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Using Project-Based Learning to Foster Mathematics Creative Thinking and Problem-Solving Skills of Elementary School Students

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Abstract: Using Project-Based Learning to Foster Mathematics Creative Thinking and Problem-Solving Skills of Elementary School Students. **Objectives:** This research aims to describe creative thinking skills and mathematical problem-solving abilities by implementing the Project-Based Learning model. **Methods:** This research used a quasi-experimental approach with a posttest-only control group design. The research was conducted at the Mano I of Catholic Elementary School during the odd semester of the 2023/2024 academic year. The research sample involved 53 fifth-grade students selected using random sampling techniques. The data collection instrument employs a descriptive test consisting of five questions each to assess creative thinking skills and problem-solving abilities. These instruments have undergone testing and have demonstrated reliability coefficients of 0.84 and 0.81, within the high category. The data collection method used in this research uses a test technique on fraction material, which consists of 10 questions with details of 5 creative thinking skills test items and 5 problem-solving ability test items. The instruments in this research are test questions, divided into creative thinking skills tests and problem-solving ability tests, each of which uses high-level thinking indicators, classified into C4 and C5 questions. The rubric for assessing creative thinking skills and problem-solving abilities is used in this research as a basis for consideration when assigning grades. The data analysis employed the Multivariate Analysis of Variance (MANOVA) test technique using the Statistical Package for Social Sciences (SPSS) version 23.0 program for Windows. Before this, several assumption tests were conducted, including tests for normality of data distribution, homogeneity of variances, and multicollinearity. **Findings:** Simultaneously, students taught utilizing project-based learning demonstrate higher creative thinking and problem-solving skills than those taught using conventional methods. The PjBL model significantly impacts elementary school students' creative thinking and mathematics problem-solving skills. **Conclusion:** The PjBL approach is an acceptable choice for educators to foster creativity.

Keywords: creative thinking skills, problem solving mathematics, project-based learning.

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INTRODUCTION

In realizing the quality of Indonesian national education that can answer global challenges, conscious efforts are needed in the form of implementing learning that leads to the formation of students' thinking skills, including in mathematics learning. That to achieve the quality of learning, a creative and innovative process is needed by choosing a learning model and/or approach that can guide students in solving problems based on higher order thinking skills (HOTS). In order for students' HOTS to develop

well, students need to be accustomed to activities that train HOTS (Adijaya, Widiana, Agung, & Suwela, 2023; Yusoff & Seman, 2018; Zetriuslita, Ariawan, Suripah, & Riyan Hidayat, 2023). In this case, students can not only remember and understand a concept, but students can analyze and synthesize, evaluate, and create a concept well, the concept that has been understood can stick in their memory for a long time. Learning for elementary school students is a concrete operational learning stage, students interact with real objects or events that can develop their competencies, so that they are able to understand mathematical concepts through learning by doing which can lead to the process of forming high-level thinking skills (Al-Farisi, Yulianti, Husda, Hidayah, & Hidayat, 2023; Kouicem, 2020; Lefa, 2014). Facilitated learning must be oriented towards HOTS in this case leading to the formation of creative thinking skills and problem-solving abilities (Munar, Winarti, Nai'mah, Rezieka, & Aulia, 2022). HOTS is a thinking ability that must be possessed by every student in solving mathematical problems. Many activities can be done with HOTS, namely (1) determining something; (2) doing something to solve; (3) loading something new; (4) making predictions; (5) solving non-routine problems (Mairing, 2020; Septian et al., 2022). In doing HOTS, students must use complete, non-algorithmic thinking in solving problems, using different problem-solving strategies. The HOTS concept comes from Bloom's Taxonomy, the cognitive domain is in a higher order, namely analyzing, evaluating, creating, and requiring mastery of the previous level (Morteza & Moghaddam, 2017; Yusoff & Seman, 2018). Field facts based on the results of sharing with teacher partners in field internship activities show that mathematics learning in the classroom encounters quite a lot of obstacles, including teachers who do not train or provide space for students to solve problems where students are more directed to solve routine problems while solving non-routine problems is less noticed. This is in line with Arends' opinion that in teaching teachers always demand students to learn and rarely provide lessons on how students learn, teachers also demand students to solve problems, but rarely teach students how to solve problems (Arends, 2012; Mairing, 2020; Widodo, Istiqomah, Leonard, Nayazik, & Prahmana, 2019). In addition, mathematics learning in the classroom remains a problem that is often discussed in the world of education as a basis for evaluating students' failure to achieve maximum learning achievement. Learning that only focuses on the ability to calculate does not support the formation of problem-solving skills (Maskur et al., 2020; Septian et al., 2022).

