

THE EFFECT OF PROJECT BASED LEARNING ON CREATIVE THINKING AND CRITICAL THINKING SKILLS OF JUNIOR HIGH SCHOOL STUDENTS IN THE TOPIC OF SYSTEMS OF LINEAR EQUATIONS IN TWO VARIABLES

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Abstract

The research was conducted to analyze the effect (PjBL) on junior high school students creative and critical thinking abilities in learning Systems of Linear Equations in Two Variables (SLETV). Quantitative method was employed through this study adopted quasi-experimental design that employed the Posttest-Only Control Group Design. Research population comprised entire grade 8 students at a junior high school 2 Purbalingga. Two classes were selected as research samples, with one serving as the experimental group that participated in PjBL based instruction and the other functioning as the control group that experienced conventional teaching practices. Data were obtained using a structured objective test accompanied by reasoning-based items. The data collected were processed and analyzed through descriptive statistical procedure, normality and homogeneity testing, Independent Samples t-test, MANOVA. The findings revealed that students obtained a higher average posttest score (83.83) than those in the control group (70.17). Statistical analysis indicated a p-value of 0.000, was under the 0.05 level of significance, demonstrating the use of PjBL significantly enhanced students creative and critical thinking skills when examined separately. In addition, the MANOVA results produced the same significance value, confirming that the learning model simultaneously affected both cognitive abilities. These findings suggest that learning activities involving project development, investigation, and authentic problem-solving situations can foster students' ability to generate ideas creatively, evaluate information critically, and construct solutions more effectively than conventional instructional approaches.

Keywords: project based learning, creativity thinking, critical thinking, systems of linear equations in two variables

Abstrak

Kemampuan berpikir kreatif dan kritis merupakan kompetensi penting perlu dikembangkan dalam aktivitas pembelajaran matematika. Penelitian ini bertujuan mengkaji pengaruh model PjBL terhadap kedua kemampuan tersebut pada materi Sistem Persamaan Linear Dua Variabel (SPLDV). Studi ini memakai pendekatan kuantitatif melalui metode kuasi eksperimen serta Posttest Only Control Group Design. Penelitian ini melibatkan seluruh siswa kelas VIII SMP Negeri 2 Purbalingga sebagai populasi penelitian, yang melibatkan dua kelas, masing-masing berfungsi untuk kelompok eksperimen dan kontrol. Di mana kelompok eksperimen menerima pengalaman belajar memakai PjBL, tetapi kelompok kontrol diberikan pembelajaran secara konvensional. Data dalam penelitian ini diperoleh melalui pelaksanaan tes uraian yang mengukur kemampuan berpikir kreatif dan berpikir kritis siswa, selanjutnya dianalisis menggunakan statistik deskriptif, uji normalitas, uji homogenitas, Independent Sample t-Test, dan Multivariate Analysis of Variance (MANOVA). Hasil penelitian mengindikasikan bahwa rata-rata skor posttest siswa dalam kelompok eksperimen sebesar 83,83, melampaui kelompok kontrol yang memperoleh rata-rata 70,17. Hasil pengujian hipotesis menunjukkan nilai signifikansi sebesar 0,000 ($< 0,05$), memperlihatkan model PjBL berperan secara signifikan terhadap kemampuan berpikir kreatif maupun kemampuan berpikir kritis siswa. Selain itu, hasil uji MANOVA juga memberikan nilai signifikansi 0,000 ($< 0,05$), menandakan dampak secara simultan kedua kemampuan tersebut. Hasil yang diperoleh menunjukkan pembelajaran berbasis proyek yang melibatkan aktivitas investigasi, kolaborasi, dan penyelesaian masalah kontekstual mampu meningkatkan kemampuan berpikir kreatif dan kritis murid secara lebih efektif dibandingkan pembelajaran konvensional.

Kata kunci: project based learning, berpikir kreatif, berpikir kritis, sistem persamaan linear dua variabel

INTRODUCTION

Continuous advancement of science, technology, and digital transformation significantly transformed the goals of education in the 21st century. International educational frameworks consistently identify critical thinking and creative thinking as essential 21st century skills that should be fostered through meaningful learning experiences. Consequently, advancement of Higher Order Thinking Skills, especially creative and critical thinking, has become one of the primary objectives of mathematics education.

