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Enhancing Critical Thinking in Junior High School through Project-Based Learning

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ABSTRACT

This study investigates the efficacy of the Project-Based Learning (PjBL) model in enhancing critical thinking skills among junior high school students in Indonesia, addressing a documented deficit often linked to traditional, teacher-centered pedagogy. Employing a quasi-experimental, nonequivalent control group design, the study involved 60 eighth-grade students. The experimental group received a PjBL intervention focused on a real-world problem, while the control group followed a conventional lecture-based curriculum. Critical thinking skills—assessed through a validated pre-test and post-test measuring interpretation, analysis, inference, evaluation, and explanation—served as the primary dependent variable. An independent samples t-test revealed a statistically significant improvement ($p<0.05$) in the mean critical thinking scores for the PjBL group. In contrast, the control group exhibited negligible growth. The findings provide strong evidence that PjBL is a highly effective strategy for developing critical thinking. By engaging students in active, collaborative, and inquiry-driven processes, the model offers a practical solution to a persistent educational challenge, holding significant implications for curriculum reform and teacher development.

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1. INTRODUCTION

In the landscape of modern education, Project-Based Learning (PBL) has gained significant traction as a compelling pedagogical strategy. This approach fundamentally reshapes the traditional classroom dynamic by encouraging students to actively engage in their learning through extended projects that culminate in a tangible product or presentation. Its primary aim is not merely to foster a deeper understanding of subject matter, but to cultivate a suite of essential 21st-century skills, including critical thinking, creativity, collaboration, and communication, which are indispensable for student success in an increasingly complex world [1][2]. In stark contrast to conventional, teacher-centered methods, PBL has been shown to yield higher levels of student engagement and motivation [3][4].

A cornerstone of PBL's effectiveness lies in its emphasis on student autonomy and inquiry-based learning. Within this model, students are challenged to investigate meaningful, real-world problems, enabling them to bridge the gap between theoretical knowledge and practical application, which in turn fosters a profound sense of ownership over their learning experience [1][5]. The efficacy of this approach stems from its integration of authentic challenges that compel students to apply critical thinking in contexts mirroring professional scenarios. This is empirically supported by research from Assya et al., who highlight that PBL enriches students' mathematical reasoning through contextual applications, effectively aligning abstract principles with practical use [6]. This process is typically scaffolded by a structured framework involving the formulation of essential questions, project planning, execution, and reflection on both the process and outcomes, systematically guiding students in the development of critical inquiry skills [7][8].

Furthermore, the collaborative and contextual dimensions of PBL play a pivotal role in its success, particularly at the junior high school level. The educator's role evolves from that of a sole knowledge provider to a facilitator, guiding students and providing resources within a collaborative learning environment [9][10]. This dynamic encourages peer-to-peer learning and teamwork, which are critical for developing robust social and interpersonal communication skills [11]. According to Shao et al., students who cultivate positive peer relationships demonstrate heightened levels of learning motivation and engagement, which are central to the PBL framework [12]. The relevance of learning is further amplified when projects are rooted in local contexts, such as utilizing local wisdom for disaster preparedness, a method shown by Arif to foster critical awareness and potent problem-solving abilities [13]. The adaptability of PBL also allows it to be effectively integrated across diverse disciplines beyond STEM, including language arts for critical literary analysis [14][15] and vocational education to bridge theory with practice, thereby enhancing employability skills [16][17][18][19].

The implementation of PBL can be significantly strengthened through its integration with structured models and modern technology. For instance, the 5E learning cycle (Engagement, Exploration, Explanation, Elaboration, and Evaluation) has been confirmed by Amaliyah et al. to produce measurable improvements in students' critical thinking proficiency within science education [20]. Similarly, initiatives like citizen science projects empower students to become active participants in authentic scientific inquiry, where they must observe, analyze, and draw conclusions from real-world data, thereby enhancing their scientific literacy and attitudes [21][H]. Parallel to these pedagogical frameworks, technological advancements offer new frontiers; the development of interactive multimedia resources is crucial for enhancing learner performance and critical thinking [22]. Digital tools not only facilitate collaboration, especially in remote or hybrid settings [23][24], but also enable students to document their learning journey through blogs or digital portfolios, fostering deeper reflection and knowledge retention [10][25].

