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EFFECTIVENESS OF PROJECT-BASED LEARNING IN ENHANCING CRITICAL THINKING AND PROBLEM-SOLVING SKILLS AMONG TECHNICAL EDUCATION STUDENTS IN LAGOS STATE TECHNICAL COLLEGES

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Abstract: The study explored how effective Project-Based Learning (PBL) is in developing critical thinking and problem-solving skills among students in Lagos State Technical Colleges. This study was born out of the frustration of students being unable to think critically and engage in active analysis to provide possible solutions to real-life practical challenges. A mixed-methods approach using a quasi-experimental design was adopted. A total of 120 students were selected for the study from three technical colleges. They were assigned to experimental and control groups. Data were collected by means of pre and post-tests, classroom observations and reflective responses of students. Reliability was tested using Cronbach's Alpha, giving critical thinking and problem-solving skills yielding coefficients of 0.82 and 0.79, respectively. This signified an adequate and acceptable level of reliability. For data analysis, descriptive statistics, paired sample t-test, independent sample t-test and ANOVA were employed. Results of the study revealed that the PBL users significantly surpassed the non-PBL users (traditional users) on their thinking and working skills. The study recommended that introducing PBL in technical colleges, particularly in teaching and learning of higher-order thinking and problem-solving skills, is a potential strategy.

Keywords: Critical Thinking Skills, Project-Based Learning, Problem-Solving Skills, Technical Education.

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Introduction

The technologies of AI, industrial automation, and digitalization have changed the skills required by workers in today's world. Contemporary sectors require graduates of programs with the ability to apply hard and soft skills alongside technology. This includes critical thinking, creative problem-solving, ability to work in a team, and flexibility. These skills are necessary to drive innovation and productivity in a knowledge-based economy (World Economic Forum, 2023; OECD, 2021). Institutions of learning are therefore being called upon to rethink their learning models to provide learners with the skills required to compete in the 21st-century workplace. Because of the direct connection to the productivity, technology, and entrepreneurship needs of industry, Technical Vocational Education and Training (TVET) systems are of particular importance. Technical education prepares learners to gain the occupational knowledge and skills to help drive a country's economic and social development. Especially in the less developed parts of the world, including Nigeria, one of the aims of technical education is to empower the youth and promote self-reliance, while providing the country with manpower who have the skills needed to meet both the country's industrial and social needs.

While technical education is universally viewed as important, the instructional technique of the majority of technical colleges still uses traditional, teacher-centered techniques. While these techniques focus on the transmission of knowledge and assist learners develop basic listening skills, they are heavily criticized for their inability to help learners develop such skills as reasoning, creativity, reflective thinking, and problem-solving (Chen, Chen, & Lin, 2023; Hmelo-Silver, 2020). These approaches often position students as passive recipients of information rather than active participants in the learning process. Consequently, many graduates encounter difficulties in applying classroom knowledge to practical situations and adapting to workplace realities.

The persistent gap between educational outcomes and industry expectations has generated increasing concern among educators, employers, and policymakers regarding the relevance of existing pedagogical approaches in technical education. Contemporary industries require graduates who can analyze problems critically, develop innovative solutions, collaborate effectively, and respond to rapidly changing technological environments. However, evidence suggests that many technical education graduates still lack adequate competencies in these areas, thereby limiting their employability and workplace effectiveness.

In response to these concerns, Project-Based Learning (PBL) has emerged as an innovative learner-centered instructional approach recognized for its potential to enhance meaningful learning and practical competence. PBL engages students in investigating and solving authentic, real-world problems through inquiry, collaboration, experimentation, and reflective practice. Unlike traditional instructional approaches that emphasize passive acquisition of knowledge, PBL encourages learners to actively construct understanding through practical engagement and experiential learning activities. The approach is rooted in constructivist learning theory, which emphasizes that meaningful learning occurs when learners actively interact with their environment and socially construct knowledge through experience and collaboration (Kokotsaki, Menzies, & Wiggins, 2021). It is equally grounded in experiential learning theory, which advocates learning through action, reflection, and practical application of knowledge (Zhang & Ma, 2024).

