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The Influence of Project Based Learning on Learning Outcomes, Creativity and Student Motivation in Science Learning at Elementary Schools

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Abstract: Project-Based Learning (PBL) is a pedagogical approach that centers on students actively engaging in real-world, meaningful projects to explore and construct knowledge. This study investigates the influence of PBL on learning outcomes, creativity, and student motivation in science learning at the elementary school level. In addition, this study aims to explore how PBL, as an instructional approach, affects learning outcomes, creativity and student motivation in science education. The research employed a quantitative approach through a quasi-experimental method. The sample consisted of elementary school students in Surabaya, Indonesia, who were exposed to PBL activities in their science classes, while a control group experienced conventional instruction. Both groups completed pre- and post-tests to assess changes in creativity and motivation. The research design employed was a true experimental design, involving the formation of two groups, namely the control and experimental groups, through random sampling. This study's results indicate that PBL significantly impacts student learning outcomes, motivation, and creativity in science education. These findings contribute to the existing literature on PBL and its influence on learning outcomes, creativity, and student motivation in science learning. The results underscore the importance of integrating PBL as a practical instructional approach in elementary school classrooms to foster creativity and enhance student motivation. Educators and policymakers can use these insights to promote innovative teaching methods that encourage active participation, critical thinking, and creative problem-solving skills in science education at the elementary level.
Keywords: project-based learning, learning outcomes, creativity, student motivation, science learning

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Introduction

Education in the 21st century is focused on preparing students to face the challenges and changes occurring in the digital and globalization era. It emphasizes the development of skills and competencies needed in the workforce and life, such as critical, creative, and innovative thinking skills, communication skills, collaboration, and problem-solving (Dhir, 2021; Hilton, 2015; Mahmud & Wong, 2022; Okros, 2020; Soulé & Warrick, 2015). Some key focuses in 21st-century education include technology literacy, educational innovation, human resource development, character education, and the use of technology in learning. According to Cardullo et al. (2015) and Liao et al. (2016), the effective use of technology as a learning medium. 21st-century education is expected to produce high-quality human resources ready to face future challenges.

In the 21st century, education emphasizes active, creative, and innovative learning, a principle in teaching Natural Sciences. In line with this, according to the Science Education in the 21st Century, the focus is on developing critical, creative, and innovative thinking skills, communication skills, collaboration, problem-solving skills, and the use of technology in the learning process (Havu-Nuutinen et al., 2017; Susilo et al., 2020; Yulianti et al., 2020). According to Hansen & Hansen (2018), natural science education is focused on natural sciences, including science, technology, and the environment. In natural science education, student motivation and creativity are vital in creating an effective learning process and building students' interest in science (Adawiyah et al., 2023). Science education also encourages students to develop critical thinking skills, collaborate, and apply the knowledge they have learned (Finnerty, 2014). Effective science education in elementary schools should ignite students' interest in science, develop a deep understanding, and enhance critical thinking skills. Additionally, according to Ates & Aktamis (2024) and Taber (2021), science education should also aim to cultivate students' creativity by connecting scientific concepts with everyday life, encouraging out-of-the-box thinking, and exploring new ideas.

Science education in elementary schools has often been dominated by a teacher-centered approach (Hidayah & Pujiastuti, 2016). Teachers are often seen as the primary source of knowledge, while students play a passive role as information receivers. This approach has led to a lack of achievement in learning outcomes and has hindered the development of students' creativity and motivation. Furthermore, elementary school science education often focuses on concept comprehension and passive information absorption (Fatkhiyani & Dewi, 2020; Hidayah & Pujiastuti, 2016). This lack of student interest in science education contributes to low critical thinking skills and creativity in applying scientific concepts. Additionally, it leads to student boredom and a lack of creativity in learning due to dependence on the teacher in the learning process (Kruk & Zawodniak, 2020; Mahmoudi-Gahrouei et al., 2024).

