APPLICATION: Applied science in Learning Research
Vol. 5 No. 3 Feb 2026, Page. 178 - 186
E-ISSN: 2797-0655

The Influence of Project-Based Learning Model on Improving Students' Critical Thinking Skills at SMAN Mojoagung Jombang

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Abstract : *This study aims to examine the effect of implementing the Project Based Learning (PjBL) model on improving students' critical thinking skills in learning Systems of Linear Inequalities in Two Variables. The study is motivated by the low level of students' critical thinking skills in solving mathematical problems related to this topic, which requires analytical reasoning and logical conclusion drawing. The PjBL model is assumed to provide meaningful learning experiences by actively involving students in problem-solving activities, both individually and collaboratively. A quantitative approach with a pre-experimental one-group pretest–posttest design was employed in this study. The research subjects were 36 students of class X-1 at SMAN Mojoagung. Data were collected using a critical thinking skills test administered before and after the implementation of the PjBL model. Data analysis included a normality test using the Shapiro–Wilk method and a paired sample t-**test** to determine the significance of differences between pretest and posttest scores.The results indicate that the application of the PjBL model significantly improved students' critical thinking skills. The mean pretest score of 42.77 increased to 79.72 in the posttest. The normality test showed significance values of 0.053 for the pretest and 0.188 for the posttest, indicating that the data were normally distributed. Furthermore, the paired sample t-test produced a significance value of 0.000 ($p < 0.05$), confirming a significant difference between pretest and posttest results. These findings demonstrate that Project Based Learning is effective in enhancing students' critical thinking skills in learning systems of linear inequalities in two variables.*

Keywords : *Project based learning; Critical thinking; Linear inequality systems of two variable*

INTRODUCTION

In the context of rapid technological and informational development, education is increasingly challenged to prepare learners with higher-order thinking skills that enable them to respond to complex global demands. Competencies such as critical thinking, creativity, communication, and collaboration are no longer optional but constitute essential skills that must be intentionally cultivated, particularly at the secondary education level. Educational reform therefore extends beyond curricular restructuring to include the effective implementation of learning practices that foster active and meaningful engagement, especially in mathematics learning contexts (Ndiung, 2024).

Education holds a pivotal role in enhancing human resource quality and strengthening national competitiveness. In Indonesia, the Merdeka Curriculum was introduced to improve learning quality by emphasizing student-centered learning, where learners actively construct knowledge and develop advanced thinking abilities. Within this framework, teachers are expected to design flexible, engaging, and learner-oriented instructional activities that promote critical thinking, particularly in mathematics, a subject often perceived by students as abstract and challenging (Mulyawan et al., 2025).

Mathematics learning integrates cognitive, affective, and psychomotor domains to support students' conceptual understanding and academic achievement (Fitriani et al, 2022). However, findings from interviews with mathematics teachers and students at SMAN Mojoagung indicate that students' critical thinking skills remain limited. Many students rely heavily on procedural steps without adequately explaining their reasoning, validating solution processes, or evaluating alternative strategies. This condition is reflected in assessment results, where approximately 80% of students scored below 50, particularly on the topic of Systems of Linear Inequalities in Two Variables. These difficulties stem from limited conceptual understanding and frequent misinterpretation of solution regions and contextual meanings. Such challenges are closely linked to the continued use of conventional, teacher-centered instructional approaches that prioritize information delivery and routine exercises, offering minimal opportunities for students to engage in independent analysis or problem-solving (Hakiki, 2022).

Addressing this issue requires an instructional model that not only increases student participation but also systematically develops critical thinking skills. One instructional approach that has gained considerable attention in mathematics education research is Project Based Learning (PjBL). This model structures learning around authentic projects that are closely connected to real-life situations. Through project-based activities, students are encouraged to identify meaningful problems, gather and analyze information, and propose solutions grounded in real-world contexts, thereby supporting deeper understanding and reasoning (Musa'ad et al, 2024.).