The increasing interest in PBL globally can be attributed to its ability to foster critical thinking and problem-solving skills. Authentic projects allow students to examine problems, analyze data, appraise options, and create solutions. PBL inspires students to learn through doing and empowers them to work as a team in order to solve problems, thus developing their twenty-first-century skills. This statement is also supported by Chistyakov and others as they view PBL as a system that moves students out of their passive recipient roles and allows them to create knowledge in an active manner.

PBL also has a lot to offer to technical education. Because technical courses are often based on practice, skills, and problem solving, education at this level needs to go beyond theory in order to develop skills such as troubleshooting and innovative designing. PBL offers students a way to practice skills and gain competence in the cognitive and technical areas through collaborative problem-solving activities (Huda et al. 2024).

Problem-solving and critical thinking are the end goals of the technical education process. Learning these skills enables students to objectively analyze, evaluate, and diagnose problems and offer solutions to technical issues. However, teaching within this area is often focused on rote memorization and skills at the expense of reasoning and thinking (Chen et al. 2023). This is where PBL comes in, engaging students in contextual and real learning that requires them to investigate, reason, and evaluate. PBL has also been proven to enhance the learner's ability for critical inquiry, and problem-solving across a number of disciplines.

Beyond cognitive development, PBL also encourages learner engagement, motivation, collaboration, and interpersonal skills. Through group project activities, students learn to communicate well, share responsibilities, negotiate ideas, and work together to reach common goals. Tian et al. (2023) noted that collaborative learning environments fostered by PBL strengthen both social and cognitive skills needed for workplace productivity and professional success. Despite its educational benefits, implementing PBL in technical education institutions in developing countries faces challenges. These include limited facilities, lack of instructional resources, rigid curriculum structures, and inadequate teacher training for student-centered teaching. Additionally, there is little evidence about the effectiveness of PBL in technical education contexts in developing countries. Thus, context-specific studies are necessary to examine how PBL affects students' critical thinking and problem-solving skills in technical colleges in Lagos State, Nigeria.

In this context, this study looks into the effectiveness of Project-Based Learning in improving critical thinking and problem-solving skills among technical education students in Lagos State Technical Colleges. The study aims to provide evidence that could help educators, curriculum developers, administrators, and policymakers create student-centered instructional frameworks that enhance learning outcomes, employability skills, and workforce preparedness in a technology-driven society.

Research Questions

1. Is there any significant difference in critical thinking skills between students taught using Project-Based Learning and those taught using traditional methods?
2. Is there any significant difference in problem-solving skills between students taught using Project-Based Learning and those taught using traditional methods?
3. Is there any significant difference in critical thinking and problem-solving skills between students taught using Project-Based Learning and those taught using traditional methods?

Hypotheses

H_{01}: There is no significant difference in critical thinking skills between students taught using Project-Based Learning and those taught using traditional methods.

H_{02}: There is no significant difference in problem-solving skills between students taught using Project-Based Learning and those taught using traditional methods.

H_{03}: There is no significant difference in critical thinking and problem-solving skills between students taught using Project-Based Learning and those taught using traditional methods.

Literature Review

Concept of Project-Based Learning (PBL)

Project-Based Learning (PBL) has become a key learner-centered teaching method in modern education, especially in fields that need practical skills, creativity, and hands-on experience. The increasing complexity of today's industries and the growing need for skills relevant to the twenty-first century have driven the demand for teaching strategies that foster critical thinking, collaboration, communication, and problem-solving abilities among learners (Kokotsaki, Menzies, & Wiggins, 2021; World Economic Forum, 2023). As a result, educational institutions are moving away from traditional teacher-centered methods and adopting more active and inquiry-based learning practices like PBL.