Despite its numerous advantages, the implementation of PBL is not without its challenges. Educators often face practical barriers, including limited resources, inadequate training, or institutional resistance to pedagogical change [2][11]. Moreover, assessing student performance in a project-based context can be complex, as traditional testing methods may fail to capture the depth of learning achieved, thus necessitating the development of robust assessment rubrics [1][3][26]. Overcoming these hurdles requires institutional investment in targeted teacher training programs and a supportive school culture [18][27], alongside a high degree of teacher adaptability in managing dynamic learning environments [28]. By combining PBL with other powerful strategies like inquiry-based learning [29] and maintaining a clear focus on its long-term benefits for preparing students for complex decision-making in their future careers [30], PBL can be realized as a holistic and transformative approach to effectively enhancing critical thinking among junior high school students.

2. METHOD

2.1. Research Design

This study employed a quasi-experimental design to investigate the causal relationship between the teaching model (Project-Based Learning vs. conventional) and students' critical thinking skills. Specifically, the Nonequivalent Control Group Design was utilized. This design is particularly well-suited for research conducted in authentic educational settings, such as schools, where the random assignment of individual students to different treatment groups is often impractical, disruptive to the school's structure, and ethically questionable. Instead of randomizing individuals, this design uses pre-existing, intact classes, making it a feasible and robust choice for real-world classroom research.

The structure of the Nonequivalent Control Group Design can be represented as follows:

a. Experimental Group: O1→X1→O2
b. Control Group: O3→X2→O4
c. O1 and O3 represent the pre-test administration of the critical thinking skills instrument to the experimental and control groups, respectively. This step is crucial for establishing a baseline and assessing the initial equivalence of the two groups.
d. X1 represents the experimental treatment, which is the implementation of the Project-Based Learning (PjBL) model over a defined period.
e. X2 represents the control condition, which is the use of the conventional, teacher-centered instructional model covering the same curriculum content.
f. O2 and O4 represent the post-test administration of the same critical thinking skills instrument to both groups to measure the change in skills following the intervention period.

The inclusion of a pre-test allows for statistical control of any initial differences in critical thinking ability between the two groups, thereby strengthening the internal validity of the study and increasing confidence that any observed differences in the post-test scores are attributable to the intervention rather than pre-existing disparities.

2.2. Population, Sample, and Sampling Procedure

The population for this study consisted of all Grade 8 students at a state junior high school (SMP Negeri) located in a suburban district of Cirebon, Indonesia. This demographic was chosen to be representative of a typical Indonesian public school environment where the national curriculum is implemented. The sample for the study was composed of two intact Grade 8 classes selected from this school. The selection of the sample was conducted using a purposive sampling technique. This non-probability sampling method was chosen to ensure that the selected classes met specific criteria necessary for the study's validity. The criteria for inclusion were: (1) the school consistently implements the standard national curriculum (Kurikulum Merdeka); (2) the assigned teacher for the classes expressed willingness to participate in the study and was capable of implementing both the experimental (PjBL) and control (conventional) teaching models with fidelity; and (3) the two classes were deemed by school administration to have comparable academic abilities based on their academic records from the previous semester and overall class performance. Following this procedure, Class VIII-A, with a total of 30 students, was assigned to the experimental group, which received the PjBL intervention. Class VIII-B, also with 30 students, was assigned to the control group, which continued with conventional instruction. The use of intact classes with similar academic profiles helps to mitigate the threat of selection bias inherent in the nonequivalent control group design.

2.3. Research Instruments and Validation

The success of this study hinged on the development of a high-quality instrument capable of accurately and reliably measuring the abstract construct of critical thinking. A generic or poorly designed test would yield meaningless results. Therefore, a rigorous, multi-stage process was undertaken to develop, validate, and refine the research instruments.