According to the Buck Institute for Education and related studies, the PjBL model typically consists of six key phases: posing essential questions, designing project plans, developing timelines, monitoring learning progress, assessing project outcomes, and reflecting on both the process and final product (Anwar et al., 2024). These phases are pedagogically aligned with the development of mathematical critical thinking skills. Each phase of Project Based Learning contributes to specific aspects of critical thinking. The essential question phase promotes students' ability to interpret situations and clearly define problems. Project planning requires students to analyze available information, evaluate alternative strategies, and make informed decisions. During project implementation and monitoring, students engage in data collection, idea testing, evidence-based reasoning, and collaborative problem-solving. The product development and presentation phase strengthens students' ability to explain mathematical solutions logically and communicate

their reasoning effectively. Finally, the reflection and evaluation phase enhances metacognitive awareness by encouraging students to assess both their problem-solving processes and outcomes (Adinda, 2019).

Critical thinking indicators commonly refer to frameworks encompassing interpretation, analysis, evaluation, inference, and explanation (Facione, 2011). In mathematics education, these indicators are reflected in students' abilities to formulate problems, connect mathematical concepts and procedures, evaluate the validity of arguments, draw logical conclusions from representations or data, and reflect on solution processes. These competencies are particularly relevant to SPLDV learning, where students are required to model contextual situations mathematically, analyze feasible solution regions, and assess the applicability of solutions within real-life contexts (Sari & Juandi, 2024).

Empirical evidence from the past decade consistently demonstrates that PjBL positively influences mathematics learning outcomes and higher-order thinking skills, including critical thinking. Studies have shown that STEM-integrated PjBL enhances students' analytical and evaluative abilities, while PjBL-based instructional materials contribute significantly to improvements in problem-solving skills and mathematical creativity across educational levels (Khoiriyah et al., 2022)(Indriyani et al., 2022)(Sayekti & Suparman, 2020). Meta-analytic findings further confirm that PjBL effectively promotes critical thinking, particularly in analytical reasoning, evaluation, and conclusion-drawing among actively engaged learners (Umie et al., 2022)

Similar findings have been reported in Indonesian secondary education contexts, where project-based mathematics learning integrated with ethno-mathematics, PISA-like problems, or STEM 4.0 approaches has been shown to strengthen students' critical thinking skills and positive dispositions toward mathematic (Hakiki, 2022). These results highlight that PjBL not only enhances cognitive achievement but also supports the development of critical and creative learner characteristics essential for 21st-century education (Sukestiyarno et al., 2024)

Given that critical thinking is a fundamental competency in mathematics learning—requiring students to evaluate information, construct logical reasoning, and justify solutions—its development should be emphasized during secondary education, when systematic and rational thinking begins to mature (Wardani & Wijayanti, 2019). The observed low level of critical thinking skills among students on the SPLDV topic at SMAN Mojoagung underscores the need for structured project-based learning interventions explicitly designed to stimulate interpretation, analysis, evaluation, inference, and explanation within mathematics instruction (Adinda, 2019).

Based on these considerations, this study entitled "The Influence of Project-Based Learning Model on Improving Students' Critical Thinking Skills at SMAN Mojoagung Jombang" aims to examine the implementation of PjBL in SPLDV learning and analyze

improvements in students' mathematical critical thinking skills using interpretation, analysis, evaluation, inference, and explanation as assessment indicator.

METHOD

This study aims to examine the effect of Project Based Learning (PjBL) on improving students' critical thinking skills in the topic of systems of linear inequalities in two variables, conducted at SMAN Mojoagung in November 2025. This research employed a quantitative approach using a pre-experimental method to investigate the effect of Project Based Learning in classroom instruction. The population of this study consisted of Grade X students of SMAN Mojoagung. The research subjects were 36 students of class X-1. The instructional model applied in this study was Project Based Learning (PjBL) using a one-group pretest–posttest design. The research design is presented in the Table 1.