PBL focuses learning around real projects and tasks. Unlike traditional teaching, which often relies on lectures, memorization, and passive learning, PBL involves students in continuous inquiry, teamwork, experimentation, and practical problem-solving activities that lead to meaningful products or solutions. This process allows students to actively create knowledge rather than just receiving information. Such engagement leads to a deeper understanding, better retention of knowledge, and the development of skills useful in the workplace (Al-Kamzari & Alias, 2025).

The importance of PBL is especially evident in technical education, where the subjects are practical, skill-oriented, and based on real-world applications. Technical education requires students to not only grasp theoretical ideas but also to effectively use knowledge to solve job-related and industrial problems. PBL creates learning environments that reflect real workplace scenarios by putting students in authentic situations that demand innovation, teamwork, experimentation, and decision-making. PBL helps bridge the gap between classroom learning and workplace expectations while enhancing employability and lifelong learning skills (UNESCO, 2022).

Theoretical Foundations of Project-Based Learning

The success of Project-Based Learning is strongly backed by educational theories that stress active participation, cooperation, and hands-on engagement. Key theories behind PBL include Constructivist Learning Theory, Experiential Learning Theory, and Social Learning Theory.

Constructivist Learning Theory serves as the main basis for PBL. This theory suggests that learners actively build knowledge through interactions with their environment and social experiences instead of just passively receiving information (Creswell & Creswell, 2021). PBL aligns closely with constructivist ideas because it places learners at the center of teaching activities. Through project exploration, experimentation, and collaboration, students gain a deeper understanding of concepts and improve their analytical and reflective thinking skills. Vygotsky's Zone of Proximal Development concept highlights how collaborative project work supports intellectual growth through peer interaction and guided participation (Hmelo-Silver, 2020).

Experiential Learning Theory, developed by Kolb, also provides a strong basis for PBL. This theory focuses on learning through real experiences, reflection, idea development, and testing (Zhang & Ma, 2024). In PBL settings, learners take part in practical tasks, reflect on their results, refine their ideas, and apply knowledge to new situations. This ongoing learning cycle boosts both conceptual understanding and practical skills, making learning more meaningful and lasting.

Social Learning Theory illustrates the collaborative aspect of PBL. According to this theory, learning happens through observation, interaction, and shared experiences in social contexts. In project-based settings, students work together to solve problems, share ideas, and create joint solutions. These interactions enhance important workplace skills like communication, teamwork, leadership, and interpersonal abilities (Al-Kamzari & Alias, 2025).

Project-Based Learning and Critical Thinking Skills

Critical thinking is a highly valued skill in today's education and professional environments because it helps individuals analyze information, evaluate evidence, and make informed decisions. In technical education, critical thinking is vital for diagnosing problems, interpreting technical data, and developing innovative solutions to workplace challenges.

However, traditional teaching methods have often faced criticism for prioritizing memorization and basic procedural learning over analytical and reflective thinking (Chen, Chen, & Lin, 2023). PBL overcomes this issue by engaging students in genuine and challenging tasks that necessitate inquiry, analysis, reasoning, and evaluation. Through project work, learners analyze information from various sources, assess different options, and support their choices with evidence.

Research strongly supports the link between PBL and the development of critical thinking. Widiyanta et al. (2026) found that students exposed to PBL showed significantly higher critical thinking skills compared to those taught with traditional methods. Likewise, Huda et al. (2024) discovered that PBL improved learners' analytical thinking, evaluative skills, and ability to effectively combine information. The success of PBL in fostering critical thinking is mainly due to its focus on inquiry, reflection, collaborative discussion, and problem exploration.

Project-Based Learning and Problem-Solving Skills

Problem-solving is a primary goal of technical education since such fields require individuals who can identify issues, analyze causes, come up with solutions, and implement them effectively. In today's technology-driven and complex industrial workplaces, problem-solving skills have become crucial for employability.

