Effect of Science, Technology, Engineering, and Mathematics (*STEM*)-Based Project Based Learning (PjBL) Model on Creative Thinking Ability

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Abstract
Creative thinking skills are still not well empowered, therefore in the process it requires a learning model that can improve these skills. This study aims to determine the effect of STEM-based PjBL model on creative thinking skills. This type of research is quantitative with the True Experiment Posttest-Only Control Design method, which is to conduct a post test together to the control group and the experimental group but only the experimental group receives treatment. The study population was grade IV students totaling 682 from 33 public elementary schools in Purwantoro sub-district. The sampling technique was cluster random sampling, 3 public elementary schools for the experimental group with 58 students using the STEM-based PjBL model and 3 public elementary schools for the control group with 56 students using the conventional learning model. Data collection techniques with creative thinking ability description tests, which have met the validity, reliability, size level, and differentiator tests. The results showed that based on the calculation of the Independent Sample t-test hypothesis test, the posttest value obtained a significance value of 0.000 < α (α = 0.05) and the calculated t value of 2.521> t table 1.673, meaning that it rejects H_0 and accepts the alternative hypothesis (H_1). The conclusion of the research is that the STEM-based PjBL model has a significant effect on the creative thinking skills of fourth grade students in Purwantoro sub-district.
Keywords: *PjBL model, STEM, creative thinking skills.*

Abstrak
Keterampilan berpikir kreatif masih belum diberdayakan dengan baik, oleh karena itu dalam prosesnya membutuhkan model pembelajaran yang dapat meningkatkan keterampilan tersebut. Penelitian ini bertujuan untuk mengetahui pengaruh model PjBL berbasis STEM terhadap keterampilan berpikir kreatif. Jenis penelitian ini adalah kuantitatif dengan metode True Experiment Posttest-Only Control Design yakni melakukan post test secara bersama kepada kelompok kontrol dan kelompok eksperimen akan tetapi hanya kelompok eksperimen saja yang mendapat perlakuan. Populasi penelitian adalah siswa kelas IV sejumlah 682 dari 33 Sekolah Dasar Negeri di Kecamatan Purwantoro. Teknik pengambilan sampel adalah cluster random sampling, 3 SD Negeri untuk kelompok eksperimen dengan 58 siswa menggunakan model PjBL berbasis STEM dan 3 SD Negeri untuk kelompok kontrol dengan 56 siswa menggunakan model pembelajaran konvensional. Teknik pengumpulan data dengan tes deskripsi kemampuan berpikir kreatif, yang telah memenuhi uji validitas, reliabilitas, tingkat kesukaran, dan daya beda. Hasil penelitian menunjukkan bahwa berdasarkan perhitungan uji hipotesis Independent Sample t-test, nilai posttest diperoleh nilai signifikansi sebesar 0,000 < α (α = 0,05) dan nilai t hitung sebesar 2,521 > t tabel 1,673, artinya menolak H0 dan menerima hipotesis alternatif (H1). Kesimpulan penelitian adalah model PjBL berbasis STEM berpengaruh signifikan terhadap keterampilan berpikir kreatif siswa kelas IV di Kecamatan Purwantoro.
Kata kunci : Model PjBL, STEM, keterampilan berfikir kreatif.

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INTRODUCTION

Creative thinking skills require space for learners to be able to explore building knowledge. This is because the characteristics of elementary school students are like playing, grouping, and entering the concrete operational stage. This is explained in Piaget's learning theory. The need for this space provides evidence that learning needs a process that adapts to the abilities and learning styles of students. for this reason, a process-oriented learning model, one of which is project-based learning (PjBL), is needed.

