Jurnal Pendidikan Indonesia
Volume 13, Number 4, 2024 pp. 810-817
P-ISSN: 2303-288X E-ISSN: 2541-7207
Open Access: https://doi.org/10.23887/jpiundiksha.v13i4.79435

Higher Order Thinking Skills in Mathematics with Project Based Learning

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ARTICLE INFO

Article history:
Received May 31, 2024
Accepted November 13, 2024
Available online December 25, 2024

Kata Kunci:
keterampilan Berpikir Tingkat Tinggi, Mathematics, Model Pembelajaran Berbasis Proyek

Keywords:
Higher Order Thinking Skills, Mathematics, Project Based Learning Models

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ABSTRAK

Penelitian ini dilakukan untuk mengatasi permasalahan guru dalam mengintegrasikan kegiatan pembelajaran yang berorientasi pada berpikir tingkat tinggi yang sampai saat ini belum menjadi prioritas. Penelitian ini bertujuan menganalisis keterampilan berpikir kreatif dan kemampuan pemecahan masalah matematika melalui penerapan model pembelajaran berbasis proyek. Dalam penelitian ini menggunakan pendekatan kuantitatif dengan metode quasi-experiment with posttest-only group design*. Adapun sampel berjumlah 53 peserta didik kelas V Sekolah Dasar yang terdiri atas dua kelas dengan rincian kelas eksperimen berjumlah 27 orang dan kelas kontrol berjumlah 26 orang dengan menggunakan teknik* random sampling*. Teknik pengumpulan data menggunakan teknik tes. Tes yang digunakan menggunakan jenis tes uraian baik untuk mengukur keterampilan berpikir kreatif maupun untuk data tentang kemampuan pemecahan masalah. Berdasarkan hasil uji realibilitas tes semua butir berada pada kategori tinggi. Teknik analisis data menggunakan MANOVA dengan bantuan SPSS 23.00. Temuan penelitian menunjukkan bahwa baik secara terpisah maupun secara simultan kemampuan berpikir kreatif dan kemampuan pemecahan masalah siswa yang memperoleh pembelajaran dengan model pembelajaran berbasis proyek lebih tinggi dibandingkan dengan siswa memperoleh pembelelajaran dengan model konvensional. Implikasi penelitian ini menunjukkan bahwa pembelajaran berbasis proyek* (PBL) *mampu meningkatkan kemampuan siswa dalam berpikir kritis, kreatif, analitis, serta pemecahan masalah yang kompleks.*

ABSTRACT

This research was conducted to overcome teachers' problems in integrating learning activities oriented towards higher level thinking which until now has not been a priority. This research aims to analyze creative thinking skills and mathematical problem solving abilities through the application of a project-based learning model. This research uses a quantitative approach with a quasi-experiment method with posttest-only group design. The sample consisted of 53 grade V elementary school students consisting of two classes with details of the experimental class totaling 27 people and the control class totaling 26 people using random sampling techniques. Data collection techniques use test techniques. The tests used are descriptive tests both to measure creative thinking skills and for data about problem solving abilities. Based on the reliability test results, all items are in the high category. The data analysis technique uses MANOVA with the help of SPSS 23.00. Research findings show that both separately and simultaneously the creative thinking abilities and problem solving abilities of students who receive learning using the project-based learning model are higher than students who receive learning using the conventional model. Implications of this research shows that project-based learning (PBL) can improve students' abilities in critical, creative, analytical thinking and complex problem solving.

1. INTRODUCTION

The current portrait of Indonesia's mathematics achievements still does not show significant improvement. Likewise in terms of forming higher order thinking skills. In terms of achievement, Indonesian students still rank low in the world (Astutik et al., 2019; Wardani et al., 2022). This is relevant to the results of previous research using broader global standards with the Program for International Student Assessment (PISA) test since joining this organization has not shown significant improvements, on the contrary. ,it's stagnant. Where in the last 10-15 years the results of the PISA study show that