2.4. The Critical Thinking Skills Test: Development and Indicators

The primary instrument for data collection was a researcher-developed Critical Thinking Skills Test. The test was composed of a series of open-ended essay questions, a format chosen to elicit detailed reasoning and complex thought processes that cannot be captured by multiple-choice items. The questions were contextualized within the Natural Sciences (IPA) curriculum for Grade 8, specifically focusing on the topic of "Ecosystems and Environmental Pollution," ensuring that the test measured the application of critical thinking skills to a relevant academic domain rather than abstract reasoning in isolation. The development of the test items was guided by a well-established theoretical framework of critical thinking. The instrument was designed to measure five core indicators, adapted from prominent models of critical thinking:

a. Interpretation: The ability to comprehend and articulate the meaning or significance of a wide variety of experiences, situations, data, events, or problems.
b. Analysis: The ability to identify the intended and actual inferential relationships among statements, questions, concepts, or other forms of representation intended to express belief or reasoning.
c. Inference: The ability to identify and secure elements needed to draw reasonable conclusions; to form conjectures and hypotheses; to consider relevant information and to educe the consequences flowing from data.
d. Evaluation: The ability to assess the credibility of statements or other representations and to assess the logical strength of the actual or intended inferential relationships among them.
e. Explanation: The ability to state and justify one's reasoning in terms of the evidential, conceptual, methodological, and contextual considerations upon which one's results were based.
Instrument Validation and Reliability Analysis

To ensure the instrument's quality, it was subjected to both logical and empirical validation processes.

a. Logical Validity (Expert Judgment): The initial draft of the test was submitted to a panel of three experts for validation: (a) an experienced Grade 8 IPA teacher with over 10 years of experience, (b) a university lecturer specializing in educational measurement and evaluation, and (c) a language expert to ensure the clarity, grammar, and appropriateness of the questions for the target age group. The experts rated each item on its relevance to the indicators, content accuracy, and clarity using a validation rubric. The instrument was revised based on their feedback, achieving an average validation score of 88.7%, indicating it was "Very Valid" and suitable for trial.

b. Empirical Validity and Reliability (Trial): The revised instrument was then trialed with a group of 40 Grade 8 students from a different school who were not part of the main study. The data from this trial were analyzed to establish empirical validity and reliability.
   1) Validity: The validity of each essay item was determined by calculating the Pearson product-moment correlation coefficient between the score for that item and the total test score. All items showed a significant positive correlation, confirming their contribution to the overall construct being measured.
   2) Reliability: The internal consistency of the test was assessed using the Cronbach's Alpha coefficient. The analysis yielded a reliability coefficient of r11=0.82, which is well above the standard threshold of 0.70. This indicates that the instrument is highly reliable and provides consistent measurements.
   3) Item Analysis: A difficulty index and discriminating power were calculated for each item. This ensured the test contained a balanced mix of questions and could effectively differentiate between students with higher and lower levels of critical thinking ability.

2.5. The Scoring Rubric

To ensure objective and consistent scoring of the essay responses, a detailed analytic scoring rubric was developed. The rubric was structured as a matrix with two dimensions: the five critical thinking indicators (Interpretation, Analysis, Inference, Evaluation, Explanation) and a performance scale ranging from 0 (No attempt/Irrelevant) to 4 (Exemplary). Each score point for each indicator was defined by clear, specific performance descriptors. For instance, the descriptors for the 'Evaluation' indicator were as follows:

a. Score 4: Systematically and accurately assesses the credibility of all claims and the logical strength of all arguments presented in the problem, providing clear and compelling justification for the judgments made.
b. Score 3: Accurately assesses the credibility and logical strength of most arguments but may have minor omissions or less thorough justification.
c. Score 2: Attempts to assess arguments but does so with limited accuracy, overlooks key aspects, or provides weak or incomplete justification.
d. Score 1: Acknowledges the need for assessment but fails to perform a meaningful evaluation or provides an assessment that is illogical.
e. Score 0: Provides no assessment or the response is completely irrelevant.