Table 1. Research Design

Group	*Pretest*	Treatment	*Posttest*
A	O_1	X	O_2

X = Treatment using Project Based Learning (PjBL)

O_1 = Pretest experimental group

O_2 = Posttest experimental group

This study was carried out through two main stages, namely the preparation stage and the implementation stage. Each stage was designed to ensure that the data collection process proceeded systematically, accurately, and in accordance with the research objectives

1. Preparation Stage
   a. Conducting Observations

      Preliminary observations were conducted at SMAN Mojoagung to obtain an overview of the learning conditions, student characteristics, and classroom environment. The observation process included a school survey, interviews with the subject teacher, and direct observation of the ongoing learning activities. The results of this observation served as the basis for developing the instructional materials
   b. Developing the Instructional Module

      The learning module was developed using the Project Based Learning (PjBL) model and was aligned with the topic of Systems of Linear Inequalities in Two Variables. The development process included formulating learning objectives, designing PjBL steps for each meeting, preparing student worksheets, and developing research instruments in the form of pretests and posttests. In implementing the PjBL model, students were assigned contextual problem-solving projects related to real-life situations, such as activity budget planning or analysis of simple production and sales problems that could be modeled using systems of linear inequalities in two variables. These projects were designed to encourage students to identify problems, formulate mathematical models, determine solution regions, and interpret the results according to the given context. The analytical thinking skills test instruments

were developed based on indicators that included the ability to identify problems, analyze relationships among concepts, formulate mathematical models, determine and interpret solutions, and evaluate problem-solving results. The pretest and posttest instruments were aligned with the learning objectives and the characteristics of the PjBL model to comprehensively measure changes in students' analytical thinking skills. All learning modules and supporting materials were completed prior to the implementation stage.

c. Sampling Procedure

The research sample was selected from class X-1. The class was chosen based on recommendations from the subject teacher and considerations of class characteristics relevant to the research objectives. After determining the sample, the researcher coordinated with the school and arranged the learning schedule.

2. Implementation Stage

a. Preliminery Activities

In this stage, the researcher provided an introduction to connect students' prior knowledge with the new material. Motivational activities were also delivered to increase students' enthusiasm for learning. The preliminary stage concluded with the administration of a pre-test to measure students' initial abilities before applying the PjBL model

b. Learning Activities

During the main instructional phase, students learned the material on Linear Inequality Systems in Two Variables through the Project Based Learning (PjBL) model. The researcher facilitated students as they engaged in all PjBL phases, including problem identification, project planning, project execution, report preparation, and presentation of their project results. Throughout the learning process, the researcher also observed and documented student activities.

c. Closing Activities

At the end of the lesson, a post-test was administered to determine the improvement in students' learning outcomes after the implementation of PjBL. Additionally, a reflection session was conducted to obtain students' responses and impressions regarding the learning model used.

RESULT AND DISCUSSION

1. Result

The implementation of the Project Based Learning (PjBL) model in this study was realized through the assignment of contextual problem-solving projects in the topic of Systems of Linear Inequalities in Two Variables. The projects required students to design solutions to real-world problems, such as preparing simple activity budget plans and analyzing production and sales problems that could be modeled using systems of linear inequalities in two variables. Through these projects, students were guided to identify

problems, formulate mathematical models, determine solution regions through graphical representations, and interpret the results in accordance with the given context.

The research results are presented in accordance with the learning stages designed in the research methodology. In the initial stage, students were given a pretes**t** to measure their analytical thinking skills prior to the implementation of the PjBL model. The pretest results indicated that most students experienced difficulties in identifying essential information in contextual problems and in formulating appropriate mathematical models. This condition was reflected in their limited ability to determine solution regions and interpret the meaning of SPLDV graphs. During the project implementation stage, students worked collaboratively in groups to complete the assigned projects following the PjBL syntax. Throughout this process, students were actively involved in discussions, information gathering, and mathematical modeling based on real-world problems. These activities encouraged students to analyze relationships among concepts and evaluate the solutions obtained. Qualitatively, an increase in student engagement and an improvement in their ability to explain the mathematical reasoning underlying each step of the solution were observed.

