The Impact of Project-Based Learning on Critical Thinking Skills in Secondary Education

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Abstract- ***This empirical study investigates the impact of project-based learning (PBL) on critical thinking skills among secondary school students through a quasi-experimental design involving 320 participants (160 in the PBL group and 160 in the traditional instruction group) from diverse educational settings, utilizing pre- and post-test assessments of critical thinking abilities measured through the Watson-Glaser Critical Thinking Appraisal, where statistical analyses, including paired t-tests and ANCOVA, revealed that students exposed to PBL demonstrated significantly higher gains in critical thinking skills ($p < 0.05$) compared to their peers in conventional learning environments, with qualitative data from student reflections and teacher interviews supporting these findings by highlighting enhanced problem-solving abilities, improved reasoning skills, increased engagement, and a greater ability to analyze complex issues, thereby suggesting that PBL serves as an effective pedagogical strategy for fostering critical thinking in secondary education while also emphasizing the importance of collaborative learning, real-world problem-solving, and self-directed inquiry as essential components in developing higher-order cognitive skills necessary for academic success and lifelong learning.***

Index Terms- ***Project-Based Learning (PBL), Critical Thinking Skills, Secondary Education, Quasi-Experimental Design, Student Engagement, Higher-Order Cognitive Skills***

I. INTRODUCTION

In the context of 21st-century education, where the ability to analyze, evaluate, and create knowledge is paramount, critical thinking has emerged as a fundamental skill for students to navigate complex real-world problems (Facione, 2011), and while traditional teacher-centered instructional methods often emphasize rote memorization rather than fostering higher-order thinking, project-based learning (PBL) has gained significant attention as an innovative, student-centered pedagogical approach that enhances critical thinking by engaging students in inquiry-driven, collaborative, and real-world problem-solving tasks (Barron & Darling-Hammond, 2008), with empirical studies demonstrating that students exposed to PBL outperform their traditionally taught peers in terms of reasoning, argumentation, and decision-making skills (Hmelo-Silver, 2004), particularly in secondary education where developing critical thinking is crucial for academic success and lifelong learning (Halpern, 2014), and as secondary education serves as a pivotal stage in cognitive development, several researchers have highlighted the need to integrate methodologies that actively promote analytical thinking rather than passive knowledge absorption (Ennis, 2011), with findings indicating that PBL fosters intellectual autonomy by allowing students to explore open-ended questions, engage in evidence-based reasoning, and develop solutions that require synthesizing information across multiple disciplines (Thomas, 2000), while comparative studies between traditional instruction and PBL reveal that students engaged in PBL demonstrate significantly higher gains in problem-solving, logical reasoning, and metacognitive skills, as evidenced in controlled experimental studies that measured critical thinking using standardized assessments such as the Watson-Glaser Critical Thinking Appraisal (Strobel & van Barneveld, 2009), and despite these promising results, challenges such as teacher preparedness, curriculum integration, and assessment of critical thinking outcomes remain key barriers to widespread PBL implementation (Tamim & Grant, 2013), thereby necessitating further empirical research to evaluate the efficacy of PBL in enhancing critical thinking in diverse educational contexts, with this study aiming to contribute to the existing literature by conducting a quasi-experimental investigation with a sample of

secondary school students to measure the impact of PBL on their critical thinking skills, while also incorporating qualitative insights from student reflections and teacher interviews to understand the broader implications of PBL in fostering higher-order cognitive abilities essential for academic and professional success in the 21st century.

Theoretical foundations of Project-Based Learning (Constructivism, Inquiry-Based Learning, etc.)

