

Students Application of Project-Based Learning to Improve Critical Thinking Competencies in the 21st Century Era

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ABSTRACT

This study aims to analyze the influence of the project-based learning model (*PjBL*) on the critical thinking skills of high school students. The study used a quasi-experimental design with a *pretest-posttest control group* approach, involving two classes XI as subjects. The experimental class applied the *PjBL* model, while the control class used the conventional lecture method. The research instrument is a critical thinking test developed based on the Ennis indicator, including the ability to analyze, evaluate, and inference. The *results of the pretest* showed that both groups had a balanced level of critical thinking ability. After the intervention, there was a significant increase in scores in the experimental group, both for students with high and low ability categories. In contrast, the improvement in the control group was lower overall. The homogeneity test showed that the variance of the two groups was homogeneous ($p > 0.05$), so the *t test* could be performed. The results of the hypothesis test through variance analysis showed significant differences between the two groups ($p < 0.05$), which indicates that the *PjBL* model effectively improves students' critical thinking skills. These findings reinforce the argument that active, collaborative, and contextual learning like *PjBL* is particularly relevant in equipping students with 21st-century skills. It is recommended that teachers integrate the *PjBL* approach into the learning process to improve the quality of education as a whole.

Keywords: Project-based learning, active learning, 21st century skills

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INTRODUCTION

The rapid development of technology and information in the era of globalization has had a major impact on various aspects of life, including in the field of education. Students now live in the midst of a rapid and complex flow of information, which requires them to not only be passive recipients of information, but also to have the ability to sort out, analyze, and evaluate that information critically. In this context, critical thinking skills are a very important part of the 21st century competencies that every learner must have. Critical thinking allows students to understand various issues in depth, ask relevant questions, evaluate arguments objectively, and make the right decisions based on existing data and facts.

Unfortunately, the conventional education system, which is still predominantly used in various educational institutions, especially at the secondary school level, tends not to support the optimal development of critical thinking skills. Traditional learning methods that are teacher-centered and rely on one-way lectures provide less space for students to explore ideas, actively participate in discussions, or solve problems independently. Students are only expected to memorize the information conveyed by the teacher and repeat it in the form of exams or assignments without really understanding its essence. As a result, the critical thinking skills that should develop through reflective and interactive processes are hampered.

This is where the importance of implementing a more innovative and responsive learning model to the needs of students in the modern era. One of the approaches that is now increasingly used and proven to be effective is the *Project-Based Learning* (PjBL) model. PjBL is a learning approach that actively involves students in the learning process through working on projects that are directly related to the real world. In PjBL, students are faced with situations or problems that require collaborative and creative solutions, thus encouraging them to think critically and systematically.

The PjBL learning model has several main characteristics that support the development of critical thinking. First, learning begins with a real problem that is challenging and open to investigation. This problem encourages students to ask questions, formulate hypotheses, and actively seek information. Second, students work in groups to complete projects, which train the ability to communicate, collaborate, and listen to a variety of perspectives. Third, PjBL requires the existence of products or tangible results from the learning process, such as reports, presentations, posters, or prototypes, all of which require analysis, synthesis, and evaluation of the information collected. Fourth, learning is carried out in a meaningful and relevant context to students' lives, thereby increasing their motivation and engagement.

Various studies have shown that the application of the PjBL model is significantly able to improve students' critical thinking skills. Thomas (2000) states that well-designed projects will spur students to use high-level thinking in solving them. Similarly, Hmelo-Silver (2004) emphasizes that problem- and project-based approaches encourage students to evaluate evidence, make arguments, and consider various alternatives in decision-making. In the Indonesian context, Harahap and Manurung (2022) conducted a study on high school students in North Sumatra and found that the group of students using the PjBL model showed a significant increase in critical thinking scores compared to the group taught using traditional methods. In addition to improvements in cognitive aspects, students also show higher enthusiasm, a positive attitude towards learning, and a sense of responsibility for the tasks given.

The implementation of the PjBL model in learning in secondary schools can be carried out through several strategic stages. First, teachers must design projects based on the curriculum and student needs. A good project is one that contains elements of real problems, has a connection to students' lives, and can be solved with an interdisciplinary approach. Second, teachers need to provide guidance and learning resources that support students in developing projects, without taking over their learning process. Third, during the implementation of the project, the teacher plays the role of a facilitator who helps students in organizing work, overcoming obstacles, and reflecting on the process that has been running. Fourth, the results of the project are presented in the form of presentations or real products, which are assessed based on rubrics that include work processes, individual contributions, and the quality of critical thinking in solving problems. Assessment in PjBL does not only focus on the final result, but also includes the process and thinking skills shown during the activity.