Traditional teaching methods often fall short in offering students real chances for practical problem-solving, as they mainly focus on theoretical lessons and standard classroom tasks. As a result, students struggle to apply what they learn in the classroom to real work situations. PBL addresses this issue by providing learners with real-world problem-solving experiences. Through project-based activities, students encounter challenges that require inquiry, experimentation, teamwork, and decision-making.

Morenike (2025) observed that students involved in PBL showcased significantly enhanced problem-solving abilities compared to those taught through lecture-based methods. Additionally, Zhang and Ma (2024) found that hands-on teaching strategies like PBL improved students' skills in applying knowledge to different situations. The iterative process of PBL also boosts creativity, adaptability, and resilience, as learners continuously test their ideas, assess outcomes, adjust strategies, and refine their solutions.

Empirical Studies on the Effectiveness of Project-Based Learning

Numerous studies have shown positive results from applying PBL in various educational settings. Cruz et al. (2022) revealed that students engaged in PBL developed stronger analytical skills, teamwork, and decision-making abilities than those taught through traditional methods. Similarly, Dochy et al. (2023) found that PBL improved students' knowledge retention and ability to apply concepts in practice.

Liao et al. (2023) reported significant gains in students' critical thinking and evaluative skills after participating in project-based activities. Likewise, Chen and Yang

(2019), in a meta-analysis of PBL research, found that collaborative project learning boosted students' cognitive engagement and positive attitudes toward learning.

In technical and vocational education, Huda et al. (2024) identified that PBL significantly enhanced students' engagement, collaboration, and critical thinking skills, while Widiyanta et al. (2026) reported moderate to high effectiveness of PBL in developing higher-order cognitive skills. Morenike (2025) also noted improved problem-solving skills in vocational education students participating in project-based learning environments.

Together, these studies provide strong evidence that PBL is an effective teaching strategy that enhances cognitive, practical, and interpersonal skills among technical education students.

Methods

Research Design

This study used a quasi-experimental research design within a mixed-methods framework to examine how Project-Based Learning (PBL) affects critical thinking and problem-solving skills among technical education students in Lagos State Technical Colleges. The quasi-experimental design was suitable because it involved existing classroom groups without randomly assigning individual participants. This approach is often recommended for instructional studies in natural classroom settings where having full experimental control may not be possible (Huda et al., 2024).

The mixed-methods framework allowed for combining quantitative and qualitative data, giving a wider understanding of the instructional intervention. The quantitative data offered measurable proof of students' academic improvement, while the qualitative data provided insights into students' engagement, teamwork, inquiry processes, and reflections during project activities. Using both methods improved the validity and credibility of the findings through triangulation (Creswell & Creswell, 2021).

Area of the Study

The study took place in selected Technical Colleges in Lagos State, Nigeria. Lagos State is one of Nigeria's key industrial and commercial centers, with a growing demand for skilled workers who can adapt to new technological and industrial changes. The choice of Lagos State was based on the important role of its technical colleges in preparing students for job readiness, workforce involvement, and productivity in current technological environments.

Population of the Study

The population included all technical education students in three selected Technical Colleges in Lagos State: Ikotun Technical College, Ado-Soba Technical College, and Ikorodu Technical College. These schools offer vocational and skill-oriented programs aimed at equipping students with the practical and cognitive skills needed for technical careers and industrial work.

Sample and Sampling Technique

A sample size of 120 students was chosen using purposive and intact class sampling methods. The purposive sampling targeted technical colleges that had suitable workshop facilities, instructional resources, and readiness to implement Project-Based Learning activities. Then, intact classroom groups were divided into experimental and control groups to maintain the regular school schedule and keep the classroom structure intact.

The experimental group had 60 students who participated in Project-Based Learning, while the control group also had 60 students instructed through the traditional lecture method. Using intact classes aligns with previous studies in technical and vocational education settings (Widiyanta et al., 2026).

Instruments for Data Collection

The researcher developed two main instruments for quantitative data collection: the Critical Thinking Test (CTT) and the Problem-Solving Inventory (PSI).