Grounded in the principles of constructivism, inquiry-based learning, and experiential learning, Project-Based Learning (PBL) emphasizes student-centered exploration, active knowledge construction, and real-world problem-solving as opposed to passive knowledge reception (Piaget, 1950), with constructivist theorists arguing that learning occurs most effectively when students actively engage with content through authentic, hands-on experiences that require critical thinking, collaboration, and reflection (Vygotsky, 1978), while Dewey's (1938) experiential learning theory further reinforces the idea that meaningful education emerges when students participate in inquiry-driven activities that mirror real-world challenges, thereby fostering deep understanding and cognitive flexibility, and as PBL aligns with Bruner's (1961) discovery learning model, which posits that learners construct new knowledge based on prior experiences and active engagement, research suggests that inquiry-based learning, a foundational element of PBL, enhances critical thinking by encouraging students to formulate questions, develop hypotheses, and systematically explore solutions in a self-directed manner (Hmelo-Silver, Duncan, & Chinn, 2007), while studies on situated learning theory emphasize that knowledge is best acquired within relevant, problem-rich contexts where students collaborate to construct meaning (Lave & Wenger, 1991), and as a result, empirical research has demonstrated that students engaged in PBL develop higher-order cognitive skills, including analysis, evaluation, and synthesis, due to the emphasis on open-ended inquiry, interdisciplinary problem-solving, and real-world application of knowledge (Barron & Darling-Hammond, 2008), whereas meta-analytic studies comparing PBL with traditional lecture-based instruction indicate that PBL fosters deeper learning outcomes, greater intrinsic motivation, and enhanced metacognitive awareness (Dochy, Segers, Van den Bossche, & Gijbels, 2003), thereby validating its effectiveness as an instructional approach grounded in constructivist and inquiry-based learning principles that not only promote knowledge acquisition but also cultivate critical thinking skills essential for secondary education and lifelong learning.

Overview of Project-Based Learning (PBL) as a pedagogical approach

Project-Based Learning (PBL) is an instructional methodology that emphasizes active student engagement, inquiry-driven learning, and real-world application of knowledge, wherein students collaborate on complex, interdisciplinary projects that require critical thinking, problem-solving, and self-directed learning (Bell, 2010), and unlike traditional teacher-centered approaches that focus on passive content delivery, PBL encourages students to construct their own understanding through hands-on exploration, iterative problem-solving, and reflective inquiry, aligning with constructivist principles that advocate for meaningful, context-driven learning experiences (Krajcik & Blumenfeld, 2006), while empirical studies have shown that PBL enhances student motivation, engagement, and deeper conceptual understanding by situating learning within authentic tasks that mirror professional and academic challenges (Barron & Darling-Hammond, 2008), and as PBL fosters the development of higher-order cognitive skills, including analysis, evaluation, and synthesis, it has been widely implemented across various disciplines, particularly in STEM education, where students engage in open-ended investigations, design innovative solutions, and apply theoretical knowledge to practical scenarios (Hmelo-Silver, 2004), with research indicating that PBL students demonstrate superior problem-solving abilities and metacognitive awareness compared to their traditionally taught peers, as evidenced in controlled experimental studies assessing critical thinking using standardized measures (Holmes & Hwang, 2016), while meta-analyses further confirm that PBL contributes to long-term knowledge retention, collaborative skills, and the ability to apply learned concepts in novel situations, reinforcing its effectiveness as a transformative pedagogical strategy (Walker & Leary, 2009), and despite its numerous benefits, challenges such as curriculum integration,

teacher training, and assessment of student outcomes remain key considerations for educators seeking to implement PBL effectively in secondary education, thereby necessitating further empirical investigations into best practices for optimizing its impact on student learning and critical thinking development.

Literature review related to the study

Critical thinking, widely defined as the ability to analyze, evaluate, and synthesize information to make reasoned judgments and solve complex problems, has been recognized as an essential cognitive skill for academic success and lifelong learning (Facione, 2011), and as contemporary education shifts towards developing higher-order thinking skills rather than rote memorization, scholars emphasize the need for pedagogical approaches like Project-Based Learning (PBL) that actively engage students in inquiry-driven, real-world problem-solving tasks to foster critical reasoning and decision-making abilities (Halpern, 2014), with constructivist theories forming the foundation of PBL by advocating for student-centered learning experiences where knowledge is constructed rather than transmitted (Piaget, 1950), while Vygotsky's (1978) theory of social constructivism highlights the importance of collaborative learning and scaffolding in developing cognitive skills, and as inquiry-based learning, a core principle of PBL, encourages students to pose questions, investigate solutions, and reflect on their learning process (Hmelo-Silver, 2004), research has consistently shown that PBL leads to deeper conceptual understanding, increased engagement, and improved problem-solving abilities compared to traditional direct instruction (Barron & Darling-Hammond, 2008), with meta-analyses demonstrating that students engaged in PBL outperform their traditionally taught peers in areas such as logical reasoning, argumentation, and creativity (Walker & Leary, 2009), and comparative studies indicate that while traditional instruction often emphasizes passive knowledge acquisition through lectures and textbook-based learning, PBL promotes active knowledge construction, allowing students to apply theoretical concepts to practical, interdisciplinary challenges that require higher-order thinking (Hmelo-Silver, Duncan, & Chinn, 2007), with experimental research showing that students exposed to PBL demonstrate significantly higher gains in critical thinking skills when assessed using standardized measures such as the Watson-Glaser Critical Thinking Appraisal (Holmes & Hwang, 2016), while the benefits of PBL extend beyond academic performance by fostering collaboration, self-regulation, and intrinsic motivation (Krajcik & Blumenfeld, 2006), challenges such as the need for extensive teacher training, curriculum alignment, and effective assessment strategies remain key barriers to widespread implementation in secondary education (Tamim & Grant, 2013), as educators often struggle with balancing the demands of standardized curricula with the open-ended nature of PBL (Ertmer & Simons, 2006), and despite these challenges, research suggests that with proper scaffolding, technology integration, and instructional support, PBL can serve as a transformative educational approach that not only enhances critical thinking but also prepares students for the cognitive demands of higher education and the workforce (Thomas, 2000), thereby necessitating further empirical research to explore effective strategies for optimizing PBL implementation in diverse educational contexts.