However, the implementation of PjBL also faces several challenges. One of them is limited time and resources. In a curriculum-dense learning system, setting aside time for the

implementation of long-term projects is not easy. Additionally, not all teachers have enough knowledge and skills to design and manage projects effectively. Another obstacle is the resistance of students who are not used to active learning and demand greater individual responsibility. To overcome these obstacles, support from educational institutions is needed in the form of training for teachers, flexibility in the implementation of the curriculum, and the provision of supporting facilities and infrastructure. In addition, strengthening an active and collaborative learning culture needs to be built from an early age so that students are better prepared to participate in learning models such as PjBL.

Seeing the potential and benefits offered by PjBL, this model is worthy of being developed more widely in the Indonesian education system, especially in an effort to improve students' critical thinking skills. In an era of dynamic and challenging globalization, students need to be equipped with critical thinking skills to deal with complex and changing problems. Education is no longer enough to just transfer knowledge, but must be able to prepare a generation of learners who are independent, innovative, and able to make wise decisions.

In conclusion, critical thinking is an important skill that is urgently needed by students in the era of globalization. Traditional teacher-centered learning methods are no longer relevant for developing those skills. The project-based learning (PjBL) model offers a more active, collaborative, and contextual approach to shaping critical thinking skills. Through challenging and real-life projects, students learn to analyze problems, evaluate information, and make decisions based on the data obtained. With careful planning and support from all parties, PjBL can be a strategic solution in improving the quality of learning and forming a generation that is critical, creative, and ready to face future challenges.

METHODS

This study used a quasi-experimental design with a *pretest-posttest control group* approach. The subjects of the study consisted of two XI classes in one of the secondary schools, which were divided into an experimental group and a control group. The experimental group received treatment through *Project-Based Learning (PjBL)*, while the control group used the conventional lecture method. The research instrument is a critical thinking test developed based on critical thinking indicators, according to Ennis, including the ability to analyze, evaluate, and inference. Tests are given before and after treatment.

The data obtained was then analyzed using a *t-test* to find out if there was a significant difference in the improvement of critical thinking skills between the two groups. The results of the analysis became the basis for evaluating the effectiveness of the PjBL model in improving the critical thinking skills of high school students.

RESULT AND DISCUSSION

Result

Descriptive statistics

Table 1 Descriptive Statistics Critical Thinking Score (Pretest and Posttest)

Learning Model	Shoe Categories	Patrick (Average $\pm$ elementary school)	Post-tests (Average $\pm$ elementary school)	N
Experiment (PjBL)	Tall	65.20 $\pm$ 4.10	85.35 $\pm$ 3.80	15
	Low	58.10 $\pm$ 3.90	76.45 $\pm$ 4.25	15
	Entire	61.65 $\pm$ 4.50	80.90 $\pm$ 4.30	30

Learning Model	Shoe Categories	Patrick (Average $\pm$ elementary school)	Post-tests (Average $\pm$ elementary school)	N
Control (Talk)	Tall	64.80 $\pm$ 3.85	72.10 $\pm$ 4.00	15
	Low	57.50 $\pm$ 4.15	65.30 $\pm$ 4.35	15
Entire	Entire	61.15 $\pm$ 4.00	68.70 $\pm$ 4.20	30
	Tall	65.00 $\pm$ 3.95	78.73 $\pm$ 6.50	30
	Low	57.80 $\pm$ 4.02	70.88 $\pm$ 6.80	30
	Entire	61.40 $\pm$ 4.25	74.80 $\pm$ 6.60	60

Table 1 Descriptive Statistics provides an overview of students' critical thinking scores grouped by learning model (Experiment/PjBL and Control/Lecture) and ability categories (High and Low) before and after treatment (*pretest-posttest*).

In the Experimental group (PjBL), students in the high category had an average pretest score of 65.20 and increased to 85.35 in the posttest. Meanwhile, students in the low category also showed a significant increase, from 58.10 on the pretest to 76.45 on the posttest. Overall, the average score of all students in the experimental group increased from 61.65 to 80.90, indicating the positive influence of the project-based learning model on students' critical thinking skills.

On the other hand, in the Control (Lecture) group, the increase in critical thinking scores was not as large as the experimental group. Students with the high category increased from 64.80 to 72.10, and the low category from 57.50 to 65.30. The overall mean of the control group increased from 61.15 to 68.70. This shows that the lecture method has a smaller impact on the improvement of critical thinking compared to PjBL.