However, in recent years, Project-Based Learning (PBL) has started to be implemented in some elementary schools. PBL emphasizes active student participation, developing critical thinking skills, and creativity through projects or tasks relevant to students' daily lives (Lestari et al., 2024; Nargis & Armelia, 2016; Shekhar & Borrego, 2017). Implementing PBL is expected to enhance students' motivation in learning science (Chang et al., 2018). In this context, student motivation can be defined as an internal drive that encourages students to actively participate in learning, explore new ideas, and be highly curious about science. PBL is also expected to stimulate the development of student creativity, as students are given the freedom to explore creative ideas, solve problems, and create something new (Flores-Fuentes & Juárez-Ruiz, 2017; Halimah et al., 2020; Honglin & Yifan, 2022; Isabekov & Sadyrova, 2018).

Previous research conducted by Zukarnain et al. (2020), Amorati & Hajek (2021), Campos-Roca (2021), Nurdin & Wahyudin (2020), and Umar & Ko (2022) have revealed that student-centered approaches like PBL have a positive influence on learning outcomes, student motivation, and creativity across various educational levels. However, the impact of PBL on learning outcomes, student motivation, and creativity in science education at the elementary school level still needs further understanding. Therefore, this study aims to investigate the effects of project-based learning (PBL) on student creativity and interest in science education at the elementary school level.

This research contributes to the existing body of knowledge by providing empirical evidence on the impact of PBL on elementary school students' learning outcomes, creativity, and motivation in science education. It highlights the importance of integrating PBL into elementary classrooms to foster a more engaging and effective learning environment. The findings can inform educators and policymakers of the benefits of student-centered teaching approaches, particularly in enhancing critical thinking, creativity, and motivation among young learners in science education.

Methods

This study adopted a quantitative approach and utilized a quasi-experimental method. The choice of quasi-experiments enabled the investigation of the impact of a specific treatment on the research subjects. The research design employed was a true experimental design involving the formation of two groups, namely the control and experimental groups, through random sampling. The study was conducted at Jambangan I Elementary School in Surabaya and Karah I Elementary School in Surabaya. Random sampling was used to select the participants. Class IV in Karah I Elementary School was assigned as the control group, and 4th-grade in Jambangan I Elementary School was assigned as the experimental group. The independent variable in this study was the influence of Project-Based Learning (PBL), while the dependent variables encompassed student learning outcomes, learning motivation, and creativity. Data collection techniques comprised pre-tests, post-tests, and questionnaires. The research instruments employed included observation sheets to assess implementing the Project-Based Learning (PBL) model, pre-test and post-test sheets, and student response questionnaires.

The hypothesis of the research are as follows.

H0 = There is a significantly influence of PBL on creativity and student motivation in science learning among elementary school students.

Ha = There is no significant influence of PBL on creativity and student motivation in science learning among elementary school students.

Results and Discussion

Validity and Reliability

Prior to their use in the study, the instruments underwent a validity test by expert to assess their content validity. The validity test involved a content validity test to evaluate the suitability of the items and a construct validity test for the questions, motivation questionnaire, and creativity questionnaire. The results of the validity tests for each instrument variable are provided below.

Research results are presented as graphs, tables, or descriptive. Analysis and interpretation of these results are required before they are discussed.

Table 1. Results of Validity Tests of Instruments

No.	Aspect	Score	Final Score
1.	Curriculum suitability	4	
2.	Material suitability	6	**90**
3.	Content suitability	26	
	Maximum score	**40**	

The final validation result for the pre-test and post-test is 90. Based on these findings, it can be concluded that the pre-test and post-test instruments have a very high level of validity and are deemed appropriate for use.