II. METHODOLOGY ADOPTED FOR THE STUDY

This study employs a quasi-experimental design to investigate the impact of Project-Based Learning (PBL) on critical thinking skills among secondary school students, involving 320 participants (160 in the PBL group and 160 in the traditional instruction group) selected from diverse educational settings based on stratified random sampling to ensure representation across different demographics, academic abilities, and socioeconomic backgrounds (Creswell, 2014), with the research conducted across multiple secondary schools, focusing on students in grades 9 to 11 across core subject areas such as science, mathematics, and social studies, where the experimental group engaged in structured PBL activities incorporating student-driven inquiry, collaborative problem-solving, and interdisciplinary projects, while the control group followed a conventional teacher-centered instructional approach emphasizing lectures, textbooks, and guided exercises (Slavin, 2007), and to assess the impact of PBL on critical thinking, the study utilized a pre- and post-test design employing the Watson-Glaser Critical Thinking Appraisal, a standardized measure

evaluating inference, recognition of assumptions, deduction, interpretation, and evaluation of arguments (Watson & Glaser, 2008), complemented by qualitative data collection through structured student reflections and semi-structured teacher interviews to gain insights into perceived cognitive and engagement-related benefits (Merriam & Tisdell, 2015), while data analysis involved paired t-tests to determine within-group improvements and ANCOVA to compare post-test performance across groups while controlling for pre-test scores, with results indicating that students in the PBL group exhibited significantly higher gains in critical thinking skills ($p < 0.05$) compared to the traditional instruction group, particularly in areas of logical reasoning, problem-solving, and analytical thinking, and further thematic analysis of qualitative responses revealed that PBL students demonstrated increased engagement, self-regulation, and deeper conceptual understanding, thereby reinforcing the pedagogical effectiveness of PBL, although ethical considerations, including informed consent, anonymity, and voluntary participation, were strictly adhered to in accordance with educational research ethics (BERA, 2011), ensuring that students and teachers participated without coercion and with a full understanding of the study's purpose, ultimately providing empirical evidence supporting PBL as a transformative instructional strategy that fosters higher-order cognitive skills essential for academic and real-world problem-solving.

Data analysis and interpretation

Statistical Analysis: Paired t-tests and ANCOVA

1. Paired t-tests

The paired t-test is used to compare pre-test and post-test critical thinking scores within each group (PBL and traditional instruction) to determine whether students showed significant improvements over time.

Hypotheses for Paired t-tests:

- Null Hypothesis (H_0): There is no significant difference between pre-test and post-test scores within each group.
- Alternative Hypothesis (H_a): There is a significant difference between pre-test and post-test scores within each group.

Paired t-test Formula:

where:

- $\bar{d}$ = mean difference between pre-test and post-test scores,
- s_d= standard deviation of the differences,
- n = number of participants in the group.

Results of Paired t-tests:

- PBL Group:
- Mean Pre-test Score: 45.2 (SD = 8.4)
- Mean Post-test Score: 62.5 (SD = 7.9)
- Mean Difference ($\bar{d}$\bar{d}$\bar{d}$) = 17.3
- t (159) = 12.45, $p < 0.001$ (statistically significant)

- Traditional Instruction Group:
- Mean Pre-test Score: 44.9 (SD = 8.6)
- Mean Post-test Score: 51.3 (SD = 8.2)
- Mean Difference ($\bar{d}$\bar{d}$\bar{d}$) = 6.4
- t (159) = 5.87, $p < 0.001$ (statistically significant)

Interpretation:

Both groups showed statistically significant improvements in critical thinking scores ($p < 0.001$). However, the PBL group had a greater improvement (mean increase = 17.3) compared to the traditional instruction group (mean increase = 6.4), indicating a stronger impact of PBL on critical thinking.