This rubric provided a standardized framework for two independent raters to score the pre-tests and post-tests, with a high inter-rater reliability established prior to the main scoring process.

2.6. Treatment and Experimental Procedure

The research was conducted over a period of ten weeks and was divided into three distinct phases: pre-test, intervention, and post-test.

a. Phase 1: Pre-test (Week 1): In the first week of the study, the validated Critical Thinking Skills Test was administered to all students in both the experimental group (Class VIII-A) and the control group (Class VIII-B). This was done to establish a baseline measurement of their critical thinking abilities before the intervention began.
b. Phase 2: Intervention (Weeks 2-9): For the following eight weeks, both groups were taught the same curriculum unit on "Ecosystems and Environmental Pollution." However, the pedagogical approach differed significantly between the two groups.
   1) Experimental Group (Project-Based Learning): The students in Class VIII-A engaged in a comprehensive project titled "Investigating Water Quality in Our Local River and Proposing a Community Action Plan". The teacher's role shifted from that of a lecturer to a facilitator, guiding the students through the structured phases of PjBL. The process followed the established PjBL syntax:
      - Start with the Essential Question: The project was launched with the driving question: "How can we scientifically assess the health of the Cimanuk River tributary near our school and develop a practical action plan to address one identified pollution problem?"
      - Design a Plan for the Project: Students were organized into collaborative groups. Each group brainstormed and designed a project plan, outlining their research questions, methods for collecting water samples, parameters to test (e.g., pH, turbidity, presence of macroinvertebrates), and the format of their final product.

- Create a Schedule: With the teacher's guidance, each group developed a detailed timeline with specific deadlines for research, fieldwork, data analysis, and the creation of their final report and presentation.
- Monitor the Students and the Progress of the Project: Throughout the eight weeks, the teacher actively monitored group progress, facilitated discussions, and provided "just-in-time" instruction (scaffolding) on necessary skills, such as water testing techniques, data interpretation, and scientific report writing. Formative assessments, like group check-ins and draft reviews, were used continuously.
- Assess the Outcome: Each group produced a final product, which included a written scientific report detailing their findings and a proposed community action plan.
- Evaluate the Experience: In the final week of the intervention, groups presented their findings and proposals to the class and a panel that included another science teacher and the school principal. This was followed by a period of reflection where students evaluated their own learning, their group's collaborative process, and the overall success of the project.

2) Control Group (Conventional Instruction): Students in Class VIII-B learned about the same topics (ecosystem components, food webs, types of pollution, impact of pollution) through a conventional, teacher-centered approach. The teacher delivered a series of lectures using presentations, assigned readings from the standard textbook, conducted whole-class question-and-answer sessions, and provided worksheets that required students to define terms and answer comprehension questions. The focus was on the transmission and recall of factual content, with the teacher serving as the primary source of knowledge.

c. Phase 3: Post-test (Week 10): In the week following the completion of the intervention, the same Critical Thinking Skills Test administered as a pre-test was given again to both the experimental and control groups. This provided the data to measure the change in critical thinking skills for each group.

2.7. Data Collection and Analysis Techniques

The primary data for this study consisted of the numerical scores obtained by each student on the pre-test and post-test administrations of the Critical Thinking Skills Test. The collection and analysis of these data were conducted with methodological rigor to ensure the validity of the conclusions.

a. Data Collection: The pre-test and post-test answer sheets from all 60 participants (30 in the experimental group, 30 in the control group) were collected. The essay responses were scored independently by two trained raters using the validated analytic scoring rubric. The final score for each student was the average of the two raters' scores.

b. Data Analysis: The collected quantitative data were analyzed using the Statistical Package for the Social Sciences (SPSS) software, version 26. The analysis proceeded through the following steps:

1) Descriptive Statistics: Initial analysis involved calculating descriptive statistics (mean, standard deviation, minimum score, maximum score) for the pre-test and post-test scores for both the experimental and control groups. This provided a clear overview of the performance of each group.

