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Problem-Based Learning (PBL) Approach Using Psychological Tools to Enhance Students' Mathematical Creative Thinking Abilities

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ABSTRACT

The purpose of this research is to examine whether the creative thinking abilities of students who receive the implementation of the Problem-Based Learning (PBL) approach using psychological tools are better than students who receive learning treatment with the PBL approach. Additionally, the study aims to determine the differences in students' mathematical creative thinking abilities when viewed in terms of their early mathematical abilities at Islamic Integrated Junior High School Al-Izzah for the academic year 2022/2023. The research method applied in this study is mixed-method research with a concurrent embedded design. The data obtained consist of posttest and pretest results, early mathematical ability tests, and interviews. This study employs analytical techniques such as descriptive statistics, and inferential statistics, followed by two-way ANOVA and Scheffe's post hoc test. The results show that the implementation of the Problem-Based Learning (PBL) approach using psychological tools has a positive impact on students' creative thinking abilities.
***Keywords**: problem-based learning (PBL), psychological tools, creative thinking abilities, and early mathematical abilities.*

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INTRODUCTION

In every level of education, there is always a subject called mathematics because mathematics plays a vital role in the world of education. Apart from the field of education, mathematics also plays a crucial role in every individual's life, such as counting and measuring. Therefore, when students learn mathematics, they can apply that knowledge in their personal lives and develop their abilities to think creatively, systematically, and in a structured manner. (Nurhasanah et al., 2021)

In learning mathematics, comprehensive understanding is required because its application involves theory and direct problem-solving practice. Mathematical problems are famously challenging for most students to solve. In order to solve mathematical problems and master the subject of mathematics, students are required to have a high level of knowledge, which necessitates possessing creative thinking skills. However, the reality shows that in Indonesia, students' mathematical creative thinking abilities are categorized as low.

This is in line with the results of TIMSS, which state that only 25 students in Indonesia are able to solve *high and advanced*-level problem-solving tasks that require creative thinking abilities (Laras et al., 2021). Therefore, it can be said that students' mathematical creative thinking abilities are categorized as low. Next, the research (Sugilar, 2013) which was conducted at Madrasah Tsanawiyah Negeri Cikembar, indicates that students' creative thinking abilities are also categorized as low. Another study conducted by (Widiani et al., 2016) at Madrasah Aliyah Negeri 1 Pontianak, it was found that students' creative thinking abilities were also categorized as low in terms of flexibility, fluency, elaboration, and originality. The explanations above indicate the need for an increase in students' creative thinking abilities, which is essential for students.

Johnson & Johnson (Suripah & Sthephani, 2017) Explaining that creative thinking is a routine to train thinking abilities by observing intuition, involving imagination, expanding remarkable perspectives, expressing new things, and bringing forth unconventional ideas. Subsequently, Munandar (Supardi U. S., 2012) argues that creative thinking involves exploring various possible answers based on acquired information while considering the diversity of quantity and relevance.

The ability to think creatively is a necessity in order to generate alternative concepts or solutions in addressing contextual issues that arise in everyday life. Therefore, it can be said that mathematical creative thinking abilities are students' efforts to obtain solutions from alternative ideas/concepts to solve problems related to mathematics. Of course, solving these problems can be linked to given questions, which become a basis for assessing students' learning outcomes (Faelasofi, 2017)

In the effort to enhance students' creative thinking abilities, it is necessary to consider their initial knowledge in terms of their early mathematical abilities first. These abilities are prerequisites that need to be fulfilled by all students in order to smoothly participate in the learning process, and they enable teachers to create a better learning environment.

Muchlishin (Akramunnisa & Indra Sulestry, 2016), states that early mathematical abilities are students' skills that naturally or intentionally develop through gradual learning, where they can provide positive or negative responses to it by applying creative and innovative thinking abilities that emphasize mastery of a subject.

Furthermore, as an effort to maximize students' creative thinking abilities, it is important to choose appropriate learning strategies. One of the learning approaches that can be used is a student-centered learning approach because this approach is more suitable for the current external conditions that require students to make wise choices regarding the problems they face. In student-centered learning, students are required to actively participate in learning activities, encouraging them to use their imagination in thinking about and solving problems independently.