PjBL is explained by Tascı, (2015) that PjBL is a learner-centered learning approach by providing more opportunities for students to actively build knowledge concepts and learn new *soft skills* such as collaboration, communication and negotiation. Susanto, (2016) also explained that project-based learning can be interpreted as a learning model that can encourage students to be active, creative and productive to improve student learning outcomes optimally. Meanwhile, Williams, (2017) and Chu et al., (2017) state that project-based learning is constructivism and is based on real-life problems to create knowledge and resolution, and provides freedom to work with a specified time. The stages of the PjBL learning model are explained by Susanto (2018), namely Start with Important Questions, Design a Project Plan, Create a Schedule, Monitor Students and Project Progress, Assess the Results, Evaluate the Experience, Assess the Results and Evaluate the Experience**.**

The Project Based Learning (PJBL) learning model involves students in working on complex problem-based tasks from learning materials and connected to the surrounding context. Students are given the opportunity to observe, survey, or analyze problems in groups. In this learning process, students are encouraged to be more active and play an active role in asking, investigating, explaining, and interacting with the problems given. Furthermore, the results of the investigations carried out by students will be produced in the form of products which will then be presented (Oktaya & Panggabean, 2022).

The characteristics of the PjBL learning model are explained by Sastradiharja & Febriani, (2023), including: a) the teacher is only a facilitator and evaluates work products; b) using projects as a learning medium; c) using problems that exist in the daily lives of students as the first step of learning; d) emphasizing contextual learning; e) creating a simple product as a result of project learning. Meanwhile, Rifai et al., (2021) explain that the characteristics of the Project Based Learning (PjBL) model are: a) students are faced with problems related to students' daily lives; b) given a project related to the material; c) students are asked to solve a problem independently; d) create a project or activity based on the problem; e) students are trained to work individually or in groups to produce a product.

The application of this PjBL learning model trains creativity, independence, as well as responsibility, critical thinking, and self-confidence in students. (Dewi, 2021) revealed several advantages in the PjBL learning model such as: a. Learning with the PjBL method can increase student learning motivation. This is in line with research conducted by Chiang & Lee, (2016) that the PjBL learning model has a positive impact on student learning motivation. b. Learning with the PjBL method can improve students' ability to cooperate and student creativity. c. Learning with the PjBL method can improve students' academic abilities. This is in accordance with research conducted by Fahrezi et al., (2020) which reveals that the PjBL learning model can improve student learning outcomes. d. Learning with PjBL methods can improve students' academic abilities. Learning with the PjBL method can improve problem solving skills, management skills and the ability to coordinate learning resources.

STEM learning is described by Kufi, (2023) as learning by combining Science, technology, engineering, and mathematics approaches to help learners build and acquire their knowledge independently and be skilled in solving real-life problems .

Zheng et al., (2022) explained that the STEM learning environment is a one-class practice that students face problems, and they use two or more to solve these problems. Meanwhile, Yulianti et al., (2022) explained that STEM-based learning methods apply knowledge and skills simultaneously to solve a case. Indarwati et al., (2021) explained that STEM learning has five stages in its implementation in the classroom, namely *observe, new idea, innovation, creativity,* and *society* Based on the description above, researchers can conclude that STEM learning is an integration of *science, technology, engineering,* and *mathematics* to solve problems related to the environment in society, so as to develop critical and creative thinking skills**.**

PjBL-STEM learning has the potential to provide meaningful learning that can increase student interest in learning, help students solve real-life problems, and support future careers. Students are invited to explore through a project activity, so that students are actively involved in the process. This fosters students to think critically, creatively, analytically, and improve higher order thinking skills. Based on research (Meita et al., 2018) in PjBL-STEM learning students work collaboratively who will be involved in solving problems designing investigations and assessing them then integrating content and skills of science, technology, engineering and mathematics. The existence of STEM learning requires students to be able to solve existing problems and make updates, discover / design new things, understand themselves, do logical thinking and master technology (Syahirah et al., 2020). STEM- PjBL can improve 21st century skills, an approach that allows students to experience firsthand the world of work that focuses on finding solutions to existing problems.

According to Rosyidah et al., (2021) found that PjBL-STEM can improve students' critical thinking skills. The application of STEM Integration to experimental subjects was also able to improve students' logical thinking. The same thing was also conveyed by Lianti et al., (2023), in their research that the critical thinking skills of the PjBL-STEM class are generally superior to the PjBL class. Furthermore, research by Mateos-Núñez et al., (2020) and Arpaci et al., (2023) concluded that the STEM approach contributes to the improvement of science and technology in elementary school children so that this approach can develop critical, creative, and innovative thinking skills in children. The STEAM approach also has a close relationship in the context of science learning. However, this approach also encourages the integration of various disciplines, such as science, technology, engineering, and mathematics (Dharin et al., 2023).