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performance has tended to decline in terms of Literacy ability which is ranked 72nd out of 77 countries, Mathematics is ranked 72nd out of 78 countries, and Science is ranked 70th out of 78 countries. 78 countries, this makes Indonesia ranked 74th (Anggraini & Wulandari, 2020; Sumarni & Kadarwati, 2019). In the 2018 PISA report, it was recorded that 28% of Indonesian students were only able to reach level 2 and above compared to the OECD average of 76%. In terms of educational attainment, Indonesia is far behind other ASEAN countries, such as Singapore which has a reporting rate of 93%, and Malaysia which has a reporting rate of 59%. For levels 5 and 6, only 1% of Indonesian students are able to reach the OECD average of 11% (Al-Farisi et al., 2020; Septian et al., 2017).. This shows that Indonesian students are weak in understanding basic mathematical concepts and solving routine problems and will not be able to do so when faced with non-routine problems.

Likewise, the results of the PISA 2022 study show that almost no Indonesian students have the best mathematics achievements at levels 5 and 6 (OECD average 9%), only 18% are at level 2 (OECD average 69%) . International mathematics literacy scores in PISA 2022 fell by an average of 21 points. Indonesia's score fell 13 points, better than the international average, where as many as 82% of countries participating in PISA 2022 experienced a decline in their mathematics literacy scores compared to PISA 2018 (Gita & Apsari, 2020; O.E.C.D., 2022). In order for students' HOTS to develop, students need to be accustomed to activities that train HOTS (Adijaya et al., 2020; Arviani et al., 2019). In this case, students can not only remember and understand a concept, but students can analyze and synthesize, initiate and create a concept, concepts that have been understood can be recorded in their long-term memory (Fatwa et al., 2018; Guo et al., 2021).

Learning for elementary school students is a concrete operational learning phase, where the student's learning process must interact with real objects or real problems in everyday life (Astuti et al., 2017; Utami et al., 2018). So, especially in mathematics learning in elementary schools, learning must emphasize direct learning to develop competence, so that they are able to understand mathematical concepts through learning by doing. In learning, teachers are required to use visual media that can make students understand the material (Septian et al., 2020; Vonny et al., 2017). Facilitated learning must be HOTS oriented for creative thinking abilities and problem solving abilities (Rohaendi & Laelasari, 2020; Widiastuti et al., 2019). HOTS is a thinking ability that every student must have in solving mathematical problems. There are many activities that can be done with HOTS, namely determining something; do something about it; load a new object; make predictions; resolve non-routine problems. The HOTS concept comes from Bloom's Taxonomy, the cognitive domain is at a higher order, namely analyzing, evaluating, creating, and requiring mastery at the previous level (Utomo, 2016; Zetriuslita et al., 2018).

The facts show that mathematics learning in class experiences quite a lot of obstacles, including teachers not giving students the opportunity to solve problems, where students are more directed to solve routine problems, while paying less attention to solving non-routine problems. In line with Arends' opinion which states that in teaching teachers always demand students learn and rarely teach students how to learn, teachers also demand students solve problems, but rarely teach students how to solve problems (Hendriani et al., 2019; Morteza & Moghaddam, 2020). Apart from that, learning mathematics in the classroom is still a problem that is often discussed in the world of education as a basis for assessing student failure in achieving maximum learning achievement. Learning that only focuses on numeracy skills does not support problem-solving abilities (Moma, 2018; Ndiung & Jediut, 2018).

Creativity is an important aspect in dealing with various types of problems because it opens students' thinking horizons to seek fundamental understanding. The HOTS level can be seen in the questions and answers given after students receive intervention in the teaching process with PjBL (Maskur et al., 2021; Ndiung et al., 2018). Creativity increases students' cognitive aspects and their awareness to evaluate and convey information critically. It is further considered a Higher Order Thinking (HOT) skill, which consists of the components of fluency, delivery, and originality. Generally refers to the ease of generating several concepts in the creative process; equality relates to the ability to abandon old ways of thinking and accept new concepts or new paths, and originality involves the ability to generate ideas that are impossible, predictable, unusual, or unique (Ginting & Parmiti, 2016; Nuraini et al., 2019). Creative students are effective problem solvers. It is true, mathematics classrooms aim to develop various skills so that students can complete their application in everyday life.(Munar et al., 2023; Nasution et al., 2020). Assessment of student learning outcomes on problem solving abilities provides insight for teachers to make various decisions for the next series of learning (Rajan et al., 2017; Widiastuti et al., 2019).

