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Differences in the Application of Problem-Based Learning and Discovery Learning Models on Students' Mathematical Problem-Solving Abilities from Mathematic Initial Abilities Students of 1 Mamosalato State Senior High School

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Abstract

This research was intended to clearly describe the differences in mathematical problem-solving abilities about initial mathematical abilities by applying the Problem-Based Learning and Discovery learning models. The research design employed a quantitative approach. The sample of this research was students of SMA Negeri 1 Mamosalato, Grade XI MIA 1, as the first and second experiment classes were XI MIA 2. This research applied an experimental method with a factorial design of 2 x 3. The instrument was administered to collect data to test initial mathematic ability and mathematical problem-solving abilities—data was analyzed in two ways: ANOVA and Tukey test (LSD test). The findings of the research were (1) there were differences in mathematical problem-solving abilities by applying the Problem-based Learning Model and Discovery Learning Model, (2) there was no interaction between the learning model and initial mathematical abilities on mathematical problem-solving abilities, (3) there was difference in students mathematical problem-solving abilities by applying Problem-based Learning Model and Discovery learning Model, especially to high initial mathematical abilities, middle initial mathematical abilities, as well as low initial mathematical abilities.

INTRODUCTION

Improving the quality of formal education in schools cannot be separated from the success of teaching and learning. The teaching and learning process is influenced by several interrelated components, including student teachers and learning models [1]. In order to improve the quality of education and learning in Indonesia, the government has again implemented a new curriculum, namely the Merdeka Belajar curriculum. According to the 2022 Minister of Education and Culture Regulation, the Merdeka Belajar curriculum is implemented in learning recovery because students experience learning loss. The implementation of the Merdeka curriculum requires that students have numeracy literacy because literacy ability is one of the learning outcomes in the Merdeka Belajar curriculum. One way to improve numeracy activities is by learning mathematics. Students' difficulties in learning mathematics are not new problems, one of which is shown by students' lack of ability to solve mathematical problems. Difficulty solving problems in

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mathematics is visible in the classroom [2]. Mathematical problem-solving is a complex cognitive activity, and overcoming and solving a problem requires several strategies [3]. According to Samosir [4], there are steps in the problem-solving process that are the most common in educational research, namely the Polya stages. According to the Polya stages, the indicators of mathematical problem-solving ability include four steps: understanding the problem, planning problem-solving, carrying out problem-solving, and checking again. One of the organizations operating in the world of international mathematics education, namely the National Council of Teachers of Mathematics (NCTM), also provides mathematics learning standards (teaching programs) for students under five years old up to grade 12, problem-solving, Reasoning, and Proof, Communication, Connection, Representation. One of the components measured in the TIMSS and PISA is the ability to solve problems in implementing learning in the 2013 curriculum, which must be able to develop 21st-century skill competencies with the term 4k, namely critical thinking skills, communication skills, creativity, and innovation and collaboration[5].

The facts say that students' mathematical problem-solving abilities in Indonesia are not yet optimal. This is based on a survey of student TIMSS in Indonesia in 2011, ranked 38th out of 42 participating countries. The PISA survey results also placed Indonesia in 62nd place out of 70 PISA-participating countries in 2016. The weak ability to solve students' mathematical problems can be seen from the low mathematics learning outcomes caused by the lack of interaction between teachers and students when students answer questions. Students prioritize the final results or answers obtained rather than the process of working on the questions, and students still have difficulty solving the questions in the form of a story [7]. According to Nusywari, if mathematical concepts are not taught clearly or students do not understand them well, their problem-solving abilities can be hampered. Based on the results of observations at SMAN 1 Mamosalato, the ability to solve mathematical problems at this school is still deficient. This can be seen from the results of the education quality report card at SMAN 1 Mamosalato in 2021 during the implementation of the national assessment.