Based on the description above, learning with the Problem-Based Learning (PBL) approach is considered appropriate for maximizing students' creative thinking abilities because PBL prioritizes a student-centered learning approach. In other words, when the learning process begins, students are required to actively seek problem-solving solutions. By doing so, students will enhance their knowledge, cultivate self-directed learning and self-confidence, as well as sharpen their creative thinking skills in resolving issues.

The learning strategy employed in this research is the utilization of *psychological tools*. *Psychological tools* are psychological aids that assist students in understanding the learning process. These tools can originate from an individual's social and cultural environment and can take the form of language, symbols, and signs.

Psychological tools also serve as a form of *scaffolding*, as they are tools that can assist students in completing tasks or comprehending ideas that they initially could not understand on their own. In other words, the role of the teacher is primarily limited to providing assistance in the form of specific techniques or skills for tasks that are beyond the students' capabilities. The teacher will initiate the *fading* process or gradually remove the assistance and support once the students are capable of completing the tasks accurately. (Sutiarso, 2009). *The psychological tool* used in this study is Geogebra.

Based on explanations above, the author is interested in conducting research to the following objectives: (1) to determine whether the students' creative thinking abilities who receive learning treatment with the *Problem-Based Learning* (PBL) approach using *psychological tools* are better compared to students who receive learning treatment with the *Problem-Based Learning approach.* (2) Whether students' creative thinking abilities who receive learning treatment with the *Problem-Based Learning* (PBL) approach using *psychological tools* are better than students who receive learning treatment with the *Problem-Based Learning* approach when viewed from the perspective of early mathematical abilities.

RESEARCH METHODOLOGY

This research adopts a mixed-method or combination method using the *concurrent embedded design* research design, which combines two research methods, namely quantitative and qualitative, with an imbalanced distribution (Sugiyono, 2012). The data on the improvement and achievement of students' creative thinking abilities obtained in this study are quantitative data that will be elaborated in detail, supported by qualitative data.

This study uses a non-equivalent control group design, where both groups cannot be randomly selected (Sridayani, 2018). In the control group, students will receive learning treatment with the *Problem-Based Learning* (PBL) approach, while in the experimental group, students will receive learning treatment with the PBL approach using *psychological tools.*

This study utilizes data collection techniques in the form of posttest and pretest for assessing creative thinking abilities, early mathematical abilities test, and interviews. The interviews in this research aim to explore students' thoughts and thought processes while solving mathematical creative thinking ability tests, as well as to seek confirmation from students on specific matters needed by the researcher.

The data analysis in this study includes descriptive statistics and inferential statistics, as well as hypothesis testing, using two-way ANOVA to determine whether there is a significant difference in students' creative thinking abilities between the experimental and control groups. Further analysis will be conducted using the Scheffe's post hoc test to identify differences in creative thinking abilities among students with low, high, and moderate early mathematical abilities.

The population in this study consists of 7th-grade students at Islamic Integrated Junior High School Al-Izzah in Serang City for the academic year 2022/2023. The sample for this study will be selected through purposive sampling, including the experimental group and the control group.

RESULTS AND DISCUSSION

This study began with administering a *pretest* to both classes. The purpose was to assess the initial mathematical creative thinking abilities of the students. After the completion of the learning process, a *posttest* was administered to both classes to evaluate their final creative thinking abilities. Additionally, interviews were conducted as supplementary qualitative data for quantitative statistical analysis. The descriptive statistical results of the *posttest* and *pretest* are as follows:

Table 1. Descriptive Statistics of Creative Thinking Abilities

	Control		**Eksperiment**	
	Pretest	*Posttest*	*Pretest*	*Posttest*
N	25	25	20	20
X min	31,25	56,25	25	68,75
X max	62,50	93,75	62,50	100
Mean	45,27	73,25	42,19	84,06
Std. Deviation	9,59	11,90	10,71	11,56

The table above indicates that the mean score of the *pretest* in the control group slightly exceeds the *pretest* score in the experimental group, with a difference of 2.8. The lowest score in the experimental group is 25, while the lowest score in the control group is 31.25. Meanwhile, the highest score is the same in both the control and experimental groups, which is 62.50. Furthermore, the standard deviations in both groups are not significantly different, indicating a similar distribution of *pretest* scores in control and experimental groups. Moving on, the mean score of the posttest in the experimental group slightly exceeds the score of the posttest in the control group, with a difference of 10.81. In the control group, the standard deviation is higher than in the experimental group. This indicates that the control group has a higher dispersion of data in the *posttest* compared to the experimental group.