When viewed from the total of all students (combined of the two groups), students with high abilities increased from 65.00 to 78.73, while the low category increased from 57.80 to 70.88. The overall average of all students (total) increased from 61.40 in the pretest to 74.80 in the posttest.

In general, this data shows that learning using the Project-Based Learning (PjBL) model is consistently more effective in improving students' critical thinking scores compared to conventional lecture methods, both in students with high and low ability levels.

Homogeneity Test

Table 2 Variance homogeneity test (Levene test for variance equivalence)

Levene Statistics	df1	DF2	Signs (p)
1.532	1	58	0.221

The Variance Homogeneity Test table displays the results of Levene's Test for Equality of Variances, which is used to test whether the variance between two groups (Experiment and Control) is homogeneous or not, as one of the requirements for performing parametric tests such as *the* t-test. In the table, the Levene Statistic value is 1.532, with the degrees of freedom $df1 = 1$ and $df2 = 58$, and the significance value (Sig./p-value) of 0.221.

The Sig. value = 0.221 was greater than the significance level of 0.05 ($p > 0.05$), meaning that there was no significant difference in variance between the experimental and control groups. In other words, the variance of data from the two groups is declared homogeneous.

The conclusion of these results is that the homogeneity assumption is met, so that advanced statistical analysis such as the t-test to compare the averages of the two groups can be carried out legitimately and validly.

Test Hypothesis

Table 3 Inter-Subject Effects Test (Hypothesis Test)

Source	Type III Number of Squares	Df	Square Average	F	Sigs (p)
Corrected Model	1852.467	1	1852.467	19.732	0.000
Intercept	335273.600	1	335273.600	3572.192	0.000
Group	1852.467	1	1852.467	19.732	0.000
Error	5445.200	58	93.883		
Entire	342571.267	60			
Corrected Total	7297.667	59			

The results of the hypothesis test presented in the Table of *Tests of Between-Subjects Effects* showed that there was a significant difference between the experimental group that used the project-based learning model (PjBL) and the control group that used the lecture method in terms of improving students' critical thinking skills. This is shown by an F value of 19.732 with a significance value (Sig. = 0.000) that is smaller than the significance level of 0.05 ($p < 0.05$). This means that, statistically, the difference between the two groups is significant, and not caused by a factor of chance. The value of Type III Sum of Squares is 1852,467 and the same Mean Square shows the large contribution of the learning model to the difference in critical thinking scores.

Thus, it can be concluded that the application of the PjBL model has a positive and significant influence on improving students' critical thinking skills compared to the use of the lecture method. These results reinforce previous findings in descriptive statistics, where students in the experimental group experienced consistently higher score increases than students in the control group. This conclusion confirms that active, contextual, and student-centered learning such as PjBL is more effective in fostering critical thinking skills that are needed in the era of globalization and the 21st century.

Discussion

The Effectiveness of PjBL in Improving Critical Thinking Skills

The results of this study show that the Project-Based Learning (PjBL) model is significantly more effective in improving students' critical thinking skills compared to conventional lecture methods. This is evident from the increase in posttest scores in the experimental group which was higher than in the control group. This increase occurs not only in students with high ability, but also in students with low abilities. This means that PjBL is able to provide a fair and effective learning space for students with various levels of ability.

This finding is in line with research by Suparmi et al. (2024) which states that PjBL is able to develop students' critical thinking skills through learning activities that require active involvement, collaboration, and problem-solving based on real contexts. In PjBL, students are

not only recipients of information, but also producers of knowledge through investigation activities and presentation of project results that they develop independently or in groups.

Comparison with Conventional Methods

The lecture method is a learning approach that is still predominantly used in the context of conventional education. However, the effectiveness of this method in developing higher order thinking skills (HOTS) is increasingly doubtful. Based on the results of descriptive statistics, it is known that the increase in critical thinking scores in the control group taught by the lecture method only increased by about 7–8 points. This figure is far behind the experimental group that uses the Project-Based Learning (PjBL) approach, which recorded an increase of more than 15 points. This data reflects that lecture methods tend to be one-way and emphasize the verbal delivery of information from teachers to students without giving room for active participation in the critical thinking process.

One of the main drawbacks of the lecture method is its passive nature. Students are more likely to be recipients of information than to be active subjects in the learning process. This causes reflective, analytical, and evaluative thinking skills—key components of higher-level thinking—to not develop optimally. Irwanto and Murdiono (2019) emphasized that teacher-centered learning models, such as lectures, are only effective in encouraging basic cognitive abilities, namely memorization and understanding. More complex areas of thinking such as analysis, synthesis, and evaluation are often overlooked.

