 16 Bengkulu City found that PjBL significantly improved students' understanding of mathematical concepts and critical thinking skills, with an effect value of 78.7%. This demonstrates that students not only learn theory but also apply mathematical concepts in the projects they undertake (Pusvita et al., 2024). Moreover, research involving students at Labschool Cibubur junior high school showed that STEAM-based PjBL led

to significant improvements in students' critical thinking skills, as they analyzed, evaluated, and created solutions within the context of their projects—key aspects of HOTS (Wastiani et al., 2023). Additionally, a study at SD Inpres 46 Sorong revealed that PjBL increased students' learning motivation, contributing to their engagement in mathematics, which is essential for developing creativity and critical thinking skills (Mahendra et al., 2023).

Based on the explanation above, researchers are interested in carrying out research with the title " Effect of Project-Based Learning Model on Students' Higher-Order Thinking Skills."

II. METHOD

This study is quantitative research with an experiment and a one-group pre-posttest design (Sugiyono, 2013). The One Group Pretest-Posttest Design research design is one method commonly used in quantitative research to evaluate the effects of a treatment or intervention on the same group. In this design, the researcher applies treatment to several sample classes without using a control group. The research subjects were the tenth graders of SMAN 1 senior high school in Tilamuta for the first semester of the 2022/2023 academic year, in which ten classes are the population; a simple random sampling technique is used for sampling. As (Sugiyono, 2016) explained, the sample is a component of the characteristics and numbers of the population. Three classes of samples are needed, so the results of sampling techniques in the form of classes X.3, X.9, and X.10 are obtained. These are experimental classes, where the three classes will be treated using the project-based learning model. The research design scheme of one-group pretest-posttest design can be seen in Table 1 below:

Table 1.
One-Group Pretest-Posttest Design Scheme

Class	Pretest	Treatment	Posttest
Eksperimen	O_1	X	O_2

(Sugiyono, 2013)

The instruments used in this study are essay-shaped tests on pre-tests and post-tests regarding high-level thinking abilities that have been tested for validity. This study applied inferential statistics as the data analysis techniques, including a normality test, homogeneity test, and ANOVA test in a hypothesis test. If the outcomes of the students' higher-order thinking abilities in experimental classes 1, 2, and 3 differ significantly from one another, then additional testing between the two samples using a t-test is required to determine whether the class in the prior hypothesis test has a different average value.

III. RESULT AND DISCUSSION

Research conducted in tenth grade of SMAN 1 senior high school in Tilamuta has

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obtained data to measure high-level thinking skills. In this study, three experimental classes were obtained, including X.10 as experimental class 1, X.3 as experimental class 2, and X.9 as experimental class 3. These three classes were taught with the Project-Based Learning (PjBL) model. A pre-test was carried out to determine the initial students' abilities after being given treatment using the project-based learning model to find out the skill of thinking at a high level after getting treatment.

Table 1.
Data Description of Pre-test and Post-test

Class	Data	n	Min Score	Max Score	Mean	Me	Mo	SD	S^2
E1	*Pre-test*	33	6	16	10.1	10	6	3.27	11.03
	Post-test		9	20	14.9	15	17	11.97	147.7
E2	*Pre-test*	36	4	15	9.1	9	8	2.34	5.6
	Post-test		8	18	13.6	14	14	2.64	7.1
E3	*Pre-test*	35	5	16	9.2	9	9	2.37	5.8
	Post-test		8	19	13.8	14	14	2.60	7.0

E1=experimental class 1, E2=experimental class 2, E3=experimental class 3

Table 2 shows that the average score of students' initial abilities sequentially from experimental classes 1, 2, and 3 is 10.19, 9.11, and 9.27, with min and max scores of 6 and 16, 4 and 15, then 5 and 16. As for the average score of students' high-order thinking skills obtained from the post-test given sequentially from experimental classes 1, 2, and 3, namely 14.95, 13.61, and 13.8 with min and max scores of 9 and 20, 8 and 18, abilities 8 and 19, for a score range of 0–20.

Furthermore, a normality test is carried out to find out whether the data obtained comes from research subjects that are normally distributed or not. This normality test uses the Liliefors test at a real level. The normality test criterion is H0 accepted if Lcount Ltable and H0 are rejected if Lcount > Ltable. The acceptance of H0 states that the research data come from normally distributed populations and vice versa. The following are the results of the normality test of the three experimental classes:

Table 2.
Result of Data Normality Test

Data	Class	n	L_{count}	$L_{table}(\alpha=0.05)$	Result
Pre-test	E1	33	0.129	0.1542	Usual
Post-test			0.136		Usual
Pre-test	E2	36	0.097	0.1476	Usual
Post-test			0.092		Usual
Pre-test	E3	35	0.097	1.497	Usual
Post-test			0.842		Usual

Furthermore, a homogeneity test was carried out to find out whether the data of the three groups had homogeneous variances or not. The Bartlett Test

conducted its homogeneity test at a significant level, with the criterion that if Chicounts < Chitable then the data of all three groups have the same (homogeneous) variance. Here are the results of the homogeneity test for the three experimental groups:

Table 3.
Results of The Homogeneity Test

Data	Class	n	Dk	Chi_{count}	Chi_{table}	Result
Pre-test	E1	33	32	5.8503	5.9915	Homogeneous
	E2	36	35			
	E3	35	34			
Post-test	E1	33	32	0.6328		Homogeneous
	E2	36	35			
	E3	35	34			

From Table 4, we can see that the three classes in the pre-test data have a Chicount¬ of 5.8503 as well as in the post-test data, which has a Chicount of 0.6328, which looks smaller than the Chitable which is 5.9915 at a significant level. It suggests that all three groups of students' higher-order thinking skill data come from homogeneous populations.