2. ANCOVA (Analysis of Covariance)

The ANCOVA is used to compare post-test critical thinking scores between the PBL and traditional instruction groups while controlling for pre-test scores.

Hypotheses for ANCOVA:

- Null Hypothesis (H_0): There is no significant difference in post-test scores between the PBL and traditional instruction groups after controlling for pre-test scores.
- Alternative Hypothesis (H_a): There is a significant difference in post-test scores between the PBL and traditional instruction groups after controlling for pre-test scores.

ANCOVA Model:

$Y_{post}=\beta 0+\beta 1 X_{pre}+\beta 2 Group+\epsilon$

where:

- Y_{post} = post-test score (dependent variable),
- X_{pre} = pre-test score (covariate),

- Group = categorical independent variable (PBL vs. traditional),
- ϵ = error term.

Results of ANCOVA:
- Effect of Pre-test Score: F (1,317) =42.38, p<0.001 (significant covariate)
- Effect of Group (PBL vs. Traditional): F(1,317)=61.75, p<0.001 (significant difference)
- Adjusted Post-test Mean Scores:
  - PBL Group: 62.3 (adjusted for pre-test)
  - Traditional Instruction Group: 51.5 (adjusted for pre-test)
- Partial Eta Squared (ηp2\eta^2_pηp2) = 0.16, indicating a moderate to large effect size of PBL on critical thinking.

Interpretation:
The ANCOVA results indicate that even after controlling for pre-test scores, students in the PBL group had significantly higher post-test critical thinking scores compared to the traditional instruction group (p<0.001p < 0.001p<0.001). The moderate-to-large effect size (ηp2=0.16) suggests that PBL has a substantial positive impact on developing critical thinking skills.

Paired t-tests confirmed that both groups improved, but PBL students had significantly greater gains. ANCOVA demonstrated that the PBL group's higher post-test scores were not due to pre-existing differences, reinforcing the effectiveness of PBL in fostering critical thinking. The statistical significance (p < 0.001) and moderate-to-large effect size (ηp2=0.16) suggest that PBL is a highly effective instructional strategy for improving critical thinking skills in secondary education.

Results and findings related to the study

Paired t-tests Results: Within-Group Comparisons

Objective: To determine if there were significant improvements in critical thinking scores within each group (PBL and Traditional Instruction) from pre-test to post-test.

PBL Group
- Pre-test Mean Score: 45.2 (SD = 8.4)
- Post-test Mean Score: 62.5 (SD = 7.9)
- Mean Improvement: +17.3 points
- t (159) = 12.45, p < 0.001 (Statistically significant improvement)

Traditional Instruction Group
- Pre-test Mean Score: 44.9 (SD = 8.6)
- Post-test Mean Score: 51.3 (SD = 8.2)
- Mean Improvement: +6.4 points
- t (159) = 5.87, p < 0.001 (Statistically significant improvement)

Both groups showed significant improvements, but PBL students exhibited substantially higher gains (+17.3 vs. +6.4 points), indicating that PBL was more effective in fostering critical thinking.

ANCOVA Results: Between-Group Comparisons
Objective: To compare post-test scores between the PBL and traditional instruction groups while controlling for pre-test scores.
- Effect of Pre-test Scores (Covariate): F (1,317) =42.38, p<0.001F (significant influence on post-test scores)
- Effect of Group (PBL vs. Traditional Instruction): F (1,317) =61.75, p<0.001 (significant difference in post-test scores)

Adjusted Post-test Mean Scores:
- PBL Group: 62.3 (adjusted for pre-test scores)
- Traditional Instruction Group: 51.5 (adjusted for pre-test scores)

Effect Size (ηp2): 0.16 (moderate-to-large impact of PBL on critical thinking skills)

Even after controlling for pre-test scores, students in the PBL group had significantly higher critical thinking scores than those in the traditional instruction group.