Alongside the administration of the *pretest*, an early mathematical ability test was conducted to assess students' understanding of prerequisite material as their baseline comprehension. The results of the early mathematical ability test are shown in the table below:

Table 2. The Results of Early Mathematical Abilities (KAM) Test

Category/Class	Experiment	Control	Total
High	7	7	14
Medium	10	9	19
Low	3	9	11

Based on Table 2, it can be observed that in the high KAM level, there are 7 students in the experimental group and 7 students in the control group who have a high level of early mathematical ability. In the medium KAM level, there are 10 students in the experimental group and 9 students in the control group. In the low KAM level, there are 3 students in the experimental group and 9 students in the control group. Next, the mathematical creative thinking abilities of students are presented when viewed in terms of their early mathematical abilities in the table below:

Table 3. Creative Thinking Abilities based on Early mathematical abilities (KAM)

Class	KAM	*Mean*	*Std. Deviation*	N
Eksperiment	High	96.43	3.34	7
	Medium	80.00	4.93	10
	Low	68.75	.000	3
	Total	84.06	10.82	20
Control	High	87.50	5.10	7
	Medium	75.00	5.41	9
	Low	60.42	3.13	9
	Total	73.25	11.90	25

Based on Table 3, several conclusions can be drawn. For students categorized as high, mean test scores in the experimental group are higher than those in the control group, as indicated by the mean score of 96.43 > 87.50 Furthermore, for students in the medium category, the experimental group has a higher mean test score than the control group, with an average score of 80.00 > 75.00. Similarly, for students in the low category, the experimental group has a higher mean test score for mathematical creative thinking abilities compared to the control group, with an average score of 68.75 > 60.42.

After conducting descriptive analysis, the *posttest* and *pretest* data will be subjected to inferential analysis, including tests for normality and homogeneity.

Normality Test

Table 4. The Results of Normality Test

Condition	Class	Shapiro-Wilk Sig.
Pretest	Eksperiment	0,366
	Control	0,053
Posttest	Eksperiment	0,067
	Control	0,066

According to Table 4, the significance values for the *pretest* are 0.366 and 0.053, which are greater than 0.05. This indicates that the distribution of creative thinking ability pretest scores is normal in both research groups. Furthermore, the significance values obtained for the *posttest* are 0.067 and 0.066, which also exceed 0.05. This means that the data is normally distributed in both research groups for the posttest of mathematical creative thinking abilities.

Homogeneity Test

To determine the variances of the two sample data groups obtained from the population, a homogeneity test will be conducted. The results of the homogeneity test are shown in the table below:

Table 5. Homogeneity Test Results

Condition	Class	Sig.
Pretest	Based on Mean	.919
	Based on Median	.923
Posttest	Based on Mean	0,544
	Based on Median	0,519

Based on the table above, it can be observed that the homogeneity test for the *pretest* data yields significance values, of 0.919 and 0.923, indicating that the variances between the data groups are homogeneous. Similarly, for the *posttest* data, the significance values are 0.544 and 0.519, indicating homogeneity of variances between the data groups.

Two-Way ANOVA

The two-way ANOVA was conducted to examine the creative thinking abilities of students in both classes. The results of the two-way ANOVA are presented in Table 6 below:

Table 6. The Results of Two-Way ANOVA

	Df	Mean Square	F	Sig.
Class	1	526.515	27.217	.000
early mathematical abilities	2	2126.619	109.93	.000

Based on Table 6, it can be observed that the experimental group has a significance value of 0.00. This indicates that 0.00 < 0.05, leading to the conclusion that students in the experimental group have better creative thinking abilities compared to the control group.

In the category of early mathematical abilities, the significance value obtained is 0.00. This indicates that 0.00 < 0.05, leading to the conclusion that, when viewed from the perspective of early mathematical abilities, the creative thinking abilities of students in the experimental group are better than those in the control group.