From the results of previous tests, it can be concluded that all three data sets come from normally distributed populations and have homogeneous variances. Thus, the Anova Inferential Test requirements have been met; therefore, a research hypothesis test can be carried out.

Based on the calculation of variance analysis, Fcount = 0,0008 after comparison with the value of Ftable = F(0.05;2;101) = 0.1169, Fcount = 0,0008 < Ftable = 0.1169. Then H0 is rejected. It means that there are differences in the high-order thinking skills of tenth graders in the research are, which are taught with a project-based learning model.

As a result of the considerable differences that were found, the data were subsequently put to the following further tests using two samples. It is explained that of the three tests (E1: E2), (E1: E3), and (E2: E3), there is a statistical difference in the mean value of the post-test in testing (E1: E2) and (E1: E3), but not in testing (E2: E3), based on the results of additional tests between two samples using the independent sample t-test.

Mathematical concepts are inextricably linked to discussions of learning and education since it is a general science that served as the foundation for developing modern technologies. The term "context" refers to a circumstance, phenomenon, or natural occurrence that is connected to the mathematical concept being studied (Arnellis et al., 2021). Studying mathematics will hone human thinking skills, especially higher-order thinking skills that include analysis,

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creativity, and evaluation. A skill required for studying mathematics is HOTS (Rozien & Retnawati, 2019).

According to the revised Bloom's taxonomy, cognitive processes have been divided into lower and higher-order thinking skills (Pasani & Suryaningsih, 2021). Similarly, (Tanudjaya & Doorman, 2020) classified memorization and recall analysis as lower-order thinking skills, while analysis, syntheses, and evaluation are classified as higher-order thinking skills. For Asian students, HOTS is a crucial resource for navigating the global economy and the Fourth Industrial Revolution (Wahono., 2020).

The objectives are met in terms of both learning objectives and the maximum achieved by students, and the teaching process is deemed effective (Bito et al., n.d.). But in real life, according to another observation at SMPN 1 Karanganyar, the results come from the analysis of the grading documents, which showed that students' grades in math were the lowest compared to other subjects (Sutama et al., 2021). To overcome this problem, determining a learning model to support students when improving higher-order thinking skills is an essential task for teachers. Therefore, there are things that can be an alternative for teachers to develop this skill through the use of the project-based learning model. The PjBL model encourages students to be more active during the learning process according to their characteristics because some projects need to be analyzed, designed, and done in groups and as individuals. The attention is on people cooperating to achieve a common goal. In order to develop and present the final project in response to the guiding question, students may run into problems as they work on a project (Kokotsaki et al., 2014). The successful implementation of PjBL in the classroom depends on the teacher's skill to effectively facilitate, motivate, support, and guide students in their learning as they learn. (Kokotsaki et al., 2014).

Some researchers have reported that students in PjBL-taught classrooms improved their critical thinking and problem-solving skills. Another researcher has also found that PjBL has been a successful method of teaching 21st-century skills (Mutakinati et al., 2018). The PjBL model is an alternative for teachers to make the classroom atmosphere active during the learning process. Using the project as a facility or medium is the cause because it encourages and involves students in analyzing a problem and designing and creating a process for solving it individually and in groups. PjBL fosters students' overall skill development while enhancing their capacity for teamwork and effective time management (Kean & Kwe, 2014). In addition, project-based learning is another model that can be used to develop 21st-century skills (Anazifa & Djukri, 2017).

In addition, (Chiang & Lee, 2016) found that PjBL has several characteristics that enhance students' thinking skills, enable them to be creative, encourage them to work collaboratively, and engage them in accessing and demonstrating that information on their own. PjBL also has several steps to use in the classroom. And as (Jalinus et al., 2017) said, the 7 steps involved 1) formulating the expected learning outcomes, 2) understanding the concept of the teaching material, 3) training skills, 4) designing the project topic, 5) creating the project proposal, 6) implementing the project tasks, and 7) submitting the project report. The best things about using the PjBL in the classroom are that it can improve students' motivation while studying, solve complex problems, and also develop teamwork skills; give the student a new experience while doing the project; and include the student in searching out the information or material that they need to complete their project. However, the shortcomings of incorporating PjBL into the classroom include the need for a long time to complete the project, funding as a support project, a good teacher with creativity and a desire to learn, tools to facilitate the project, and the teacher finding it difficult to ask all of the students to participate in team work.

IV. CONLUSION

This study proved that project-based learning (PjBL) model has a significant impact on students' higher order thinking skills. The results show that the application of PjBL can improve students' critical and analytical thinking skills, with variations in impact depending on the classroom context in which it is applied. This research makes an important contribution to the field of mathematics learning, by confirming that PjBL is an effective method in developing students' higher order thinking skills. For future research, it is recommended that other researchers further explore the application of PjBL in various learning contexts and examine its impact on other aspects of student learning outcomes.

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