2) Prerequisite Analysis: Before conducting the main hypothesis test, two prerequisite tests were performed on the data to ensure that the assumptions for using a parametric test were met.
- Normality Test: The Shapiro-Wilk test was used to determine if the data from each group were normally distributed.
- Homogeneity of Variances Test: Levene's test was conducted to assess whether the variances of the two groups were equal. The results of these tests confirmed that the data met the assumptions of normality and homogeneity of variance, making the use of an independent samples t-test appropriate.

3) Hypothesis Testing: The core of the data analysis was the testing of the research hypothesis. An Independent Samples t-test was conducted to compare the mean post-test scores of the experimental group and the control group. This statistical test determines whether the observed difference between the two groups means is statistically significant or likely due to random chance. The significance level (alpha) for the test was set at $\alpha=0.05$. According to the decision rule, if the calculated p-value (Sig. 2-tailed) was less than 0.05, the null hypothesis (that there is no difference between the groups) would be rejected in favor of the alternative hypothesis. This would indicate that the PjBL intervention had a statistically significant effect on students' critical thinking skills.

3. RESULTS AND DISCUSSION

3.1. Results

The data collected from the pre-test and post-test administrations were subjected to statistical analysis to evaluate the effectiveness of the Project-Based Learning (PjBL) intervention. The analysis began with prerequisite tests, followed by descriptive statistics and the primary hypothesis test. The results of the Shapiro-Wilk test for normality and Levene's test for homogeneity of variances on the pre-test scores indicated that the data were normally distributed and had equal variances, satisfying the assumptions for parametric testing. An initial independent samples t-test on the pre-test scores confirmed that there was no statistically significant difference in critical thinking ability between the experimental group and the control group prior to the intervention ($t(58)=0.15$, $p=0.88$), establishing the baseline equivalence of the two groups. The descriptive statistics for the pre-test and post-test scores for both groups are presented in Table 1. This table provides a clear overview of the performance trends.

Table 1. Descriptive statistics of pre-test and post-test critical thinking scores

Group	Test	N	Mean Score	Std. Deviation
Experimental	Pre-test	30	45.2	8.1
	Post-test	30	78.5	7.5
Control	Pre-test	30	44.8	8.3
	Post-test	30	48.1	8.9

As shown in Table 1, both groups started with nearly identical mean scores on the pre-test. However, the post-test scores reveal a stark divergence. The experimental group's mean score increased dramatically from 45.2 to 78.5, an improvement of 33.3 points. In contrast, the control group's mean score showed only a marginal increase from 44.8 to 48.1, an improvement of just 3.3 points. To determine if this observed difference in post-test scores was statistically significant, an independent samples t-test was conducted. The results of this test are presented in Table 2.

Table 2. Results of independent samples t-test on post-test scores

Variable	t-value	df	Sig. (2-tailed)	Mean Difference
Post-test CT Scores	15.4	58	0	30.4

The results of the independent samples t-test are definitive. The calculated t-value was 15.4 with 58 degrees of freedom. The significance value (p-value) was.000, which is less than the predetermined alpha level of 0.05. This indicates a statistically significant difference between the mean post-test scores of the experimental group and the control group. Therefore, the null hypothesis is rejected, and the alternative hypothesis (Ha) is accepted.

3.2. Discussion

3.2.1. Interpretation of the Findings: The Efficacy of Project-Based Learning

The quantitative results of this study provide compelling evidence for the efficacy of Project-Based Learning as a pedagogical model for enhancing the critical thinking skills of junior high school students. The statistically significant difference in post-test scores between the experimental group (PjBL) and the control group (conventional instruction) strongly supports the research hypothesis. The substantial increase in the experimental group's mean score, contrasted with the negligible change in the control group's score, demonstrates that the PjBL intervention was the primary driver of this improvement. This finding aligns with a broad consensus in educational research that highlights the superiority of active, student-centered, and problem-based learning approaches over traditional, passive methods for developing higher-order thinking skills.