Creative thinking skills are explained by Ermawati, (2019) that creative thinking is a thought process that produces various possible ideas and ways. Zubaidah (in Nisa Auliyah et al., (2021)) explains that creative thinking is the skill of finding new things that have not existed before Leen et al., (2014) explains that creative thinking is the skill of finding new things that have not existed before, original, developing new solutions to each problem, and involves the ability to solve problems, produce new things, varied, and unique ideas. Susanto, (2016) explains that the indicators of having creative thinking skills are: fluency or *thinking fluently (thinking fluently*); flexibility or *thinking flexibly (thinking flexibly*); originality or thinking originality *(thinking originally*); and elaboration or the ability to *detail* complex things (*detailing ability)*.

Based on the description above, this study can formulate the problem formulation, namely: is there an effect of the *Science, Technology, Engineering, and Mathematics* (STEM)-based *Project Based Learning* (PjBL) model on creative thinking skills? For this reason, this study aims to determine the effect of the STEM-based PjBL model on creative thinking skills.

METHODS

This research uses a type of quantitative approach with the *True Experiment Posttest-Only Control Design* method which is to conduct a post test together to the

control group and the experimental group but only the experimental group receives treatment. Research data collection was conducted in March-October 2024. The quantitative method is empirical research in which the data is in the form of something that can be calculated. Quantitative research pays attention to data collection and analysis in numerical form (Punch, 2013). The *True Experiment Posttest-Only Control Design* method is described as follows:

R_2	X	O_2
R_4	---	O_4

Description:
X = Treatment using CLIS Learning Model
R = Respondent
O_2 = Experimental class posttest
O_4 = Control class posttest

The population of this study was grade IV students totaling 682 from 33 public elementary schools in Purwantoro sub-district using *Cluster Random Sampling* technique. The results consisted of 2 groups, namely the experimental group and the control group. The experimental group consisted of 3 public elementary schools with a total of 58 students using the *STEM-based* PjBL learning model. The control group consisted of 3 elementary schools with a total of 56 students using conventional learning models. Data collection techniques using a description test that has been tested for validity, reliability, difficulty level, and distinguishing power. The validity test in this study uses the Pearson coefficient value using the Pearson Product Moment formula, after which it is tested using the t test and then the interpretation and correlation index are seen. Validation is a measurement to determine the accuracy and accuracy of a measuring instrument Purnomo, (2018) Measurement of data reliability is carried out after measuring the validity of the data using the Cronbach's alpa method. Data analysis used hypothesis testing with Independent Sample t-test to see the effect of the *Science, Technology, Engineering, and Mathematics* (*STEM*)-based *Project Based Learning* (PjBL*)* model on creative thinking skills.

RESULTS AND DISCUSSION

Research Results

Based on the results of descriptive statistical calculations that have been carried out, data is generated in the form of statistical analysis of validity tests, reliability tests, difficulty tests, differentiator tests, prerequisite tests, hypothesis tests, as follows:

Validity Test

To test the validity of each question in the description test, it is done by comparing r count with r table. where if r count> r table then it can be said that a statement item is declared valid. vice versa if if r count < r table then a statement item is declared invalid. This study used a total of 58 respondents. Thus, the r table, namely with the formula df = n - k = 58 - 2 = 56. Thus, the resulting number in the r table is 0.2181.

Table 1. Results of the Validity Test of Descriptive Test Materials

X	r count	r table	Sig.	N	Description
P1	0,691	0,2181	0,000	56	Valid
P2	0,694	0,2181	0,000	56	Valid
P3	0,692	0,2181	0,000	56	Valid
P4	0,573	0,2181	0,000	56	Valid
P5	0,347	0,2181	0,012	56	Valid

Based on the table above, r count > r table. This indicates that the descriptive test materials can all be declared valid.