Mathematics holds a strategic part in cultivating students logical, systematic, coupled with reflective thinking skills. Mathematics is a subject that holds its own unique distinction compared to other fields of study (Artika et al., 2023). The actual situation of education in Indonesia shows concerning results. The results of the 2022 PISA survey placed Indonesia at score of 366, far below the OECD average of 472. This result shows that students' ability to analyze, reason, and solve complex problems remains low. Students' critical thinking ability is still categorized as low because learning processes have not encouraged deep analysis and evaluation (Yudha et al., 2022).

Creative thinking and critical thinking are complementary competencies that are fundamental to effective mathematics learning. Creative thinking is an active process and a capability used to express or solve problems in order to generate and create new ideas based on previously mastered concepts (Facione & Peter, 2020). The evaluation of creativity centers on four distinct dimensions: fluency, flexibility, originality, and elaboration (Muda et al., 2022). Critical thinking may be understood as a deliberate coupled with introspective evaluation method by which integrates interpretation, analysis, assessment, and drawing conclusions (Facione & Peter, 2020). Many students experience difficulties in mathematical modeling, selecting efficient solution methods, and evaluating the correctness of their answers when solving SLETV problems. Students struggle to understand and solve two-variable linear equation systems because of their limited metacognitive skills (Hidayanti & Fajar, 2019).

One instructional approach that has received considerable attention is Project-Based Learning (PjBL). PjBL engages students in authentic projects that involve investigation, collaboration, problem-solving, and reflection throughout the learning process. Project-Based Learning actively engages students in an investigative process that culminates in a tangible

final product (Yusri et al., 2024). Several foundational elements constitute the distinct characteristics of Project-Based Learning : Student engagement, Inquiry Process, Collaboration, Communication, Vreation of Product, and Reflection (Dias & Brantley-Dias, 2017). PjBL enhances students' conceptual understanding, learning motivation, problem-solving ability, and higher-order thinking skills across various mathematical topics. Project-Based Learning significantly develops students' critical thinking abilities by engaging them in inquiry, detailed analysis, and problem-solving tasks (Anggraini et al., 2025).

Previous research has shown that PjBL improves students' academic achievement, conceptual comprhension, problem-solving competencies, creativity, critical thinking, mathematical literacy, coupled with collaborative learning. Outcomes of the meta-analysis show implementation PjBL approach significantly improves participants critical thinking skills coupled with learning outcomes (Kwon & Lee, 2025). Project-based learning significantly shapes critical thinking abilities mathematics instruction under Merdeka Curriculum (Johan Fanani, 2024). PjBL has proven capable of developing students' creative thinking skills because it provides contextual and real-world problem-based learning experiences (Hakim et al., 2025). Students creative thinking abilities within the structure System Administration subject are positively influenced by implementation PjBL (Darwin et al., 2023). Implementation PjBL approach yields significant improvement in students academic achievements regarding the SPLDV material (Manurung et al., 2024). The development of PjBL approach in material on SLETV can enhance students' problem-solving skills (Ni Wayan Sri Maeti et al., 2025).

Despite the expending literature on evidence supporting how effective Project-Based Learning mathematics learning, most previous studies have focused on a single advanced thinking skills, such as creativity and critical thinking, separately. Moreover, empirical studies investigating the simultaneous development of both skills through Project-Based Learning context of Systems of Linear Equations in Two Variables (SLETV) remain limited. Therefore, to address this gap this study investigates the effects of PjBL on students creative and critical thinking abilities simultaneously. In addition, this study employs Multivariate Analysis of Variance (MANOVA) to offer more thorough evaluation of the effects of Project-Based Learning on both dependent variables. Unlike previous studies that primarily examined these skills separately, this study contributes to the existing literature in three ways. First, it

simultaneously investigates students' creative and critical thinking skills within a single analytical framework. Second, it focuses on Systems of Linear Equations in Two Variables (SLETV), a mathematical topic that requires the integration of divergent and analytical reasoning. Third, this study employs MANOVA to identify simultaneous impact Project-Based Learning on two dependent variables, thereby providing deeper understanding impact in mathematics learning. Accordingly, The present study focuses on evaluating how the implementation of Project-Based Learning influences students' creative and critical thinking abilities when learning Systems of Linear Equations in Two Variables (SLETV).