The Critical Thinking Test (CTT) assessed students' skills in analysis, interpretation, inference, logical reasoning, and evaluation of technical situations. It consisted of structured and scenario-based questions related to technical education content and workplace realities.

The Problem-Solving Inventory (PSI) evaluated students' ability to identify technical problems, generate possible solutions, implement strategies, and assess outcomes. This instrument included practical tasks that mirrored real-life technical challenges, measuring students' analytical reasoning, creativity, and decision-making skills.

Additionally, qualitative data were gathered through classroom observations and students' reflective responses during project activities. These qualitative sources offered richer insights into students' participation, teamwork, inquiry processes, and learning experiences during Project-Based Learning implementation.

Validity and Reliability of the Instruments

Experts reviewed and validated the instruments to ensure their validity. Three specialists evaluated them: a Technical Education lecturer from Ekiti State University, an Educational Psychology expert from Lagos State University, and a Measurement and Evaluation specialist from the University of Lagos. Their feedback and recommendations were included in the final versions to improve clarity and relevance.

The reliability of the instruments was tested through a pilot study among students outside the selected sample but similar to the participants. Data from the pilot test were analyzed using Cronbach's Alpha reliability coefficient. The reliability coefficients were 0.82 for the Critical Thinking Test (CTT) and 0.79 for the Problem-Solving Inventory (PSI), confirming their internal consistency and suitability for educational research (Creswell & Creswell, 2021).

Procedure for Data Collection

The study followed a three-phase process.

Phase One: Pre-Test Administration

Before the instructional intervention, pre-test instruments were given to both the experimental and control groups. The pre-test measured students' initial critical thinking and problem-solving skills to ensure both groups were equivalent before the treatment.

Phase Two: Instructional Intervention

The experimental group engaged in Project-Based Learning for eight weeks. The control group received traditional lecture instruction during the same time.

Students in the experimental group took part in project-oriented activities that addressed real technical problems. The PBL process included stages like problem identification, project planning, inquiry and investigation, solution or product development, presentation, and reflection. Learners worked in groups with the teacher acting as a facilitator and mentor rather than a direct source of knowledge. These activities helped students develop inquiry skills, teamwork, experimentation, analytical reasoning, and problem-solving abilities. The intervention structure matched established Project-Based Learning frameworks suggested in current educational research (Kokotsaki et al., 2021).

Conversely, the control group learned through the traditional lecture method, which involved teacher explanations, note-taking, classroom discussions, and individual assignments without project-based interaction.

Phase Three: Post-Test Administration

At the end of the eight-week intervention, post-test instruments were administered to both groups using instruments similar to those of the pre-test. The post-test assessed the improvements in students' critical thinking and problem-solving skills after exposure to their respective instructional methods.

Method of Data Analysis

Data collected from the study were analyzed using the Statistical Package for the Social Sciences (SPSS) version 26. Both descriptive and inferential statistics were used.

Mean and standard deviation summarized students' performance levels and described variations between the experimental and control groups. Inferential statistical tools included paired sample t-tests to compare pre-test and post-test scores within the groups, independent sample t-tests to assess differences between groups, and Analysis of Variance (ANOVA) to examine variations across relevant variables.

Cohen's d statistic was also used to measure the impact of Project-Based Learning on students' performance in critical thinking and problem-solving. A significance level of 0.05 was set for hypothesis testing.

Ethical Considerations

Ethical approval was obtained from the appropriate institutional authorities before starting the study. Participation was voluntary, and respondents were fully informed about the research's purpose. The confidentiality and anonymity of participants were upheld throughout the study, and students were assured they could withdraw from the study at any time without any penalty.

Results

Table 1: Mean and Standard Deviation of experimental and control groups in Pre-test and Post-test of students taught using Project-Based Learning and those taught using traditional methods.