Major Findings related to the study

i. PBL Significantly Enhances Critical Thinking Skills

- Students exposed to PBL showed significantly greater improvements in critical thinking compared to those in traditional instruction.
- The mean improvement in the PBL group (+17.3 points) was nearly three times greater than in the traditional group (+6.4 points).

ii. PBL Leads to Higher-Order Cognitive Gains

Areas of improvement:

a. Logical reasoning
b. Problem-solving skills
c. Analytical thinking
d. Inference and evaluation of arguments

Qualitative data (student reflections and teacher interviews) supported this, with students in the PBL group demonstrating higher engagement, self-regulation, and deeper conceptual understanding.

iii. PBL Encourages Active and Collaborative Learning

- Students in the PBL group reported greater engagement and motivation, attributing their progress to hands-on problem-solving and teamwork.
- Teachers observed that PBL students were more proactive in seeking solutions and evaluating multiple perspectives.

iv. PBL Has a Substantial Educational Impact

- The effect size of 0.16 (partial eta squared) indicates that PBL has a moderate-to-large impact on critical thinking development.
- PBL should be integrated into secondary education curricula to foster critical thinking, which is essential for academic success and real-world problem-solving.

This study provides strong empirical evidence that PBL is a highly effective instructional strategy for improving critical thinking skills in secondary education. The statistical findings support the notion that PBL fosters deeper cognitive engagement, problem-solving abilities, and analytical reasoning compared to traditional methods.

III. KEY PATTERNS AND THEMES EMERGING FROM THE DATA

The study reveals that Project-Based Learning (PBL) significantly enhances critical thinking skills among secondary students compared to traditional instruction, as demonstrated by higher post-test mean scores (PBL: 62.3, Traditional: 51.5) and greater mean improvement (PBL: +17.3, Traditional: +6.4), $p < 0.001$ (Watson & Glaser, 2008), with ANCOVA results indicating a substantial effect size (ηp2=0.16\eta^2_p = 0.16ηp2=0.16) (Slavin, 2007), suggesting that PBL fosters logical reasoning, problem-solving, and analytical thinking through active, student-centered learning approaches that emphasize collaboration, real-world problem-solving, and inquiry-driven tasks, further supported by qualitative data from student reflections and teacher interviews, which highlight that PBL students demonstrated higher engagement, self-regulation, and deeper conceptual understanding compared to their peers in conventional classrooms (Merriam & Tisdell, 2015), while paired t-tests confirm statistically significant within-group improvements in both instructional methods (PBL: $t(159) = 12.45$, Traditional: $t(159) = 5.87$, $p < 0.001$), but with notably stronger gains in PBL settings, indicating that PBL cultivates higher-order cognitive skills essential for academic success and real-world applications (Creswell, 2014), further reinforced by studies demonstrating that students in inquiry-based learning environments exhibit stronger reasoning and analytical capabilities than those in direct instruction models (Hmelo-Silver, 2004), with additional thematic analysis revealing that PBL fosters interdisciplinary learning, enhances student motivation, and encourages the application of knowledge to novel contexts, aligning with findings that active learning approaches improve retention and critical thinking (Prince, 2004), as illustrated by examples where students engaged in real-world problem-solving scenarios such as designing sustainable cities or analyzing historical events through debate showed higher critical thinking scores and deeper conceptual engagement (Barron & Darling-Hammond, 2008), ultimately reinforcing the pedagogical effectiveness of PBL in developing analytical reasoning, problem-solving skills, and cognitive flexibility in secondary education (Kolodner et al., 2003).

IV. DISCUSSION RELATED TO THE STUDY

These findings are consistent with the literature showing the ability of Project-Based Learning (PBL) in improving critical thinking among secondary school students ($p < 0.001$) (Watson & Glaser, 2008), and further supported by an ANCOVA ($F(1,317)=61.75, p<0.001, \eta p2=0.16F$ indicating a moderate-to-large effect size, supporting previous research suggesting that student-centered, inquiry-based pedagogies are more effective than direct instruction for cognitive engagement and analytical reasoning (Hmelo-Silver, 2004) while additional qualitative insights gathered from student reflections and teacher interviews revealed that PBL students were more engaged, self-regulated and motivated to explore complex issues (Merriam & Tisdell, 2015) highlighting a pedagogical shift away from a passive learning environment towards real-world problem solving through collaboration and self-directed inquiry to build the critical thinking skills needed for academic and lifelong learning (Prince, 2004), yet despite these strengths, there are limitations to this study including the potential for variability in PBL implementation given the nature of design and such factors as varying school resources impacting instructional quality and the Watson-Glaser Critical Thinking Appraisal, while widely used, may not measure other higher-order skills developed through PBL such as creativity and metacognition (Creswell, 2014), and thus requiring further longitudinal studies with multiple assessments to demonstrate PBL's long term impact on higher-order thinking skills (Slavin, 2007), while practical suggestions for teachers and policymakers include restructuring curriculum so that guided implementation of PBL principles become embedded in national curricula to promote design consistency, improving teacher professional development so teachers know how to implement inquiry-driven learning, and technology and interdisciplinary materials to support project-based instruction (Kolodner et al., 2003) for more authentic tasks such as designing sustainable communities, debating history or applying scientific inquiry to environmental challenges for improving reasoning, problem-solving, and engagement that would demonstrate the need for reform in the active learning design methodologies of education to meet 21st-century workforce preparedness and educational needs (Darling-Hammond et al., 2008).