METHODS

Research Design

A quasi-experimental design within a quantitative research framework was adopted in this study. The investigation employed Posttest-Only Control Group Design, this study involved two classes, with one serving as the experimental group and the other as control group. Student in experimental class were exposed to instruction through the Project Based Learning (PjBL) approach, while the control class followed conventional teaching practices. Details are summarized in Table 1.

Table 1. Research Design

Group	Treatment	Posttest
Experimental	X	O
Control	-	O

Description:

X : Treatment using Project Based Learning

O : Posttest

- : No special treatment

Population and Sample

This research took place at Junior High School 2 Purbalingga during semester II of the 2025/2026 academic period. All eighth-grade students constituted the research population. Sample selection was determined through teacher recommendations, resulting in the selection of two classes. One class was designed as the experiment class and was taught using Project Based Learning (PjBL) approach, whereas the other functioned as the control group and received conventional learning.

Research Instruments and Learning Procedures

The study employed assessment tools designed assess students creative and critical thinking abilities in Systems of Linear Equations in Two Variables (SLETV). Prior to their implementation, the instruments underwent validity and reliability testing to ensure their appropriateness for data collection. The research was initiated by determining the experimental and control groups. Subsequently, students in the experimental group participated in learning activities according to the PjBL model, while the control group received instruction through traditional methods. The intervention was conducted over four instructional sessions, consisting of two sessions for participants in the experimental group and two sessions for participants in the control group, with each session lasting 2×40 minutes. During the implementation of PjBL, students participated in a contextual buying and selling project designed to facilitate the learning of Systems of Linear Equations in Two Variables (SLETV). The teacher prepared several products and provided transaction information involving purchased items. Working collaboratively in groups, students were required to determine the price of each product by formulating and solving SLETV models based on the available transaction data. At the end of the project, each group presented its findings and explained the mathematical reasoning used to determine the prices of the products. Students' creative thinking abilities were assessed which were evaluated using the indicators of fluency, flexibility, originality, and elaboration, whereas critical thinking skills were evaluated through interpretation, analysis, evaluation, and inference indicators using analytic scoring rubrics. After the entire learning process had been completed, posttest was administered to both groups to assess students learning outcomes. evaluate student creative and critical thinking skills.

Data Analysis

Research data were SPSS software was employed to perform the statistical analyses. The analysis process began with assumption testing, consisting of Shapiro–Wilk normality test and Levene's homogeneity test for examining normality and homogeneity assumptions. Subsequently, An Independent Samples t-test was performed to utilized investigate influence PjBL approach creative and critical thinking abilities separately. To determine whether the learning model simultaneously affected both dependent variables, MANOVA was also performed.

RESULTS AND DISCUSSION

Descriptive Analysis

Two classes were selected to participate in the study, with class VIII G was selected as the experimental group, whereas Class VIII H participated in control group. H assigned to control group. The experimental group was exposed to instruction based on the PjBL approach, while the control group students were taught by means of traditional methods instructional methods. Before conducting hypothesis testing, descriptive statistics were employed to examine the distribution and general characteristics of students' posttest performance in both groups. A summary of these descriptive statistical findings is provided in Table 2.

Table 2. Descriptive Statistics of Student Posttest Scores

Descriptive Statistic					
Class	N	Minimum	Maksimum	Mean	Standar Deviasi
VIII H (Control)	30	50	95	70,17	13,486
VIII G (Experimental)	30	65	100	83,83	9,621

Table 2 presents the descriptive statistics of posttest scores achieved by students in the experimental and control groups classes. According analysis, average score the posttest performance experimental group, who learned using *Project Based Learning* (PjBL), was 83.83. Meanwhile, the average posttest score of students in the control class, who received conventional learning, was 70.17. Additionally, the standard deviation in the experimental class was 9.621, which is smaller compared to the control class's 13.486. This indicates that the score distribution in the experimental class was more homogeneous. Descriptively, these results provide an initial indication that the application of PjBL potentially yields improved learning outcomes compared to conventional teaching methods.