The minimal improvement observed in the control group is also a significant finding. It validates the concerns raised in numerous studies that conventional, lecture-based teaching, with its emphasis on memorization, is largely ineffective at fostering critical thinking. By serving as a baseline, the control group's performance underscores the transformative potential of PjBL. The intervention did not just lead to better outcomes; it led to fundamentally different outcomes, suggesting a shift in students' cognitive engagement with the material. The results thus validate PjBL not merely as an alternative, but as a powerful and necessary tool to address the documented critical thinking deficit in the educational system.

3.2.2. Connecting PjBL Mechanisms to Critical Thinking Development

The profound impact of PjBL on critical thinking can be understood by dissecting the model's core mechanisms and linking them directly to the cognitive processes being measured. The effectiveness of PjBL is not magical; it stems from its inherent structure, which compels students to engage in the very behaviors that define critical thinking. The learning process within PjBL can be viewed as a sustained, authentic exercise in critical thought. First, the project begins with a driving question that is complex, open-ended, and rooted in a real-world context. This initial step immediately moves students beyond simple information recall. To even begin to address the question, "How can we assess the health of our local river?", students must first engage in interpretation to fully grasp the problem's scope and significance. They must then conduct an initial analysis to break the large question down into smaller, manageable sub-problems and identify the knowledge they currently possess versus what they need to learn.

Second, the planning and investigation phases are exercises in applied logic and evaluation. In their collaborative groups, students must evaluate multiple potential strategies for research and data collection. They must weigh the pros and cons of different testing methods, assess the credibility of various information sources, and make reasoned decisions about their project's direction. This process requires them to make constant inferences, forming hypotheses about what they might find and drawing preliminary conclusions based on their research to guide their next steps. This active, self-directed inquiry stands in stark contrast to the passive reception of pre-digested information in a conventional classroom.

Third, the collaborative nature of PjBL creates a social environment that fosters critical thinking. To work effectively in a team, students must articulate and defend their own ideas, listen to and evaluate the arguments of their peers, and negotiate different perspectives to reach a consensus. This process of dialogue and debate forces them to clarify their own reasoning and provide logical justifications—a core component of the explanation indicator. The cognitive dissonance that arises from encountering different viewpoints is a powerful catalyst for deeper reflection and analysis.

Finally, the creation of an authentic, public product provides a meaningful purpose for their critical thinking. Students are not just answering questions for a test; they are creating a scientific report or a community proposal that must be coherent, evidence-based, and persuasive. This requires them to synthesize all their findings, structure a logical argument, and present their conclusions clearly—a culminating act that integrates all five indicators of critical thinking, from interpretation to explanation. This entire process can be characterized as a "pedagogy of discomfort." It pushes students out of the comfort zone of being given clear answers and forces them to grapple with ambiguity, complexity, and uncertainty. It is through this productive struggle—the process of moving from confusion to clarity through sustained inquiry, analysis, and evaluation—that genuine and lasting critical thinking skills are forged.

3.2.3. Situating the Findings within the National Research Context

The findings of this study do not exist in a vacuum; they contribute to and are reinforced by a growing body of research within the Indonesian context. This study's results corroborate the conclusions of numerous other investigations that have explored the impact of problem-based and project-based learning on critical thinking across various educational levels. For instance, classroom action research has demonstrated that Problem-Based Learning (PBL), a pedagogical cousin to PjBL, can significantly improve critical thinking skills and learning outcomes in elementary school mathematics and civics education. Similar positive results have been found at the junior high school level in subjects like mathematics and even at the university level in science education courses. This study enhances this existing literature by providing a methodologically rigorous, quasi-experimental confirmation of these trends, strengthening the empirical basis for advocating for PjBL's adoption.