After the completion of all project-based learning activities, students were administered a posttest. The posttest results demonstrated a significant improvement compared to the pretest results. The effectiveness test employed in this study consisted of a normality test and a paired sample t-test. The normality test was conducted using the Shapiro–Wilk method with the assistance of SPSS Statistics 22, analyzing pretest and posttest scores. Data were considered normally distributed when the significance value exceeded 0.05. As the normality test indicated that the data were normally distributed, the analysis was continued using a paired sample t-test with SPSS Statistics 22. The results of the normality test are presented in Table 2, and the results of the paired sample t-test are presented in Table 3.

Table 2. Result of Normality Test

	Shapiro-Wilk		
	Statistic	df	Sig.
Pretest	.941	36	.053
Posttest	.958	36	.188

Based table 2 on the Shapiro–Wilk normality test, the significance value of the pretest was 0.053 and that of the posttest was 0.188. Since both values exceed 0.05, it can be concluded that the pretest and posttest data are normally distributed.

Table 3. Result 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	pretest – posttest	-35.55556	6.64807	1.10801	-37.80494	-33.30617	-32.090	35	.000

Furthermore on table 3, the paired sample t-test revealed a significance value of 0.000. This value is below the significance threshold of 0.05, indicating that H_0 is rejected and H_a is accepted. In other words, the application of the Project Based Learning (PjBL) model had a significant effect on improving students' critical thinking skills in the topic of systems of two-variable linear inequalities at SMAN Mojoagung Jombang.

2. Discussion

The research findings indicate a significant difference between pretest and posttest scores on the topic of Systems of Linear Inequalities in Two Variables. This improvement demonstrates that students experienced measurable progress after participating in project-based learning activities. The projects required students to design solutions to real-world problems, such as preparing simple activity budget plans and analyzing production and sales issues that could be modeled using systems of linear inequalities in two variables. Through these projects, students were guided to identify problems, formulate mathematical models, determine solution regions through graphical representations, and interpret the results according to the given context. Students also demonstrated increased engagement in discussions, greater confidence in expressing ideas, and stronger abilities to connect mathematical concepts with real-life situations.

The implementation of Project Based Learning (PjBL) enabled students to explore problems, collaborate in groups, and develop various problem-solving strategies. This active involvement encouraged students to think more critically, particularly when identifying problems, designing solution steps, and presenting their project outcomes. Such activities trained students to analyze information more deeply and make decisions based on logical reasoning. These findings are consistent with the results of the normality and paired sample t-tests, which confirmed that the data were normally distributed and that a significant difference occurred following the implementation of PjBL. This evidence strengthens the conclusion that PjBL is more effective in improving mathematics learning outcomes than conventional teacher-centered approaches, which provide fewer opportunities for active student participation.

Furthermore, project-based learning was found to enhance students' learning motivation. Students perceived the assigned tasks as more meaningful because they were directly involved in completing projects connected to real-life contexts. This made the learning process more relevant, enjoyable, and capable of fostering a stronger sense of responsibility toward the assigned tasks. Overall, the results of this study reinforce the conclusion that Project Based Learning is an effective instructional model for improving students' critical thinking skills in mathematics learning. By emphasizing collaboration, creativity, and problem solving, PjBL offers richer learning experiences and supports the development of essential 21st-century skills.

CONCLUSION

Based on the results of the normality test, the data were normally distributed, with significance values of 0.053 for the pretest and 0.188 for the posttest. Furthermore, the paired sample t-test revealed a significance value of 0.000, indicating that the implementation of the project based learning (PjBL) model had a significant effect on improving students' critical thinking skills in the topic of systems of linear inequalities in two variables at SMAN Mojoagung Jombang.

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