Table 2. Results of Validity of Each Instrument

No.	Learning outcome			Motivation			Creativity		
	R_{count}	R_{table} (n=60)	Description	R_{count}	R_{table} (n=30)	Description	R_{count}	R_{table} (n=30)	Description
1.	0.709	0.254	Valid	.363	0.361	Valid	.858**	0.361	Valid
2.	0.439	0.254	Valid	.545**	0.361	Valid	.943**	0.361	Valid
3.	0.716	0.254	Valid	.721**	0.361	Valid	.732**	0.361	Valid
4.	0.455	0.254	Valid	.620**	0.361	Valid	.479**	0.361	Valid
5.	0.501	0.254	Valid	.404*	0.361	Valid	.792**	0.361	Valid
6.	0.400	0.254	Valid	.389	0.361	Valid	.922**	0.361	Valid
7.	0.574	0.254	Valid	.875**	0.361	Valid	.752**	0.361	Valid
8.	0.588	0.254	Valid	.772**	0.361	Valid	.479**	0.361	Valid
9.	0.524	0.254	Valid	.801**	0.361	Valid	.526**	0.361	Valid
10.	0.744	0.254	Valid	.797**	0.361	Valid	.839**	0.361	Valid
11.	0.551	0.254	Valid	.734**	0.361	Valid	.922**	0.361	Valid
12.	0.804	0.254	Valid	.521**	0.361	Valid	.761**	0.361	Valid
13.	0.683	0.254	Valid	.729**	0.361	Valid	.459*	0.361	Valid
14.	0.549	0.254	Valid	.870**	0.361	Valid	.835**	0.361	Valid
15.	0.599	0.254	Valid	.550**	0.361	Valid	.975**	0.361	Valid
16.	0.501	0.254	Valid	.598**	0.361	Valid	.742**	0.361	Valid
17.	0.428	0.254	Valid	.603**	0.361	Valid	.479**	0.361	Valid
18.	0.526	0.254	Valid	.813**	0.361	Valid	.792**	0.361	Valid
19.	0.613	0.254	Valid	.807**	0.361	Valid	.851**	0.361	Valid
20.	0.550	0.254	Valid	.822**	0.361	Valid	.922**	0.361	Valid

Based on the test results, it is revealed that all the instruments utilized are deemed valid, with the r-count exceeding the r-table. Subsequently, the valid test items were further assessed for their reliability through a reliability test. The reliability test calculations for learning outcomes, motivation, and creativity are presented in the table below.

Table 3. Results of Reliability

Variable	Cronbach's Alpha	N of Items	Description
Learning Outcomes	0,890	20	Reliable
Motivation	0.932	20	Reliable
Creativity	0.962	20	Reliable

Based on the data above, the reliability test calculations yielded results of 0.890 for the learning outcomes variable, 0.932 for the motivation variable, and 0.962 for the creativity variable. These results indicate that the reliability coefficients for all three variables are ≥ 0.6. Therefore, it can be concluded that all the instruments are considered reliable.

Descriptive Analysis

Before conducting hypothesis testing, a descriptive analysis was performed to depict the data on learning outcomes, motivation, and creativity for the experimental and control groups. The descriptive summaries of learning outcomes, motivation, and creativity for the experimental and control groups are presented in the following diagrams.

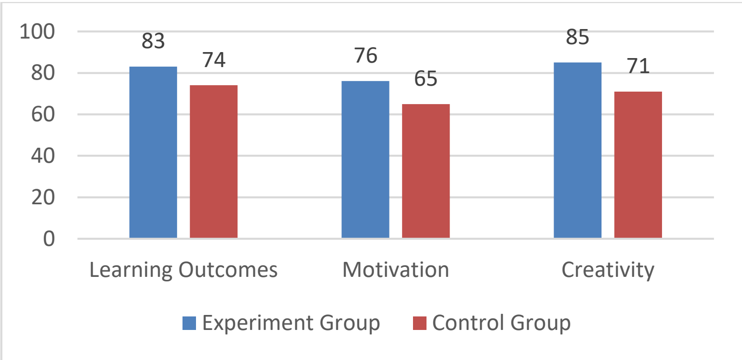

Figure 1. Summaries of Each Variable

Based on the above diagram, it is evident that the experimental group achieved an average learning outcome of 83, a motivation score of 76, and a creativity score of 85. Conversely, the control group obtained lower scores, with an average learning outcome of 74, motivation score of 65, and creativity score of 71.

Hypothesis Testing

Hypothesis testing was conducted using a paired sample t-test to determine the influence of project-based learning strategies on children's creative thinking ability. A paired sample t-test was performed by comparing the scores of the control and experimental groups regarding learning outcomes, as well as the questionnaire results for motivation and creativity. However, two prerequisite tests were conducted before conducting the hypothesis testing: the normality test and the homogeneity test. The hypotheses used in the normality test were as follows:

a. H_0 = The data is not normally distributed if Sig. < 0.05
b. H_1 = The data is normally distributed if Sig. > 0.05