The implementation of computer-based nation assessments (ANBK) shows that students' numeracy ability achievements are below the minimum competency, namely with a score of 1,52 in the range of 1 to 3 with an average district score of 1,63 an average provincial score of 1,59 and an average of 1,59 the national average scores is 1,66. This can be seen from the proportion of competent ability 0%, proficient ability 13,04%, essential ability 78,26%, and those requiring particular intervention 8,7%. The information provided by the quality report can help in designing continuous improvement strategies. This includes policy development, training of teaching staff, and changes in approaches to learning methods and models.

Learning mathematics will be more in-depth and meaningful if the learning model provided is effective and can increase students' motivation and curiosity. For example, students may be given a contextual problem or question that stimulates their thinking power. Therefore, the learning models that include these aspects are the problem-based and discovery learning models [8]. The research chose these two learning models because they are supported by the theory that underlies the problem-based learning model, namely Jean Piaget and Ausube's learning theory, and the theory that underlies the discovery learning model, namely Jerome Bruner's learning theory. According to Damanik & Syahputra [9], discovery learning is a learning

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model that guides students to discover unknown knowledge for themselves to improve their abilities at the student's discovery stage. At the same time, the problem-based learning model is a learning model that uses problems as a starting point for gaining new knowledge [10]. Internal factors influencing student learning outcomes are students' initial mathematics abilities. Students's initial mathematics abilities are a determining factor in the success of mathematics learning. According to Lestari [11], each individual has different learning abilities.

The student's initial abilities are the abilities that they already have before they take part in the learning that will be given. These initial abilities describe the student's readiness to receive the lessons that the teacher will deliver. Initial abilities in this study were categorized into high, middle, and low initial abilities. Several researchers have conducted research studies on the problem-based learning model and discovery learning model as well as initial abilities, such as Damanik [9], that there are differences in students' mathematical problem-solving abilities between students taught using the problem-based learning model and the discovery learning model. Hasibuan & Sinaga, [12] concluded that there are differences in mathematical problem-solving abilities regarding initial abilities when using the problem-based and discovery learning models. Research conducted by Safitri & Setiawan [13] concluded that the discovery learning model had a higher average than the problem-based learning model regarding initial abilities. Danial [14] concluded that there are differences in the critical thinking abilities of students with high, middle, and low initial abilities who are taught using problem-based learning and discovery learning models. Failah [15] stated that the discovery learning model provides higher average mathematics learning outcomes than the problem-based learning model.

METHODS

This quasi-experimental research was carried out at SMA Negeri 1 Mamosalto Morowali Utara. The research consists of experimental class 1, which is taught using the problem-based learning model, and experimental class 2, which is taught using the discovery learning model, each of which is divided into three categories of initial mathematical abilities, namely students who have high, middle, and low initial mathematical abilities.

The population in this study was all 11th-grade students of SMA Negeri 1 Mamosalato consisting of 4 classes totaling 122 students taken in two classes using purposive sampling technique, namely class XI MIA 1 as experimental class 1 totaling 30 students who were taught using the problem-based learning model and class XI MIA 2 as the experimental class 2 consists of 30 students who were taught using the discovery learning model. Classes XI MIA 1 and XI MIA 2 were chosen because the students are highly interested in learning in both classes. The design in this research uses a 2x3 factorial design.

Table 1. 2x3 Factor Analysis Research Design

Learning Model (A) / Initial Abilities (B)	Model Discovery (A_1)	Model PBL (A_2)
KAM high (B_1)	A_1B_1	A_1B_1
KAM Sedang (B_2)	A_1B_2	A_2B_2
KAM Low (B_3)	A_1B_3	A_2B_3

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Information :
A_1 = Discovery learning model
A_2 = Problem-based learning model
B_1 = High initial mathematical abilities
B_2 = Middle initial mathematical abilities
B_3 = Low initial mathematical abilities
A_1B_1 = mathematical problem-solving abilities, and the person with high initial mathematical abilities using the discovery learning model.
A_1B_2 = mathematical problem-solving abilities with middle initial mathematical abilities using the discovery learning model.
A_1B_3 = mathematical problem-solving abilities with low initial mathematical abilities using the discovery learning model.
A_2B_1 = mathematical problem-solving abilities with high initial mathematical abilities using the problem-based learning model.
A_2B_2 = mathematical problem-solving abilities with middle initial mathematical abilities using the problem-based learning model.
A_2B_3 = mathematical problem-solving abilities with low initial mathematical abilities using the problem-based learning model.