In terms of achievement, Indonesian students are still ranked low in the world. This issue is relevant to the results of a study conducted by the Organisation for Economic Cooperation and Development (OECD) using broader global standards with the Program for International Student Assessment (PISA) test since joining this organization has not shown significant improvement, on the contrary, it has stagnated, where in the last 10-15 years the results of the PISA study showed a tendency to decline in performance in terms of Literacy skills ranked 72 out of 77 countries, Mathematics ranked 72 out of 78 countries, and Science ranked 70 out of 78 countries, this makes Indonesia ranked 74 (Schleicher, 2019). The results of the PISA 2022 study show that almost no Indonesian students have the best achievements in mathematics for levels 5 and 6 (OECD average 9%), they are only at level 2 only 18% (OECD average 69%). The international mathematics literacy score in PISA 2022 fell by an average of 21 points. Indonesia's score dropped 13 points, better than the international average where 82% of PISA 2022 participating countries experienced a decline in mathematical literacy scores compared to PISA 2018 (OECD, 2023).

Creativity is a powerful weapon in dealing with various types of problems because it opens students' insights to seek fundamental understanding (Runisah, Herman, & Dahlan, 2017). Creativity can also improve students' cognitive aspects and their awareness to assess and evaluate information critically (Changwong, Sukkamart, & Sisan, 2018) which is then considered a High Order Thinking (HOT) skill, which consists of four components such as fluency, flexibility, and originality (Astutik, Mahardika, Indrawati, Sudarti, & Supeno, 2020; Sriwongchai, 2015; Takko et al., 2020). In general, fluency refers to the ease of producing several concepts in the creative process; flexibility is related to the ability to abandon old ways of thinking and accept new concepts or new paths, and originality involves the ability to generate unpredictable, unusual, or unique ideas, and elaboration is the ability to enrich and develop an idea or product, and add or detail the details of an object, idea or situation so that it becomes more interesting. The student behavior described is looking for deeper meaning to the answer or problem solving with detailed steps (Handayani, Hajidin, Duskri, & Maidiyah, 2018). Creative students are effective problem solvers. It is true that mathematics classrooms aim to develop various skills so that students can complete their applications in everyday life (K1z1ltoprak & Köse, 2017). Therefore, as creativity increases, student achievement in mathematics will increase. Cognitive abilities are usually evaluated according to the revised version of Bloom's taxonomy, namely students' ability to remember, understand, apply, analyze, evaluate, and create certain knowledge (Morteza & Moghaddam, 2017). Assessment of student learning outcomes in problem-solving skills provides insight for teachers to make various decisions for future learning series (Zetriuslita et al., 2023).

One of the learning models that can increase students' creativity in solving mathematical problems is the project-based learning (PjBL) learning model. The characteristics of the PjBL model include students being faced with concrete problems, finding solutions, and working on projects in teams to solve problems (Guo, Saab, Post, & Admiraal, 2020; Nasution, Ambiyar, & Lubis, 2022). In the PjBL model, students not only understand the content but also develop skills in students on how to play a role in society. The skills developed in PjBL include communication and presentation skills, organizational and time management skills, research and investigation skills, self-assessment and reflection skills, group participation and leadership, and critical thinking.

The implementation of the PjBL model is important, especially in mathematics learning in elementary schools, considering that so far the formation of creative thinking skills and problem-solving abilities has not been a priority. With PjBL, it can provide opportunities for teachers to manage learning in the classroom by involving project work that contains complex tasks based on very challenging questions and problems and guides students to design, solve problems, make decisions, carry out investigative activities, and provide opportunities for students to work independently (Nuraini, Asri, Fajri, Sarwati, & Ariandani, 2022). This is supported by (Zubaidah, Fuad, Mahanal, & Suarsini, 2017) that one of the factors that helps in the formation of students' creative thinking skills and mathematical problem-solving abilities is the learning model used by the teacher. Research shows how useful guidance from teachers is, for example by using scaffolding, supporting student exploration in a student-centered learning atmosphere (Gita & Apsari, 2018). On this basis, it is very urgent to conduct research that aims to describe the improvement of creative thinking skills and mathematical problem-solving abilities by implementing the Project Based Learning (PjBL) learning model.