Table 4. Results of the Normality Test

Group	Variable	Kolmogorov-Smirnov[a]			Shapiro-Wilk			Description
		Statistic	df	Sig.	Statistic	df	Sig.	
Experiment	Learning outcomes	.151	30	.080	.938	30	.082	Normal
	Motivation	.148	30	.094	.931	30	.053	Normal
	Creativity	.118	30	.200*	.936	30	.071	Normal
Control	Learning outcomes	.141	30	.132	.926	30	.058	Normal
	Motivation	.131	30	.198	.952	30	.190	Normal
	Creativity	.145	30	.107	.954	30	.210	Normal

Based on the obtained significance values for all variables in both groups (>0.05), it can be concluded that the data obtained are normally distributed. After conducting the normality test, the homogeneity test was conducted. The homogeneity test is used to determine whether the data from both groups are homogeneous or not. Homogeneity testing in this study was performed using the SPSS 26.0 for Windows software with the Lavene one-way ANOVA test based on the criteria.

a. H_1 = if the Sig. value > 0.05, then the variances of both groups are homogeneous.
b. H_0 = if the Sig. value < 0.05, then the variances of the data in both groups are not homogeneous

Table 5. Results of the Homogeneity Test

Test of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
Experimental group and control group	Based on Mean	3.558	26	147	.062
	Based on Median	2.655	26	147	.103
	Based on Median and with adjusted df	2.655	26	99.711	.140
	Based on trimmed mean	3.331	26	147	.065

Based on the homogeneity test results above, it can be observed that the column labelled "Sig" shows a value of 0.062 > 0.05. This indicates that the experimental and control groups' data are homogeneous. After conducting the classical assumption tests, hypothesis testing is performed to determine whether there is a significant difference in learning outcomes, motivation, and creativity between the experimental and control groups.

Hypothesis testing is conducted using the Paired Sample t-test, which compares the differences between two paired samples. The hypotheses in this study are as follows:

1. If the significance value is > 0.05, it means that there is no difference in learning outcomes, motivation, and creativity between the two groups.
2. If the significance value is < 0.05, it means that there is a difference in learning outcomes, motivation, and creativity between the two groups.

The following are the results of the paired sample t-test for the two groups.

Table 6. Results of Paired Sample t-test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Exp_LearningOut-Cont_LearningOut	9.00000	11.77373	2.14958	4.60362	13.39638	4.187	29	.000
Pair 2	Exp_Motivation - Cont_Motivation	12.93333	12.56688	2.29439	8.24078	17.62588	5.637	29	.000
Pair 3	Exp_Creativity - Cont_Creativity	13.30000	16.69018	3.04720	7.06778	19.53222	4.365	29	.000

Based on the test results, it is found that there is a significant difference in learning outcomes, motivation, and creativity between the control group and the experimental group, as indicated by the obtained significance value (Sig.) < 0.05. Therefore, it can be concluded that Project Based Learning (PBL) impacts learning outcomes, motivation, and creativity.

Discussion

Based on the results of the T-test analysis, it can be observed that H0 is accepted, indicating that Project-Based Learning (PBL) improves student learning outcomes, motivation, and creativity in elementary school science education. This section discusses the impact of PBL on these key educational aspects, providing valuable insights into its effectiveness. The analysis revealed that students who participated in PBL activities demonstrated significantly higher achievement levels compared to those in traditional learning settings. This positive effect on learning outcomes suggests that PBL engages students in a more active and hands-on approach, enhancing their understanding and retention of subject matter. By involving students in real-world problems and projects, PBL allows them to apply their knowledge meaningfully, leading to deeper learning and better assessment performance (Gratchev, 2023; Zhang et al., 2023). For instance, students working on a science project about ecosystems might explore local habitats, gather data, and present their findings, thus internalizing the concepts more effectively than through passive learning.

PBL was also found to have a considerable impact on student motivation. Engaging students in real-world projects and problem-solving tasks fosters a sense of ownership and relevance in their learning. This approach stimulates intrinsic motivation and a desire to explore and discover knowledge independently. As a result, students exhibit higher levels of enthusiasm, engagement, and perseverance in their learning journey (Campos-Roca, 2021; Cooper & Kotys-Schwartz, 2022; Gratchev, 2023; Sari, 2018; Pebriana et al., 2024). The active involvement in the learning process, combined with the relevance of the tasks, makes students more interested and motivated to learn, which is essential for long-term educational success. This aligns with the findings of Campos-Roca (2021), Cooper & Kotys-Schwartz (2022), Gratchev (2023), Sari (2018), and Pebriana et al. (2024), who highlighted the importance of motivation in sustaining student engagement throughout the learning process.