The technique used in collecting data in this research is using test instruments, namely an initial mathematics ability test in the form of a 25-number multiple choice and a mathematical problem-solving ability test in the form of a 5-number essay.

RESULTS AND DISCUSSION

The test uses two-way Anava statistics, requiring that the data analyzed come from a normally distributed population and that the data variance be homogeneous. The normality test for the mathematical problem-solving ability test uses the Kolmogorov Sminorv with p-value α = 0.05, as Table 2.

Table 2. Normality Test, Mathematical Problem-Solving Ability Test

Unstandardized Residual	Test of Mathematical Problem-Solving Ability
Jumlah (N)	60
Asymp. Sig. (2-tailed)	0,070

Based on Table 2 shows that the sample size is [N = 60, p=0,070], the significance value is greater than the alpha value = 0,05, and it can be concluded that the mathematical problem-solving ability test data is normally distributed.

Table 3. Homogeneity Test Mathematical Problem-Solving Ability Test

Test of Mathematical Problem-Solving Ability	Levene Statistic	df1	df2	Sig.
	1.399	5	54	0.239

The homogeneity test was carried out for post-test data in experimental class 1, taught using the problem-based learning model, and experimental class 2, taught using the discovery learning model. From the data above, it can be seen that the results of the Levene test indicated

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that the variance of mathematical problem-solving ability data is homogeneous [F =(5.54) = 1.39, p= 0.239] with a probability significance value of 0.239. So, the data above has the same variance (0.239 > 0,05), so the post-test data is homogeneous.

Table 4. Two-Way Anova Descriptive Statistics

	Discovery learning model (A_1)	Problem-based Learning Model (A_2)	Total
High initial mathematical abilities (B_1)	N = 5 Mean = 89, 60 SD = 6,768	N = 7 Mean = 80,14 SD = 7,471	N = 12 Total = 84,08 SD = 8,415
Middle initial mathematical abilities (B_2)	N= 16 Mean = 79,19 SD = 9,649	N = 12 Mean = 72,25 SD = 9,304	N = 28 Mean = 76,21 SD = 9,961
Low initial mathematical abilities (B_3)	N = 9 Mean = 72,33 SD = 12,738	N = 11 Mean 61,27 SD =7,92	N = 20 Mean = 66,25 Sd=11,5

The data processing results of the two-way ANOVA test and the Tukey test can be seen in Tables 5, 6, and 7

Table 5. Summary Two-way Anova

Dependent Variable: Value of mathematical problem-solving abilities

Source	df	Mean Square	F	Sig.
Corrected Model	5	748,401	8,432	0,000
Intercept	1	299446,197	3373,741	0,000
Learning Model	1	1091,326	12,296	0,001
Initial Mathematic Ability	2	1234,316	13,907	0,000
Learning Model * Initial Mathematic ability	2	25,167	0,284	0,754

Table 6. Tukey test and LSD test Dependent Variable: Value of mathematical problem-solving abilities Tukey HSD

(Initial Mathematic Ability)		Mean Difference (I-J)	Std. Error	Sig.
High	Middle	7.87*	3,251	0,048753
	Low	17.83*	3,440	0,000010
Middle	High	-7.87*	3,251	0,048753
	Low	9.96*	2,758	0,001896
Low	High	-17.83*	3,440	0,000010
	Middle	-9.96*	2,758	0,001896

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Table 7. LSD Test Notation

Initial Mathematic Ability	Mean	LSD test notation
High	84,871	c
Middle	75,719	b
Low	66,25	a

1. Test the first hypothesis.

The results of the ways Anova calculation with the help of spss version 25 application in table 5 in the learning model inform that the significance value is 0,001. This shows that the significance value is smaller than the alpha value $\alpha =$ 0,05. Thus, the first hypothesis states differences in students' mathematical problem-solving abilities by applying problem-based learning and discovery learning models.