The application of the project-based learning model is especially important in mathematics learning in elementary schools, considering that the formation of creative thinking abilities and problem solving abilities is not a priority scale. PJBL can provide teachers with the opportunity to manage learning in the classroom by involving project work with complex tasks based on very challenging questions and problems as well as guiding students in designing, solving problems, making decisions, carrying out

investigative activities, and providing opportunities for students to work . independently (Rajan et al., 2017; Utomo, 2016). One of the factors that helps in forming students' creative thinking abilities and mathematical problem solving abilities is the teaching model used by the teacher. Research shows how useful guidance from teachers, for example using scaffolding, supports student exploration in a student-centered learning atmosphere (Rohaendi & Laelasari, 2020; Zetriuslita et al., 2018).

The novelty of this research lies in the application of project-based learning (PBL) as a strategic approach to improving higher order thinking skills (HOTS) in mathematics learning. Different from previous research which may only highlight the effectiveness of PBL methods in general, this research specifically explores the influence of PBL on the development of critical, creative, analytical and problem-solving thinking skills in a mathematical context. Another novelty is the integration of contextual projects that are more relevant to students' real lives, thus allowing them to solve more complex authentic problems. In addition, this research offers a more structured project design model, with HOTS-based planning, implementation and evaluation stages, which can be used as a practical reference for teachers and curriculum developers. These findings provide an important contribution to the development of learning models that are in line with the demands of 21st century education, which prioritizes mastery of higher order thinking skills as students' core competency. It is hoped that this novelty can become a reference in curriculum development, preparation of learning tools, as well as educational policies oriented towards strengthening HOTS skills in schools. Therefore, it is very urgent to carry out research that aims to describe increasing creative thinking abilities and mathematical problem solving abilities by applying Project Based Learning model.

2. METHOD

This research was conducted at SDK Mano I, East Manggarai Regency using a quasi-experimental design with posttest-only group design by Creswell (Ndiung et al., 2021; Wardani et al., 2019). The aim of this research is to describe the differences between the experimental group and the control group in creative thinking abilities and mathematical problem solving abilities. The experimental group was presented with the PjBL Model, while the control group was presented with the conventional Learning Model. This research consists of three steps, namely pre-experiment, experiment, and post-experiment. The treatment was carried out in eight meetings, both in the experimental group and the control group, which was then equipped with a post-test to evaluate students' creative thinking abilities and mathematical problem solving abilities. This research involved 53 fifth grade elementary school students who were selected using random techniques. Class V consists of two classes, namely class VA as an experimental class with 27 people and class VB as a control class with 26 people. Data were analyzed using descriptive and inferential statistical analysis.

Data on students' creative thinking abilities and mathematical problem solving abilities were collected using essay tests; each consisting of 5 items. The creative thinking skills rubric was adapted from Bosch (Moma, 2018; Septian et al., 2017). Using a scale of 0-4. The content of the test instrument measuring mathematical problem solving abilities was validated by 3 experts in the field of mathematics learning and checked using the content validity ratio (CVR) developed by Lawshe. The competencies achieved by students in learning can be presented in Table 1.

Table 1. Mathematics Test Instrument Grid

Competency Based	Test Indicator	Cognitive Domain
Explain and do addition and subtraction of two fractions with different denominators	Solve problems adding and subtracting two fractions with different denominators	C_4K_2
Explain and do it multiplication and division fractions and decimals	Solve the problem multiplication and division fractions and decimals	C_4K_2
	Explain the problem related to operations calculate the mixture fractional form	C_4K_3
Solve the problem deals with multiplication and division of fractions and decimals	Solve the problem related to fractions for comparison	C_5K_3

Notes: C measures cognitive processes and K measures knowledge dimensions

The instruments used in this research have been validated and their reliability has been verified empirically. The reliability coefficient of the thinking skills rubric is calculated based on inter-rater

reliability. The reliability coefficient of 0.84 is included in the high category, and the reliability coefficient of learning outcomes of 0.81 was tested using the Cronbach's Alpha formula. Data analysis used Multivariate Analysis of Variance (MANOVA) which was preceded by an assumption test, namely the normality test of data distribution, homogeneity test of data group variance, and multicollinearity test. Data analysis used the Statistical Package for Social Sciences (SPSS) for window version 23.0 program.