In addition to improved learning outcomes and motivation, PBL nurtured students' creativity. Engaging in open-ended projects encourages students to think critically, brainstorm ideas, and find innovative solutions (Bonaparte, 2019; Lee et al., 2018; Nurkaeti et al., 2020; Tharakan, 2018). PBL provides a platform for students to express their creativity, explore multiple perspectives, and develop their problem-solving skills. The results indicate a significant enhancement in students' creative thinking abilities due to PBL participation. This finding supports the research conducted by Coyne et al. (2016), Hu et al. (2015), and Meng et al. (2023), who found that PBL can significantly enhance students' creative thinking.

Traditional science education in elementary schools often involves teacher-centered approaches, where teachers are the primary source of knowledge, and students play a passive role. This method has led to a lack of achievement in learning outcomes and has hindered the development of students' creativity and motivation. Studies by Hidayah & Pujiastuti (2016) and Pamungkas et al. (2019) highlight that traditional methods focus on concept comprehension and passive information absorption, resulting in low levels of critical thinking skills and creativity among students. In contrast, PBL's active and student-centered approach addresses these shortcomings by engaging students in meaningful and relevant tasks.

The findings of this study are consistent with previous research by (Flores-Fuentes & Juárez-Ruiz (2017), Halimah et al. (2020), Honglin & Yifan (2022), and Isabekov & Sadyrova (2018) found that PBL enhances students' creativity in thinking. Furthermore, PBL also improves student learning outcomes (Adawiyah et al., 2023; Nurdin & Wahyudin, 2020). Additionally, Adawiyah et al. (2023) emphasized the importance of student motivation, expectations of success, and alignment of teaching methods with intended learning outcomes. PBL aligns with these principles by providing new motivation to improve creativity, memory, motor coordination, and analytical skills (Campos-Roca, 2021).

The findings suggest that PBL is an effective pedagogical approach that can transform traditional science education by making it more engaging, relevant, and conducive to developing essential 21stcentury skills. This research adds to the growing body of evidence supporting the adoption of PBL in elementary school settings and provides practical insights for educators looking to enhance student learning experiences and outcomes.

In conclusion, this study demonstrates the positive impact of Project-Based Learning on student learning outcomes, motivation, and creativity in elementary school science education. The findings strongly support the adoption of PBL as a pedagogical strategy to foster a more engaging and effective learning environment. Educators and policymakers should consider integrating PBL into the curriculum to promote deeper understanding, intrinsic motivation, and creative thinking among students. Future research could further explore the long-term effects of PBL and implementation across different subjects and educational contexts.

Conclusion

This study's results indicate that PBL significantly impacts student learning outcomes, motivation, and creativity in science education. Implementing PBL in the classroom positively influences students' achievement levels, as they demonstrate higher levels of understanding and retention of scientific concepts than traditional instruction. Furthermore, PBL enhances student motivation in science learning. By engaging students in real-world projects and problem-solving tasks, PBL fosters a sense of ownership and relevance in their learning, increasing intrinsic motivation and a desire to explore and discover knowledge independently. This heightened motivation translates into higher enthusiasm, engagement, and perseverance in learning. Moreover, PBL promotes student creativity in science education. By encouraging students to think critically, brainstorm ideas, and find innovative solutions, PBL provides a platform to express their creativity and develop their problem-solving skills. Through hands-on and interactive projects, students can explore multiple perspectives, think creatively, and develop a deeper understanding of scientific concepts.

The findings of this study contribute to the growing body of research supporting the implementation of PBL in elementary school classrooms. The evidence suggests that PBL can effectively enhance student learning outcomes, motivation, and creativity. As educators strive to provide engaging and meaningful learning experiences, PBL emerges as a promising pedagogical approach for fostering holistic development among elementary school students. It is important to note that further research is needed to explore the long-term effects of PBL and its implementation in different contexts. Additionally, investigating the role of teacher facilitation and support in PBL is crucial for maximizing its benefits. Nonetheless, the present study provides valuable insights and a foundation for future studies to build upon, reinforcing the potential of PBL as an effective instructional approach in elementary education.

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