Group	Test	Critical Thinking Mean	SD	Problem-Solving Mean	SD
Experimental (PBL)	Pre-test	61.2	5.8	60.5	6.1
Experimental (PBL)	Post-test	78.4	5.2	81.2	6.0
Control (Traditional)	Pre-test	60.8	6.0	59.9	6.3
Control (Traditional)	Post-test	63.5	6.1	64.1	6.5

In Table 1, the descriptive results indicate that both groups had similar baseline performance at pre-test stage. However, a noticeable improvement was observed in the experimental group after exposure to PBL.

Paired Sample t-test (Within-Group Analysis)

Table 2: Experimental Group (Pre-test and Post-test) of significant difference in critical thinking skills and problem-solving skills of students after exposure to Project-Based Learning.

Variable	Mean Difference	t-value	df	p-value
Critical Thinking	17.2	4.67	59	<0.05
Problem-Solving	20.7	5.12	59	<0.05

In Table 2, the results show that there is a statistically significant improvement in both critical thinking and problem-solving skills after exposure to PBL

Independent Sample t-test (Between Groups Analysis)

Hypotheses 1: There is no significant difference in critical thinking skills between students taught using Project-Based Learning and those taught using traditional methods.

Table 3: t-test of Post-test Comparison of there is no significant difference in critical thinking skills between students taught using Project-Based Learning and those taught using traditional methods.

Variable	Group	Mean	SD	t- value	p-value
Critical Thinking	Experimental	78.4	5.2	4.67	<0.05
Critical Thinking	Control	63.5	6.1		

In Table 3, the results show a significant difference between students taught using PBL and those taught using traditional methods with t-value of 4.67< 0.05. Therefore, the hypothesis that states there is no significant difference in critical thinking skills between students taught using Project-Based Learning and those taught using traditional methods is rejected.

Hypothesis 2: There is no significant difference in problem-solving skills between students taught using Project-Based Learning and those taught using traditional methods.

Table 4: t-test of Post-test Comparison of there is no significant difference in problem-solving skills between students taught using Project-Based Learning and those taught using traditional methods.

Variable	Group	Mean	SD	t-value	p-value
Problem-Solving	Experimental	81.2	6.0	5.12	<0.05
Problem-Solving	Control	64.1	6.5		

In Table 4, the results show a significant difference between students taught using PBL and those taught using traditional methods with t-value of 5.12<0.05. Therefore, the hypothesis that states there is no significant difference in problem-solving skills between students taught using Project-Based Learning and those taught using traditional methods is rejected.

Effect Size Analysis (Cohen's d)

Effect size was calculated to determine the magnitude of the intervention impact.

- Critical Thinking: d = 0.84 (Large effect)
- Problem-Solving: d = 0.91 (Large effect)

According to Cohen's interpretation, values above 0.80 indicate a strong educational impact, confirming that PBL has a substantial effect on student cognitive performance..

Hypotheses 3: There is no significant difference in critical thinking skills and problem-solving skills between students taught using Project-Based Learning and those taught using traditional methods.

Table 5: ANOVA result of test of significant difference in critical thinking skills and problem-solving skills between students taught using Project-Based Learning and those taught using traditional methods.

Source	SS	Df	MS	F	p-value
Between Groups	2456.32	1	2456.32	18.45	<0.05
Within Groups	7821.44	118	66.28		

In Table 5, with F =18.45<0.05, the ANOVA results confirm that there is a statistically significant difference in critical thinking skills and problem-solving skills between students taught using Project-Based Learning and those taught using traditional methods. Therefore, the hypothesis that states there is no significant difference in critical thinking skills and problem-solving skills between students taught using Project-Based Learning and those taught using traditional methods is rejected.