2. Test the second hypothesis.

The results of the two-way ANOVA calculation with the help of the SPSS version 25 application in Table 5 in the learning model* initial mathematic ability indicate that the significance value is 0,754. This shows that the significance value is greater than the alpha value $\alpha =$ of 0,05, so the second hypothesis states that there is no interaction between the learning model and initial mathematical abilities on mathematical problem-solving abilities.

3. Test the third hypothesis.

The results of the two ways Anova calculation using the Tukey test in Table 6, namely by comparing the significance value of high initial and middle initial mathematics ability, is 0,048753. This shows that the significance value is smaller than the alpha value $\alpha =$ 0,05. So, in Table 7, the notation of the LSD test between high ability and the middle has a different notation; namely, high initial mathematic ability has the notation c, and middle initial mathematic ability has the notation b. So, the third hypothesis states differences in students' mathematical problem-solving abilities when applying the problem-based and discovery learning models in students with high initial mathematical abilities.

4. Test the fourth hypothesis.

The results of the two ways Anova calculation using the Tukey test in Table 6, namely by comparing the significance value of middle initial mathematics ability and low initial mathematics ability, is 0,001896. This shows that the significance value is smaller than the alpha value $\alpha =$ 0,05. So in Table 7, the notation of the LSD test between middle ability and low has a different notation, namely middle initial mathematic ability has the notation b, and low initial mathematic ability has the notation a. So, the fourth hypothesis states that there are differences in students mathematical problem-solving abilities by applying problem-based learning model and discovery learning Model, in a student who has middle initial mathematical abilities.

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5. Test the fifth hypothesis.

The results of the two ways Anova calculation using the Tukey test in Table 6, namely by comparing the significance value of low and high initial mathematics ability, is 0,000010. This shows that the significance value is smaller than the alpha value $\alpha = 0{,}05$. So, in Table 7, the notation of the LSD test between low ability and high has a different notation: low initial mathematic ability has the notation a, and high initial mathematic ability has the notation c. So, the fifth hypothesis states differences in students' mathematical problem-solving abilities when applying the problem-based and discovery learning models in students with low initial mathematical abilities.

Discussion

The results of the research data description show that students' mathematical problem-solving ability score in the class given the discovery learning model obtained an average of 78,86, higher than the average mathematical problem-solving ability score in the class given the problem-based learning model of 70,06.

1. There are differences in students' mathematical problem-solving abilities when applying problem-based and discovery learning models.

The discovery learning model and the problem-based learning model are learning models that lead students to seek their knowledge. Based on the results of the two-way ANOVA analysis test, it was found that discovery learning had a higher average score compared to the problem-based learning model. The conclusion was that there were differences in problem-solving abilities between students who learn with the discovery and problem-based learning models. So, learning that uses the discovery learning model is better for developing students' mathematical problem-solving abilities. The average score of students proves this taught using the discovery learning model, which is higher than the average score of students taught using the problem-based learning model. During the learning process, researchers pay attention to the discovery learning class. Students are quicker to discover concepts from sequences and arithmetic series material than students in classes that use the problem-based learning model. Students tend to take longer to think about what concepts to use to solve the given mathematical problems. So, in the learning outcomes between students who learn using the discovery learning model and the problem-based learning model, there are significant differences in learning outcomes.

This aligns with Mawadi & Mawarti [16] research, which concluded that there are differences in the mathematical problem-solving abilities of students who learn with problem-based and discovery learning models. Mathematical problem-solving abilities can be improved with the discovery and problem-based learning models.

2. There is no interaction between the learning model and initial mathematical abilities on mathematical problem-solving abilities.

Based on the results of two-way ANOVA calculations, it is reported that the significance value is 0,754. This shows that the significance value is greater than the alpha value of 0,05, so the second hypothesis states that there is no interaction between initial mathematical abilities and learning models on the mathematical problem-solving abilities. Accepted in this study,

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researchers observed that the scores of students who had high initial abilities in experimental class 1 or the class taught using the problem-based learning model these students got low scores on the post-test for mathematical problem-solving abilities as well as students who had low initial mathematical abilities in experimental class 2 or the class taught with the discovery learning model in post-test for mathematical problem-solving abilities the students got a high score the meaning that the value of mathematical problem-solving abilities taught with the two models namely problem-based learning and discovery learning models as well as the value of students' initial mathematical abilities show differences.