V. MAJOR RECOMMENDATIONS RELATED TO THE STUDY

This study recommends the major implementation at national, state, and district levels to teach student-centered pedagogies using Project-Based Learning (PBL), in an integrated framework with consistency and quality while additionally supporting inquiry-based learning to improve logical reasoning, problem-solving skills, and analytical thinking (Hmelo-Silver, 2004); and investing in professional development programs for teachers so educators can have instructional strategies to enable student-centered inquiry and collaborative problem-solving experiences and provide opportunities for interdisciplinary learning (Darling-Hammond et al., 2008); using instructional scaffolding, formative assessment, and guided reflection (Kolodner et al., 2003) to maximize student engagement and cognitive depth; restructuring assessment metrics by investing in implementing performance indicators, rubrics for high-order thinking, and real-world problem-solving tasks that reflect the complexity of academic and professional environments (Barron & Darling-Hammond, 2008); besides collaborations with educators, industry experts, and policy-makers to design real-world, interdisciplinary projects excite students in knowledge transfer across disciplines, such as designing sustainable cities, adapting responses to climate change, or mathematical applications on economics problems increasing engagement, self-directed learning, and adaptability to complex problem-solving (Merriam & Tisdell, 2015); adjustment of short-term study durations, teacher expertise, and differences in school resources that may hinder the effects of PBL implementation outcomes (Slavin, 2007); and systemic educational reforms that prioritize active and experiential learning to develop critical thinking skills required for success in higher education and the work force (Watson & Glaser, 2008).

CONCLUSION

The findings of this study provide strong empirical evidence that Project-Based Learning (PBL)

significantly enhances critical thinking skills among secondary school students, as demonstrated by higher post-test scores in the PBL group (62.3) compared to the traditional instruction group (51.5), with a substantial mean improvement of +17.3 in PBL versus +6.4 in traditional learning ($p < 0.001$), and an ANCOVA effect size ($\eta p2=0.16$) indicating a moderate-to-large impact of PBL on cognitive skill development (Watson & Glaser, 2008), reinforcing prior research that highlights the superiority of inquiry-based, student-centered pedagogies over conventional teacher-directed instruction in fostering problem-solving, analytical reasoning, and logical thinking (Hmelo-Silver, 2004), with qualitative data from student reflections and teacher interviews further supporting these findings by revealing that PBL students demonstrated increased engagement, self-regulation, and the ability to critically evaluate complex issues, consistent with studies emphasizing the role of active learning in improving retention and higher-order thinking skills (Prince, 2004), while the study's thematic analysis confirmed that PBL facilitates interdisciplinary learning, encourages collaboration, and enhances students' motivation to engage in real-world problem-solving tasks, aligning with research demonstrating that students exposed to authentic, project-based scenarios such as designing renewable energy solutions, conducting socio-economic impact assessments, or applying mathematical models to business case studies showed deeper conceptual understanding and a greater capacity for critical reasoning (Barron & Darling-Hammond, 2008), yet despite these strengths, the study acknowledges limitations such as variability in teacher expertise, differences in school resources that may affect instructional quality, and the reliance on the Watson-Glaser Critical Thinking Appraisal as the primary measure of cognitive skills, suggesting the need for future longitudinal studies incorporating diverse assessment methods to evaluate the sustained impact of PBL on students' academic performance, adaptability, and career readiness (Creswell, 2014), while implications for educators and policymakers emphasize the necessity of integrating structured PBL frameworks into national curricula, investing in professional development programs to equip teachers with inquiry-driven instructional strategies, and restructuring assessment models to include performance-based evaluations that capture the depth of students' cognitive engagement beyond standardized tests (Slavin, 2007), ultimately concluding that PBL is a transformative educational approach that fosters the development of essential critical thinking skills required for success in higher education, professional environments, and lifelong learning, reinforcing the urgency for systemic educational reforms that prioritize experiential learning methodologies to prepare students for the demands of the 21st-century workforce (Kolodner et al., 2003).

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