METHOD

This study is a quantitative study with a quasi-experimental type to investigate the effect of implementing the PjBL learning model in improving creative thinking skills and mathematical problem-solving abilities in elementary school students. The research design chosen was a quasi-experiment with posttest-only control group design (Creswell & Creswell, 2018) involving two different groups, namely the experimental group and the control group with different treatments. The experimental group applied the PjBL learning model while the control group used the conventional learning model. The population of this study consisted of students of Mano I Catholic Elementary School. The sample consisted of 53 people using random sampling techniques divided into two groups, 27 students in the experimental group and 26 others in the control group with treatments given in 8 face-to-face meetings. The data collection method used in this study used a test technique on fraction material consisting of 10 questions with details of 5 creative thinking skills test questions and 5 problem-solving ability test questions. The instruments in this study were test questions categorized into creative thinking skills tests and problem-solving ability tests, each of which used high-level thinking indicators classified into C4 and C5 questions. The assessment rubric for creative thinking skills and problem-solving abilities was used in this study as the basis for consideration in giving scores. The instruments used in this study have been validated and their reliability has been empirically verified. The reliability coefficient of creative thinking skills of 0.84 and the reliability coefficient of learning outcomes of 0.81 are included in the high category, tested using the Cronbach Alpha formula. Data analysis used several stages, namely starting with descriptive analysis which was then followed by prerequisite analysis, namely the normality test of data distribution, the homogeneity test of data group variance, and the multicollinearity test which aims to ensure that the data meets the required assumptions. Then a statistical differential analysis was carried out with the Multivariate Analysis of Variance (MANOVA) test technique using the Statistical Package for Social Sciences (SPSS) for window version 23.0 program.

RESULT AND DISCUSSION

The hypothesis tested in this study is that the creative thinking skills and mathematical problem solving abilities of students who receive the PjBL model are higher than students who receive learning through conventional learning models. After being given treatment for eight meetings, both experimental and control groups were given a posttest for creative thinking skills and mathematical problem solving abilities. The results of the descriptive statistical analysis of the results of the creative thinking posttest and students' mathematics learning outcomes can be presented in Table 1.

Table 1. Descriptive analysis

Variable	Group	N	Mean	Median	Std. Deviation	Variansi
Creative Thinking Skill	Experiment	27	70.14	72	10.87	105.19
	Control	26	59.82	64	9.98	84.16
Mathematics Prolem Solving	Experiment	27	67.94	69	8.79	117.78
	Control	26	57.29	60	7.42	78.93

Based on the data in Table 1, it can be concluded that the average creative thinking ability and the average mathematical problem solving ability of students who receive learning with the PjBL model are higher than students who receive mathematics learning through learning models with conventional teaching models. In line with his research (Çelik, Erta_, & 0lhan, 2018; Cruz, Lencastre, & Viseu, 2023) shows that the application of PjBL in online learning can answer the needs of participants, generate interest and motivation in teaching mathematical structure concepts.

Furthermore, the post-test data of the two groups above were tested for assumptions in this case the normality test of data distribution, the homogeneity test of variance of data groups, and the multicollinear test. The results of the assumption test with the help of the SPSS 23.0 program. Based on the Kolmogorov-Smirnov statistical test, the post-test data for the experimental class and the control class have a sig. Kolmogorov Smirnov value, namely Á> 0.05, which indicates that the data for the two groups are normally distributed. Furthermore, based on the data homogeneity test using the Box's M test with a sig. value of 0.078 > 0.05, it shows that the data of the two groups have homogeneous variance. Then a multicollinear test was carried out to see the relationship between the creative thinking ability variable and students' mathematical problem-solving ability, both of which are dependent variables, and to ensure that both can be used as different criteria so that there is no overlap. Multicollinearity testing was carried out based on the Variance Inflation Factor (VIF) value and tolerance value. The results of the multicollinearity analysis can be seen in Table 2.

Table 2. Multicollinearity analysis

Coefficients							
Model	**Coefficient Non- standard**		**Coefficient Standard**	**T**	**Sig.**		**Collinearity Statistics**
	B	**Std error**	**Beta**			**Tollerance**	**VIF**
Constant	35.334	3.949		8.948	0.000		
Creative Thinking Skills	.220	.073	.269	3.012	0.000	.636	1.573
Problem-Solving Skills	.293	.051	.513	5.739	0.000	.636	1.573

Based on the Multicollinearity test results data in Table 4 above, the VIF value is 1.573 <10 and the tolerance value is more than 0.1. Thus, it can be said that the variables of creative thinking ability and mathematical problem solving ability do not experience multicollinearity so that they can be used as different criterion variables. In line with the results of the analysis of this study, (Shrestha, 2020) said that multicollinearity occurs when multiple linear regression analysis includes several variables that are significantly correlated not only with the dependent variable but also with each other. Multicollinearity causes several significant variables studied to be statistically insignificant. Likewise (Daoud, 2018), Multicollinearity is a phenomenon when two or more predictors are correlated, if this happens, the standard error of the coefficient will increase.