Reliability Test

The purpose of the reliability test is to determine whether the description test material used is reliable or reliable as a variable measuring instrument. The credibility of the description test material can be seen from the *Cronbach's Alpha* value, where if the *Cronbach's Alpha* value> 0.60 then the questionnaire can be said to be reliable, but if the *Cronbach's Alpha* value <0.60 then the questionnaire is considered unreliable.

Table 2. Results of Reliability Test for Descriptive Test Materials

Cronbach's Alpha	N of Items
0,621	5

Based on Table 2, the results of SPSS testing show the *Cronbach's* Alpha value of the Description Test Material is more than 0.60 (0.621> 0.60). So, each question from the Description Test Material is declared reliable.

Test Level of Difficulty

The level of difficulty is the degree of difficulty of a question item expressed in the form of a number (Lestari et al., 2017). The question is called good if the question is not included in the category too easy or too difficult. The level of difficulty states the extent to which the question is easy and difficult for students. The greater the percentage of students answering the question correctly, the easier the question, on the other hand, the smaller the percentage of students answering the question correctly, the more difficult the question (Rizky Ananda Setiyawan & Palupi Sri Wijayanti, 2020). Based on the test of the difficulty level of the description test material, there are 3 items in the medium category, 1 item in the easy category, and 1 item in the difficult category.

Distinguishing Power Test

The distinguishing power of a question item is the ability of the item to distinguish between students who can answer questions correctly and students who answer questions less precisely (Lestari et al., 2017). Analyzing differentiating power means examining test questions in terms of the ability of the test to distinguish students who fall into the weak/low category and the strong/high percentage category. Based on this research, there is a composition of the description test material consisting of: 1 easy question, 3 medium questions, and 1 difficult question.

Prerequisite Test

Normality Test

The normality test in this study was carried out to see whether the sample came from a normally distributed population or not (as a prerequisite for the t-test). This study uses the Shapiro-Wilk normality test because the sample in this study is less than 100 (<100). The results of the normality test in this study can be seen in the following table

Table 3. Normality Test Results

		Unstandardized Residual
N		56
Normal Parameters[a]	Mean	.0000000
	Std. Deviation	1.58937713
Most Extreme Differences	Absolute	.172
	Positive	.172
	Negative	-.080
Kolmogorov-Smirnov Z		1.241
Asymp. Sig. (2-tailed)		.077

Based on the normality test results in Table 3. Using SPSS version 26, it is known that the significance value is 0.077> 0.05, it can be concluded that the sample from the population is normally distributed.

Homogeneity Test

The homogeneity test is used to determine whether some population variants are the same (homogeneous) or not. This test is carried out as a prerequisite in the independent sample t test analysis. Homogeneity test can be done if the data group is in normal distribution. The homogeneity test is carried out to show that the differences that occur in parametric statistical tests (eg t test) really occur due to differences between groups, not as a result of differences within groups. Based on the homogeneity test, it can be seen from each homogeneity test statistical value x^2_{count} (0.752) < x^2_{tabel} (3.841). The results of the homogeneity test calculation can be concluded that the sample population is homogeneous.

Balance Test

The balance test is conducted to ensure that the two sample groups to be compared have the same or balanced initial characteristics. Based on the balance test that has been carried out using the t test (*treatment*), it can be seen that the tcount is 1, 134, while the critical area is t> - 1.673 or t < 1.673. It can be concluded that the experimental group and control group do not have significant differences in the variables tested. Both groups were balanced before being given treatment, so the difference in learning outcomes obtained after treatment can be more confidently attributed to differences in learning models.

Hypothesis Test (t Test)

Statistical testing of the t test is used to determine how much influence the *Science, Technology, Engineering, and Mathematics* (STEM) based *Project Based Learning* (PjBL) model has on creative thinking skills. This study used 56 samples. t table = t (a/2; n-k-1) = (0.025; 56) = 1.673 then the t table used in this study based on the formula of the sample is 1.673. The basis for decision making is as follows: First, if the significance value> 0.05 or t count < t table, it can be concluded that H0 is accepted, and Ha is rejected or there is no effect of variable X on variable Y. Second, if the significance value < 0.05 or t count > t table, it can be concluded that H0 is rejected, and Ha is accepted or there is an effect of variable X on variable Y.