Normality and Homogeneity Test

The normality data evaluated by the Shapiro Wilk test employed. This test selected due to number of participants in each group was below 50, making it suitable for small-sample analysis. The outcomes Table 3 presents the normality test result.

Table 3. Results of Normality Test for Posttest Data

Normality Test			
Class	Statistic	Shapiro Wilk df	Sig.
VIII H (Control)	0,933	30	0,059
VIII G (Experimental)	0,935	30	0,067

The outcomes displayed as shown indicate that the significance values for the control and experimental groups were 0.059 and 0.067, respectively. Because both values were greater than 0.05, the null hypothesis of normality was accepted, suggesting posttest data were normally distributed in both groups.

Following the normality assessment, Levene's Test was applied to evaluate whether the variances of the experimental and control groups were equal. Findings of the homogeneity test are summarized in Table 4.

Tabel 4. Results of Homogeneity Test for Posttest Data				
Homogeneity Test				
	Levene Statistic	df1	df2	Sig.
Based on Mean	3,364	1	58	,072
Based on Median	2,113	1	58	,151
Based on Median and with adjusted df	2,113	1	48,594	,152
Based on Trimmed Mean	3,611	1	58	,062

The outcome shown in Table 4 revealed a significance value of 0.072. Obtained value was above 0.05, indicating that homogeneity assumption of variances was satisfied. Consequently, result suggest that inferred that the experimental and control groups possessed homogeneous variances, fulfilling one of the requirements for subsequent parametric analyses.

Hypothesis Testing

To assess the effectiveness PjBL approach in developing students creative and critical thinking abilities, hypothesis testing was carried out utilizing the Independent Samples t-test. whether there were differences in students' creative and critical mathematical thinking abilities between those who learned using *Project Based Learning* (PjBL) were taught using conventional teaching methods. The test was conducted using a 5% significance level ($\alpha = 0.05$). Outcome are presented in Table 5

Table 5. Result Independent Sample t-test				
Independent Sample t-test				
		T-test for Equality of Means		
		df	Sig. (2-tailed)	Mean Difference
Nilai	Equal Variances Assumed	58	,000	-13,667

The Independent Sample t-test produced a two-tailed significance (Sig.) value of 0.000, which was well below the established significance level of 0.05. This result led to the rejection of the null hypothesis, confirming a significant statistical difference in learning outcomes

between the experimental group and the control group. Students in experimental group, who learned through PjBL approach, reached better performance in both creative and critical mathematical thinking than individuals in the control group receiving conventional instruction. The obtained results provide evidence that the PjBL model is effective in fostering higher-order thinking abilities, particularly in learning Systems of Linear Equations in Two Variables (SLETV).

To examine combined effect of the instructional model on both dependent variables, MANOVA was performed. Analysis was intended to assess whether implementing Project Based Learning (PjBL) approach produced a statistically influence effect on students' creative and critical thinking abilities while learning Systems of Linear Equations in Two Variables (SLETV). The outcomes MANOVA test are summarized in Table 6.

Table 6. Results of MANOVA Test

Multivariate Analysis of Variance (MANOVA)					
Effect		Value	F	Hypothesis df	Error df
Class	Wilks' Lambda	,535	24,741	2,000	57,000
					Sig. ,000

The multivariate test results shown in Table 6 indicate that the class variable produced a Wilks' Lambda F statistic of 24.731 yielding a p-value of 0.000. Because this value was substantially under 0.05 significance criterion, the null hypothesis could not be accepted. The outcomes of this study are consistent with the evidence obtained from the Independent Sample t-test, confirming the existence that the experimental and control groups differed significantly. Furthermore, the obtained results suggest PjBL approach has a meaningful impact not only on creative and critical thinking abilities individually but also on both cognitive abilities simultaneously, highlighting the model's effectiveness in developing advanced skills

Discussion

Research findings indicate prove application PjBL significantly improves impact regarding students critical thinking abilities. positive impact improving student ability to think creatively and critically compared to conventional learning.

The increase in creative thinking abilities occurs because, in *Project Based Learning*, students are trained to generate various ideas for solving problems within assigned projects. Creativity develops as students are exposed to freedom to generate ideas within a supportive learning environment (Beghetto, 2019). In the topic of SLETV, students are required to model real-world problems into mathematical forms using various strategies, which directly trains

indicators of fluency, flexibility, and novelty of ideas. *Project Based Learning* develops creativity through contextual learning approaches.