An increase in the standard error means that the coefficients for some or all independent variables may differ significantly. As in this study, the creative thinking skills variable and the problem solving ability variable differ significantly because the two predictors are not correlated so that there are no symptoms of multicollinearity. Since the results did not show multicollinearity, the procedure was continued with hypothesis testing using Multivariate Analysis of Variance (MANOVA). Hypothesis testing was carried out using inferential analysis assisted by the SPSS application program version 23.0. A summary of the results of the MANOVA analysis of the data on students' creative thinking skills and mathematical problem-solving skills can be seen in Table 3.

Table 3. MANOVA analysis

Multivaria	**te Tests[b]**					
Effect		**Value**	**F**	**Inter Group df**	**Within Group df**	**Sig.**
Intercept	Pillai's Trace	.991	5682.327[a]	2.000	50.000	< 0.001
	Wilks' Lambda	.009	5682.327[a]	2.000	50.000	< 0.001
	Hotelling's Trace	115.966	5682.327[a]	2.000	50.000	< 0.001
	Roy's Largest Root	115.966	5682.327[a]	2.000	50.000	< 0.001
Learning	Pillai's Trace	.260	17.195[a]	2.000	50.000	< 0.001
Model	Wilks' Lambda	.740	17.195[a]	2.000	50.000	< 0.001
	Hotelling's Trace	.351	17.195[a]	2.000	50.000	< 0.001
	Roy's Largest Root	.351	17.195[a]	2.000	50.000	< 0.001

a Exact Statistic

b Design: Intercept + Learning Model

Based on the data in Table 5 above, it is obtained that the Wilks' Lambda F value = 17, 195, and sig. <0.001, with a sig value <0.05, it can be said that simultaneously the creative thinking ability and mathematical problem solving ability of students who receive learning with the Project Based Learning model are higher than students who receive mathematics learning through conventional learning models. The PjBL learning model also has a strong and important impact on students' creative thinking skills and mathematical problem solving abilities. The difference in creative thinking skills and problem solving abilities in the experimental group and the control group cannot be separated from the implementation of the PjBL model syntax in the learning process, especially in mathematics in elementary schools. By paying attention to the results of the data analysis, this study indicates that PjBL is effective in improving students' high-level thinking skills both in creative thinking skills and related to problem solving abilities. The findings of this study are in line with his research (Guo et al., 2020) showing that project-based learning (PjBL) is understood as a promising approach that improves student learning both in affective aspects related to perceptions of benefits and learning experiences and cognitive aspects. Likewise, research conducted by (Brassler & Dettmers, 2017; Nasution et al., 2022) shows that through the implementation of PjBL and problem-based learning (PBL) it can improve interdisciplinary skills, reflective behavior and students' disciplinary attitudes. In its

implementation in the experimental class, PjBL in this study uses syntax and worksheets that lead to the formation of students' thinking skills and mathematical problem-solving abilities. This is supported by his research (Çelik et al., 2018) which states that project-based learning has a positive impact on academic achievement. Furthermore, students expressed that through the implementation of project-based learning and its adequate methods in the learning process, they could increase their interest in the subject and connect its content with everyday life experiences. Likewise, (Rajan, Gopanna, & Thomas, 2019) stated that project-based learning is effective in increasing students' motivation and critical thinking skills.

■ CONCLUSION

The Project-Based Learning (PjBL) learning model is one of the learning models with creative techniques that can guide students to be able to solve unusual problems by involving realistic problems using projects that support creativity and products that can be produced by students. The results of the study showed that the creative thinking skills and mathematical problem-solving abilities of students who used the PjBL learning model were higher than students who learned mathematics through conventional learning models, both separately and simultaneously. Thus, it can be said that project-based learning can be used by elementary school teachers in mathematics learning to form Higher Order Thinking Skills (HOTS) abilities in grade V students, especially in fraction material. Therefore, to prove its effectiveness on other subject matter or other subjects can be done by further researchers. Based on the research findings, it shows that the PjBL model is one of the important factors in improving the creative thinking skills and mathematical problem-solving abilities of elementary school students. Thus, the theoretical implications of this study are that students have high motivation, self-confidence, communication skills and concern in participating in mathematics learning so that an interactive, enjoyable, meaningful learning process occurs and has a harmonious relationship between students and teachers and between students and other students. While as a teacher has the awareness to innovate in the knowledge of the content of the material and use a variety of models and learning approaches to train students to have creative thinking skills and good problem solving abilities so as to form students who become good problem solvers. The practical implication of this study is used as input for teachers and prospective teachers to evaluate themselves in relation to the use of learning models that have been carried out and the learning outcomes that have been achieved by paying attention to the variation in the use of learning methods that can train students' creative thinking skills and improve problem solving abilities. This study still has limitations, namely examining only three components of creative thinking, namely fluency, flexibility, and originality while the elaboration component has not been developed and only applies to the achievement of fractional problem solving competency so that it can be a concern for further researchers, especially in the context of elementary schools.

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