Table 4. Results of the t-test

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	10.604	1.899	.355	5.584	.000
	STEM-based PjBL	.317	.118		2.521	.000

Based on Table 4, it is known that the significant value for the effect of variable X on variable Y is 0.000 <0.05 and the t value is 2.521> t table 1.673 so it can be concluded that Ha is accepted and H0 is rejected, which means that there is an effect of the *Project Based Learning* (PjBL) model based on *Science, Technology, Engineering, and Mathematics* (STEM) on creative thinking skills.

Discussion

Based on the results of the above research, it is proven that there is an effect of the *Science, Technology, Engineering, and Mathematics* (STEM) based *Project Based Learning* (PjBL) model on creative thinking skills. This is reinforced from the results of data calculations that the calculation of the Independent Sample t-test hypothesis test

on the results of the posttest value obtained a significance value of 0.000 < α (α = 0.05) and a calculated t value of 2.521> t table 1.673, this can be interpreted that the STEM-based PjBL model has an influence on students' ability to think creatively. This is in line with Fitriyah & Ramadani, (2021) research which states that the *Project Based Learning* (PjBL) learning model that integrates *Science, Technology, Engineering, and Mathematics* (STEM) has proven effective in stimulating students' creative thinking skills. In the STEM-based PjBL model, students are invited to complete real projects that are relevant to everyday life. The complex problem-solving process in this project requires learners to think creatively, analyze information, and design innovative solutions. Thus, learners are trained to not only master academic concepts, but also develop creative thinking skills.

According to (Dina Aulia Yudistira Munthe et al., 2023) and Sukmawijaya et al., (2024) stated that STEM-based PJBL provides ample space for students to explore their ideas freely. In addition, STEM-based PJBL also encourages collaboration between students, so they can learn from each other and share ideas. This is very important to develop good communication skills and teamwork. According to Firmantara et al., (2023), students who follow STEM-based PJBL-based learning tend to have higher creative thinking skills compared to students who follow conventional learning. They are more able to generate ideas that are original, flexible, and relevant to the context of the problem. This is because STEM-based PPA provides opportunities for students to develop complex problem solving skills, which is one of the important components of creative thinking. In line with the research of Mateos-Núñez et al., (2020) and Arpaci et al., (2023) concluded that the STEM approach contributes to the improvement of science and technology in elementary school-age children so that this approach can develop critical, creative, and innovative thinking skills in children.

Overall, the STEM-based PJBL model is a very potential learning approach to improve students' creative thinking skills. Lianti et al., (2023) also explained that the critical thinking skills of the PjBL-STEM class were generally superior to the PjBL class. The implementation of the PjBL-STEAM approach in learning provides significant benefits, including the development of 21st century skills, student motivation, and understanding of science concepts Susanti et al., (2023). By providing authentic and relevant learning experiences, STEM-based PJBL not only helps students master the subject matter, but also improves learners' creative thinking skills.

CONCLUSION

This research proves that the *STEM-based* PjBL model has a significant effect on students' creative thinking skills. The *STEM-based* PjBL model has a significant effect on the creative thinking skills of fourth grade students in Purwantoro sub-district. Through the Independent Sample t-test hypothesis test, it was found that the posttest results of students who followed the model were significantly different compared to students who received conventional learning. Sample t-test results of posttest values obtained a significance value of 0.000 < α (α = 0.05) and the value of t count 2.521 > t table 1.673, meaning rejecting H_0 and accepting the alternative hypothesis (H_1). Therefore, through the application of the STEM-based PjBL model can help students to improve creative thinking skills. Based on these findings, it is necessary to conduct further research to evaluate the effect of the STEAM approach through PjBL in other sciences. This aims to strengthen that innovative and interactive teaching models such as PjBL can be a useful learning strategy in developing students' creative thinking skills.

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