This shows no interaction between students' initial mathematical abilities and the learning model on students' mathematical problem-solving abilities, in line with research conducted by Riska & Amir [17], which concluded that there was no interaction between learning models and initial abilities in improving mathematical problem-solving abilities.

3. There are differences in students' mathematical problem-solving abilities when applying the Problem-based Learning Model and the Discovery Learning Model in students with high initial mathematical abilities.

Based on the analysis of the results of inferential statistical analysis, a significance value of 0,048753 < 0,05, which means there were differences in the mathematical problem-solving abilities of students who have high initial mathematical abilities between students who study with the discovery learning model and the problem-based learning model in the average value of initial abilities. High mathematics in the discovery learning model is higher, 89,60, than the average initial high mathematics ability score for students who study the problem-based learning model, which is 80,14.

The problem-based and discovery learning models can improve students' mathematical problem-solving abilities, but the mathematical problem-solving abilities taught using the discovery learning model are higher than those taught using the problem-based learning model. This is because students who learn using the discovery learning model can find concepts and ideas more quickly than those with the problem-based learning model. This research is in line with that carried out by Purba [19], which states that there is a difference in initial mathematical abilities between students who learn with problem-based learning and the discovery learning model.

4. There are differences in students' mathematical problem-solving abilities when applying the problem-based and discovery learning models in students with middle initial mathematical abilities.

Based on the results of the further test analysis (Tukey test), there is a difference in the mathematical problem-solving abilities of students who have modeling initial mathematical abilities between students who study with the discovery learning model and the problem-based learning model in experimental class 2 which is taught with the discovery learning model. The value of mathematical problem-solving abilities in students with middle initial abilities compared to experimental class 1 students who were taught using a problem-based learning model. This shows differences in mathematical problem-solving abilities in students with middle initial abilities between students taught with the discovery and problem-based learning models.

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The average mathematical problem-solving ability value for students with middle initial abilities who learn using the discovery learning model is higher than those who use the problem-based learning model. This is supported by Hasrida [18] research that mathematical problem-solving for students with middle initial abilities is students taught using the discovery learning model have different values from those taught using the problem-based learning model.

5. There are differences in students' mathematical problem-solving abilities when applying the problem-based and discovery learning models in students with low initial mathematical abilities.

Based on the results of further tests (Tukey and LSD test), it was concluded that there were differences in the mathematical problem-solving abilities of students with low initial mathematical abilities between students who studied using the discovery learning model and the problem-based learning model. This was proven by the average score of students with low initial abilities in the learning model. Discovery learning, which is 72,33, is higher than the average score of students with low initial abilities and who had difficulty using the problem-based learning model, which is 61,27.

The results of the Tukey test (LSD test), which compared the significance value of high initial mathematics ability in students who studied with the discovery learning model and the problem-based learning model, namely 0,000010 with alpha value α = 0,05, turned out that the value 0,000010 < 0,05 which shows that there is difference in students mathematical problem-solving abilities by applying Problem-based Learning Model and Discovery learning Model, in a student who has low initial mathematical abilities.

CONCLUSION

There are differences in students' mathematical problem-solving abilities by applying problem-based and discovery learning models. There was no interaction between the learning model and initial mathematical abilities on mathematical problem-solving abilities. There are differences in students' mathematical problem-solving abilities when applying the problem-based and discovery learning models, especially in students with high initial mathematical abilities. There are differences in students' mathematical problem-solving abilities when applying the Problem-based Learning Model and the Discovery Learning Model in students with middle initial mathematical abilities. There are differences in students' mathematical problem-solving abilities when applying the Problem-based Learning Model and the Discovery learning Model in students with low initial mathematical abilities.

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