Furthermore, students' critical thinking skills also increased significantly. This is because *Project Based Learning* demands students to analyze problems, plan solutions, test strategies, and evaluate group work results. *Project Based Learning* effectively enhances critical thinking by engaging students in exploratory and problem-solving tasks (Anggraini et al., 2025).

The main advantage of *Project Based Learning* lies in its characteristics: student-centered, contextual, and collaborative. Unlike conventional learning, which is teacher-centered and tends to be theoretical, PjBL invites students to construct knowledge independently. In the topic of SLETV, which is abstract, the project-based approach makes concepts concrete and meaningful for students. Project Based Learning (PjBL) approach was found to effectively improves concept understanding and academic achievement in SLETV material (Untari et al., 2025).

Considering the findings and the discussion presented above, it can be concluded that described, this may be stated that the application of the *Project Based Learning* (PjBL) approach makes enhance contribution to improving student creative thinking and critical thinking skills mathematics. This learning model enables students to learn actively, collaboratively, and contextually, thereby developing the advanced thinking skills required mathematics learning and daily life.

CONCLUSION

Analytical results obtained in this study revealed that adoption PjBL approach has meaningful positive impact among students creative thinking abilities in learning Systems of Linear Equations in Two Variables (SLETV). Support for this conclusion comes from the independent samples t-test, which showed a p-value of 0.000, lower than the established threshold of 0.05. Furthermore, average posttest score of 83.83 was achieved by the experimental group, exceeding the average score of 70.17 obtained by students assigned to the control group. Effectiveness of PjBL may be explained by to its focus on project-based activities encourage learners to explore multiple ideas, apply different problem-solving approaches, and produce innovative solutions. Through these learning experiences, students are provided with opportunities to strengthen essential creative thinking in this study was evaluated using four indicators, namely fluency, flexibility, originality, and elaboration.

Study findings indicate PjBL contributes significantly to the enhancement students critical thinking abilities, as indicated by a p-value of less than 0.05. Unlike conventional learning, which tends to make students passive, PjBL demands active student involvement in interpreting problems, analyzing information, evaluating solutions, and drawing logical conclusions. The investigation process and group discussions within the PjBL syntax consistently train reasoning and deep thinking abilities, which are the core of critical thinking.

Simultaneously, the adoption of Project Based Learning approach significantly influences both creative and critical thinking ability. The MANOVA results obtained a significance value of $0.000 < 0.05$. These findings prove that both abilities develop in parallel and support each other during the learning process. Creative thinking is needed to find various ways of solving problems, while critical thinking is needed to analyze and select the most appropriate strategy. PjBL provides a learning environment that accommodates the development of both high-level thinking skills optimally.

Based on descriptive statistical analysis, the standard deviation value achieved by the experimental class was 9.621, smaller compared with the control class value of 13.486. This reveals that the distribution scores achieved in the experimental group was higher homogeneous. This means that learning using PjBL not only improves students' average abilities in general but also equalizes abilities among students, making learning outcomes more consistent and balanced for all students.

In light of the findings, the execution of PjBL in classroom teaching is recommended for mathematics instruction, particularly in topics that allow students to relate mathematical concepts to authentic real-world situations, including Systems of Linear Equations in Two Variables (SLETV). For future researchers, this study can be further developed by integrating technology or other learning media to maximize the potential of students' thinking skills more broadly.

ACKNOWLEDGMENTS

In this study, the author explains that great appreciation to everyone who has offered guidance, assistance, and contributions during the execution of the study and the writing of this manuscript article. Gratitude is conveyed to the supervisors for their valuable direction, input, and suggestions for the perfection of this research. Acknowledgments are

also extended to all lecturers Departments of Mathematics Education at University of Muhammadiyah Purwokerto for providing deep knowledge and insights during the study period.

The author also thanks the principal and mathematics teachers at SMP Negeri 2 Purbalingga for their permission and assistance in facilitating the data collection process. Gratitude is also conveyed to colleagues, beloved family, and friends who consistently provided motivation, prayers, and moral and material support. May all kindness and contributions given by all parties become valuable deeds and receive abundant blessings.

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