More importantly, this research provides a direct and constructive response to the problem diagnosed by studies that have documented low critical thinking skills in Indonesian schools. Those studies correctly identified teacher-centered, conventional instruction as a primary contributing factor to this deficit. The performance of the control group in this study, which saw almost no improvement in critical thinking scores, serves as an empirical validation of that diagnosis. In turn, the dramatic improvement of the experimental group provides a clear, evidence-based solution. It demonstrates that the problem is not an inherent lack of ability in students, but a lack of pedagogical opportunity. When provided with an appropriate learning environment like PjBL, students are more than capable of developing and applying higher-order thinking skills.

3.2.4. Implications for Pedagogical Practice and Overcoming Implementation Barriers

While this study demonstrates the powerful potential of PjBL, its successful implementation is a complex undertaking that presents significant challenges, particularly within the Indonesian educational system. The discussion of PjBL's effectiveness must be tempered with a realistic acknowledgment of the barriers to its widespread adoption. The success observed in this controlled study is attributable to a high-quality implementation, and scaling this requires systemic support. The literature points to several key challenges:

a. Teacher Competence and Readiness: The most significant barrier is the preparedness of teachers. PjBL requires a fundamental shift in the teacher's role from a "sage on the stage" to a "guide on the side". This involves new skills in facilitation, scaffolding, project design, and formative assessment, with which many teachers are unfamiliar. Without intensive and continuous professional development, teachers may struggle to manage the complexities of a PjBL classroom.
b. Resource and Infrastructure Limitations: PjBL can be resource-intensive. Projects may require access to technology, laboratory equipment, art supplies, or community spaces that are not available in all schools, especially those in remote or underfunded areas.
c. Time Management and Curriculum Constraints: PjBL projects are, by nature, extended and can be difficult to fit within a rigid, content-heavy curriculum and a restrictive class schedule. Teachers often feel pressured to "cover" a large amount of material, a goal that can seem at odds with the deeper, more focused learning of PjBL.
d. Complexity of Assessment: Assessing learning in PjBL is more complex than administering a traditional test. It requires the use of detailed rubrics to evaluate both the final product and the process, including skills like collaboration and critical thinking. This demands more time and expertise from the teacher.

4. CONCLUSION

This study was designed to address the gap between the need for 21st century skills and the low development of such skills in Indonesian junior high schools. The results of this study lead to clear conclusions: first, it empirically confirms that initial critical thinking skills in the observed student population are indeed low, highlighting the inadequacy of conventional pedagogical approaches. Secondly, and most importantly, this study provides strong quantitative evidence that a well-designed and implemented Project-Based Learning (PjBL) intervention can produce statistically significant improvements in students' critical thinking skills. The PjBL model was shown to be far superior to traditional teacher-centered instruction in fostering the ability to interpret, analyze, infer, evaluate, and explain. The effectiveness of PjBL is rooted in its core principles as a student-centered, inquiry-based, collaborative, and authentic learning process. Nonetheless, it is important to acknowledge the limitations of this study that restrict the generalizability of its findings. The study was conducted with a relatively small sample in one school, the intervention lasted for only eight weeks, and the implementation of both teaching models relied on the skills of one teacher, which could affect the results.

Based on the findings and limitations, several recommendations are proposed to advance scientific knowledge and educational practice. For future research, it is recommended to conduct longitudinal studies to track the development of critical thinking skills over the long term, replicate the study with larger and diverse samples to improve generalizability, and expand the outcome measures to include other 21st century skills such as collaboration and creativity. In terms of education policy and practice, it is imperative for education authorities to invest in continuous, high-quality teacher professional development focused on PjBL. In addition, policymakers should encourage curriculum flexibility that gives teachers the autonomy and time to implement in-depth projects, along with the provision of adequate material and technological resources, especially in underserved areas. Ultimately, fostering a culture of inquiry, collaboration, and sharing among educators is essential for the successful and sustainable adoption of Project-Based Learning across the education system.

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