3. RESULT AND DISCUSSION

Result

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

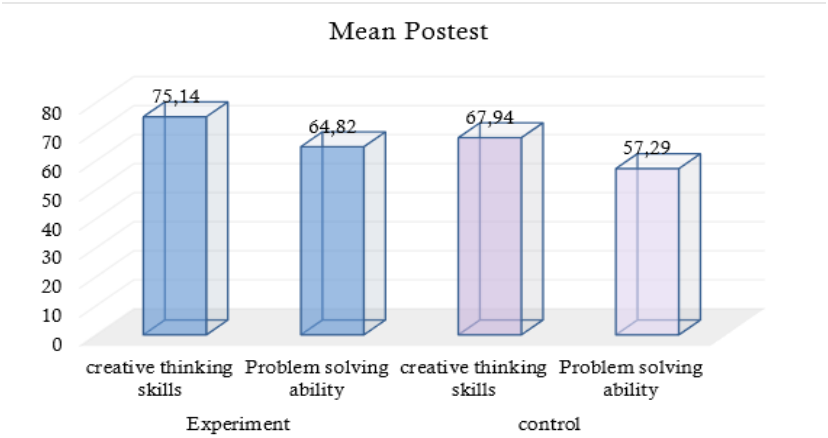

Figure 1. Descriptive Recap of Posttest Data

Based on the data in Figure 1 above, it can be concluded that the average creative thinking ability and average mathematical problem solving ability of students who receive learning using the PjBL model is higher than students who receive mathematics learning through conventional learning models. From the existing data, proceed with the assumption test, in this case the normality test of the data distribution, the homogeneity test of the variance of the data group, and the multicollinear test. The results of the assumption test with the help of the SPSS 23.0 normality program have a Kolmogorov sig value exceeding 0.05. Therefore, it can be said that all groups of students' creative thinking ability scores and mathematical problem solving ability scores in this study came from a normally distributed population. Then, a homogeneity of variance test was carried out on the data on creative thinking abilities and data on students' mathematical problem solving abilities using the Box covariance matrix equality test to test the homogeneity of variance simultaneously, namely the creative thinking ability group and the students. mathematical problem solving ability group. Then a multicollinearity test was carried out to see the relationship between the variables of creative thinking ability and students' mathematical problem solving abilities, both of which are dependent variables, and to ensure that the two can be used as different criteria so that there is no overlap. . Multicollinearity testing is carried out based on the Variance Inflation Factor (VIF) value and tolerance value. The results of the multicollinearity test analysis show a VIF value of less than 10. Thus, it can be said that the variables of creative thinking ability and mathematical solving ability do not experience multicollinearity so they can be used as different criteria variables. In this case, the two variables can be used as criterion variables separately and simultaneously.

With results showing the absence of multicollinearity, the procedure continued with hypothesis testing using Multivariate Analysis of Variance (MANOVA). Hypothesis testing was carried out using inferential analysis assisted by the SPSS version 23.0 application program. A recap of the results of the MANOVA analysis of data on students' creative thinking abilities and mathematical problem solving abilities is presented in Table 2.

Table 2. Manova analysis recap

Influence		Mark	F	Between Groups df	Inside Group df	Say.
Intercept	Pillai Trail	0,991	5682.327[A]	2.000	98.000	< 0.001
	Lambda Wilks	0.009	5682.327[A]	2.000	98.000	< 0.001
	Hotelling Trace	115.966	5682.327[A]	2.000	98.000	< 0.001
	Roy's Biggest Root	115.966	5682.327[A]	2.000	98.000	< 0.001
PjBL Learning Model	Pillai Trail	0.260	17.195[A]	2.000	98.000	< 0.001
	Lambda Wilks	0.740	17.195[A]	2.000	98.000	< 0.001
	Hotelling Trace	0.351	17.195[A]	2.000	98.000	< 0.001
	Roy's Biggest Root	0.351	17.195[A]	2.000	98.000	< 0.001

Based on the data in Table 2 above, the F Wilks' Lambda 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 using the Project Based Learning model is higher than students who receive mathematics learning through conventional learning models. The PjBL learning model also has a strong and important influence on students' creative thinking abilities and mathematical problem solving abilities.