Scheffe's Post Hoc Test

To further examine the differences in creative thinking abilities among the low, medium, and high categories of early mathematical abilities, the Scheffe's post hoc test was conducted. The results of the Scheffe's post hoc test are presented in the following table:

Tabel 7. Scheffe's Test Results

(I) early mathematical abilities	(J) early mathematical abilities	Mean Difference (I-J)	Sig.
High	Medium	14.3327*	.000
	Low	29.4643*	.000
Medium	High	-14.3327*	.000
	Low	15.1316*	.000
Low	High	-29.4643*	.000
	Medium	-15.1316*	.000

In Table 7 above, if there is an asterisk (*) in the *Mean Difference* column, it indicates a significant difference. If there is no asterisk, it means there is no significant difference. Since there is an asterisk (*) in the table above, we can conclude that a significant difference has been found in the creative mathematical thinking abilities of students with high, medium, and low early mathematical abilities.

Creative Thinking Ability

Based on the explanation above, it can be concluded that students' creative thinking ability, who received treatment with the PBL approach aided by *psychological tools,* is better compared to students who learned using the PBL approach alone.

This is because learning with the PBL approach using *psychological tools* transforms a problem into a learning objective with the aid of meticulously designed *psychological tools.* This enables the intended meaning to be effectively conveyed in problem-solving. In seeking problem-solving solutions, educators motivate students to find relevant and necessary information. Then, during the problem-solving activities, the teacher organizes the students to be ready to learn, and the teacher gives the students guidance to solve the problems individually and in groups, using psychological tools. As a result, students gain comprehensive learning experiences in problem-solving. The educator guides the students in presenting or developing their problem-solving results, and also directs the students to analyze and evaluate the outcomes of their problem-solving efforts. As a result, the learning process does not begin with explaining the definitions, characteristics, or guidelines accompanied by examples, but rather starts by orienting students towards the problem.

Creative Thinking Ability as Assessed by Early Mathematical Ability

Furthermore, when observed based on the early mathematical ability, it indicates that the mathematical creative thinking ability of students who received learning treatment with the *problem-based learning* approach using psychological tools is better than students who received learning treatment with the *problem-based learning* approach alone. This is in line with the opinion (Sadova, 2019) this is in line with the statement that initial ability is one of the variables that influences students' level of creative thinking because there is a correlation between one concept of the subject matter and another. Thus, basic skills, which are the students' initial abilities, play a crucial role during the learning process, and the level of initial ability also impacts the students' speed in mastering the subject matter.

The mathematical creative thinking ability of students is best categorized in the high early mathematical abilities (KAM) group. This can be observed from the highest average total scores in the KAM category, which are 14,3327 and 29,4643. Furthermore, supported by interviews, it is stated that in students with high early mathematical ability, when they are given problems that involve the indicator of flexibility, they are able to explain their problem-solving steps and identify multiple ways to solve the problem. In the fluency indicator questions, students in the high early mathematical ability category are able to solve the problems without difficulty. Furthermore, they can also explain the problem-solving process they have undertaken. In questions that involve the elaboration indicator, students in the high early mathematical ability category are capable of providing detailed explanations of the problem-solving process they have undertaken. They can also explain how they write their answers in a detailed manner. In questions with the originality indicator, they explain that the approach they used is a strategy they discovered on their own.

On the other hand, the students' mathematical creative thinking ability is less satisfactory in the low early mathematical abilities (KAM) category, with scores of -29,4643 and -15,1316. Results from interviews show that they can describe the measures they have taken in response to queries regarding the flexibility indicator, proving this. However, in questions with the fluency indicator, they express difficulty in solving the problems, resulting in inconsistencies between the diagrams and formulas in their answers. In questions that involve the elaboration indicator, students in the low initial mathematical ability category are also unable to provide detailed explanations regarding the answer to the problem. In questions with the originality indicator, they attempt to solve the problem in their own way, but are unable to complete it. Therefore, significant differences are found in the mathematical creative thinking abilities among students with low, medium, and high early mathematical abilities.

CLOSING

Based on the presented research results, it can be concluded that students' creative thinking abilities in the class that implemented learning with the problem-based learning (PBL) approach using psychological tools are better than students who received learning using the PBL approach alone. In addition, when viewed from the perspective of early mathematical abilities, there are significant differences in students' creative thinking abilities. This means that the class that implemented learning with the PBL approach aided by psychological tools has a better creative thinking ability among students compared to the class that applied the PBL approach alone, considering their early mathematical abilities.

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