On the contrary, learning approaches such as PjBL are actually able to stimulate high-level thinking skills because they raise contextual problems that are close to students' real lives. Through PjBL, students are not only invited to understand the material, but also trained in identifying problems, formulating research questions, searching and processing data, and drawing conclusions based on the findings they have obtained themselves. This process encourages students to think systematically and logically, as well as develop problem-solving skills independently and collaboratively.

Thus, the lecture approach needs to be revisited in modern learning practices. To improve the quality of education and produce learners who are able to think critically, creatively, and reflectively, learning strategies are needed that encourage students' active participation and are relevant to the context of their lives. Project-based learning is one of the alternatives that has proven to be more effective in building high-level thinking skills that are needed in the face of the challenges of the 21st century.

Categorically Improving Critical Thinking Skills

Discussions based on score categories showed that both students with high and low abilities improved after participating in project-based learning. Students with high categories in the experimental group increased from an average score of 65.20 to 85.35. Meanwhile, students in the low category increased from 58.10 to 76.45. This means that PjBL can reach out and develop critical thinking skills of students with different cognitive backgrounds.

This is strengthened by the findings of Wahid (2024) who stated that the PjBL approach is flexible because it allows learning differentiation that suits the abilities of each student. In project-based learning, students are not only directed to understand the material, but also challenged to apply it in the completion of real tasks. This process stimulates reflective thinking, the ability to question, and argumentative decision-making—all of which are hallmarks of critical thinking.

The variance homogeneity test showed that the data from the experimental and control groups were homogeneous, with a significance value of 0.221 (> 0.05), meaning that there was

no significant difference in the variance of the two groups. Thus, *the t-test* and further analysis can be validly performed.

Furthermore, the hypothesis test conducted through *the Tests of Between-Subjects Effects* showed significant results with an F value of 19.732 and a significance (Sig.) of 0.000 ($p < 0.05$). This proves that the difference in the increase in critical thinking scores between the experimental and control groups did not occur by chance, but rather as a result of differences in treatment. This conclusion is consistent with a study by Ramadhani et al. (2024) which states that students who take part in PjBL learning have higher learning independence and critical thinking skills compared to students who are taught conventionally.

Implications for Curriculum Learning and Development

These findings provide strategic implications for educational practices, particularly at the secondary school level, which are currently moving towards a more contextual and character-development-oriented approach through the Independent Curriculum. The Project-Based Learning (PjBL) model has been proven to not only improve students' cognitive abilities, but also to form an attitude of responsibility, cooperation skills, and problem-solving skills independently and collaboratively. This is in line with the spirit of Merdeka Belajar which emphasizes meaningful, experiential, and relevant learning to students' real lives.

According to Darwis et al. (2022), the application of PjBL helps students build connections between lessons in the classroom and the realities of their lives outside of school. Learning is no longer theoretical and isolated, but rather a holistic experience that fosters students' critical thinking, creativity, and adaptability. This is very important in preparing the younger generation to face the challenges of an increasingly complex and dynamic future, both in the world of work and in social life.

However, the implementation of PjBL cannot be done instantly. Teacher readiness is needed in terms of learning planning, classroom management, and authentic project-based assessment. Teachers need to play the role of facilitators who are able to guide the student learning process actively and reflectively. Therefore, systemic support from the government, in the form of training, provision of time, and adequate facilities and infrastructure, is needed. National education policies need to seriously integrate and encourage project-based learning innovations as part of a more holistic, inclusive, and relevant education transformation to the needs of the 21st century.

CONCLUSION

The Project-Based Learning (PjBL) model has been proven to be effective in improving students' critical thinking skills at the secondary school level. PjBL provides space for students to be actively involved in the learning process through challenging and meaningful activities. In this model, students are not only passively receiving information, but encouraged to explore real problems, formulate questions, seek information, and present solutions. The process trains them in conducting in-depth analysis, evaluating various sources of information, and compiling logical and creative synthesis.

The critical thinking skills developed through PjBL are essential in facing the challenges of the 21st century, where students are required to be able to solve problems independently, work in teams, and make decisions based on data and strong argumentation. Therefore, it is recommended that educators start considering the application of PjBL as an alternative learning approach that is more effective than conventional methods. In addition to improving academic skills, PjBL also supports the development of students' soft skills such as communication, responsibility, and collaboration. The implementation of PjBL that is planned and supported by

an adequate learning environment will have a long-term positive impact on students' cognitive development and character.

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