Discussion

The findings of this research are in line with previous relevant research regarding the influence of the Project Based Learning model on mathematical creative thinking abilities (Arviani et al., 2019; Maskur et al., 2021).. The findings of this research are also supported by other research which shows that the project based learning (PjBL) learning model is able to have an influence on increasing student activity in learning (Gita & Apsari, 2020; Sumarni & Kadarwati, 2019). This research also really supports students to understand more deeply the material presented. Student activities can ultimately also influence learning outcomes. So that the learning process that occurs is not monotonous and boring, students will more easily understand the material to be studied with the various activities carried out. Also, several other studies that support the findings of this research show that the application of PjBL learning based on simple teaching aids can be used to develop critical thinking skills and creative thinking skills (Al-Farisi et al., 2020; Vonny et al., 2017).

The implementation in the experimental class is a project based learning model in this research using six steps that need to be followed in order to form students' thinking abilities and mathematical problem solving abilities (Arviani et al., 2019; Widiastuti et al., 2019), namely Project Determination. At this stage, the teacher explains the topic and then continues with students asking questions about how to solve the problem; Project completion planning steps. The teacher groups students according to project creation procedures. In the competency to solve fraction problems, students show their enthusiasm through worksheets completed in groups. Then students solve problems through discussion activities and even directly experience problems in society related to fractions; Preparation of project implementation schedule. At this stage determine the steps and schedule between the teacher and students in completing the project; Completion of projects with teacher facilities and monitoring. Monitoring carried out by teachers on student activity when completing projects as well as realizations made in solving problems; Preparation of reports and presentation/publication of project results. Teachers and students hold discussions to monitor student realization based on work results and products. The discussions carried out are used as reports as presentation material to other people; and Project evaluation. At this stage the teacher provides direction on the project presentation process, then reflects and summarizes in general what has been obtained through the teacher observation instrument.

The implication of this research is that the Project Based Learning (PjBL) model has a huge positive impact on students' creative thinking abilities and mathematical problem solving abilities, especially in 21st century education amidst uncertain global competition. Each step of PjBL syntax plays an important role in forming students' analytical and evaluative capacities. By following prescribed activities, students are consistently trained to analyze and research information before accepting it. Critical thinkers question and criticize assumptions, seeking to establish the validity and reliability of acquired knowledge. PjBL creates an environment that fosters these skills by engaging students in real-world problems. This approach encourages students to reflect on their own assumptions, explore diverse perspectives, and engage in

thoughtful inquiry. By challenging preconceptions, students improve their critical thinking, creative, and problem-solving abilities. These skills are invaluable in the 21st century, as they equip students with the tools necessary to thrive in a complex and competitive global landscape. Problem-Based Learning not only facilitates the acquisition of subject-specific knowledge but also fosters the critical thinking skills necessary for future-proof learning.

Meanwhile, the limitation of this research is that in problem solving abilities, there are 26% of students who have low abilities in understanding problems, so this has an impact on solving problems related to creative thinking abilities in the aspects of originality and fluency. Thus, teachers must be able to facilitate learning activities by increasing practice in solving problems by constructing more non-routine problems. Apart from that, students are given space to be able to express themselves to solve problems by communicating their ideas and thoughts in front of the class. Moreover, this research was only conducted on fifth grade students who only focused on fractions.

4. ACKNOWLEDGE

Thank you to the Paulus Ruteng Foundation for supporting research through the LPPM UNIKA Santu Paulus Ruteng institution. Research contract number 19/USP/L02/KPT/11/2013.

5. CONCLUSION

The project-based learning model is a learning model with creative techniques that can guide students to be able to solve unusual problems that involve realistic problems using projects that support creativity and products that can be produced by students. The results of the research show that the creative thinking abilities and mathematical problem solving abilities of students who use the project learning model are higher than students who learn 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 fifth grade students, especially in the subject of fractions. Therefore, future researchers can prove its effectiveness in other subject matter or in other subjects.

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