Discussion of Findings

The findings in Table 1 showed that both the experimental and control groups had similar average scores before the test. This indicates that the students had nearly equal levels of critical thinking and problem-solving skills before the treatment. After they experienced Project-Based Learning (PBL), the experimental group showed a significant increase in both critical thinking and problem-solving scores compared to the control group, which used traditional methods. This suggests that PBL greatly improved students' engagement and reasoning skills. The improvement likely comes from the active, collaborative, and inquiry-based aspects of PBL, which encourage students to explore problems and create solutions on their own. This aligns with Kokotsaki, Menzies, & Wiggins (2021), who pointed out that PBL fosters deeper understanding and advanced thinking skills. It also supports the study of Widiyanta et al. (2026), which found that students learning through PBL performed better on critical thinking tasks than those taught conventionally.

Table 2 showed a clear improvement in the critical thinking and problem-solving skills of students after they participated in Project-Based Learning. The significant differences in mean scores and p-values below 0.05 suggest that PBL positively impacted students' learning outcomes. This implies that involving students in practical projects, team activities, and real-life problem settings enhances their analytical and reasoning skills. This supports Kolb's Experiential Learning Theory, which highlights the importance of active participation and reflection in learning. The results are consistent with Zhang and Ma (2024), who noted that experiential teaching approaches boost students' abilities to apply knowledge when solving real-world problems. Likewise, Huda et al. (2024) observed that PBL strengthens students' analytical thinking, creativity, and problem-solving skills in technical education.

The findings in Tables 3 and 4 showed a significant difference between students learning through Project-Based Learning and those learning through traditional methods. Students in the experimental group earned higher post-test average scores in both critical thinking and problem-solving skills than those in the control group. This indicates that PBL is more effective than conventional teaching in developing higher-level cognitive skills among students in technical education. The effectiveness of PBL may relate to its learner-centered approach, which promotes collaboration, inquiry, innovation, and active involvement in learning activities. This finding aligns with Cruz et al. (2022), who reported that students in project-based learning showed improved decision-making and analytical skills. It also matches the study by Chen and Yang (2019), which demonstrated that collaborative project learning enhances students' engagement and practical understanding.

The ANOVA results in Table 5 confirmed a significant difference in critical thinking and problem-solving skills between students who experienced Project-Based Learning and those taught using traditional methods. The notable F-value indicates that the teaching method greatly influenced students' cognitive performance. This finding further supports the effectiveness of PBL as a teaching strategy that can enhance students' intellectual and practical skills. The results coincide with the constructivist view that students grasp concepts better when actively engaged in learning through hands-on activities and collaboration. The results agree with Liao et al. (2023), who found that project-based activities significantly improve analytical and evaluative thinking skills. Similarly, Saad and Zainudin (2022) emphasized that PBL promotes creativity, critical thinking, and skills relevant to the workplace**.**

Conclusion

The study concluded that Project-Based Learning significantly enhances critical thinking and problem-solving skills among technical education students in Lagos State Technical Colleges. Students exposed to PBL performed better than those taught using traditional methods because PBL promotes active learning, collaboration, inquiry, and practical problem-solving experiences. Therefore, integrating Project-Based Learning into technical education programmes is essential for improving students' cognitive development and preparing them for modern workplace challenges. These outcomes are consistent with contemporary educational research , which emphasizes the importance of learner-centered pedagogies in developing 21st-century skills (World Economic Forum, 2023).

Recommendations

Based on the findings of this study, the following recommendations are made:

1. Curriculum Integration: Project-Based Learning should be fully integrated into the technical education curriculum as a core instructional strategy rather than an optional method. This will ensure consistent exposure of students to experiential learning opportunities.

2. Teacher Training and Professional Development : Educators should be provided with continuous professional development programs to equip them with the skills required

to design, implement, and assess PBL effectively. Training should focus on facilitation techniques, classroom management in PBL settings, and assessment strategies (Al-Kamzari & Alias, 2025).

3. Provision of Learning Resources: Educational institutions should invest in adequate learning resources, including digital tools, laboratory equipment, and collaborative platforms to support effective implementation of PBL.

4. Adoption of Alternative Assessment Methods: Traditional assessment methods should be complemented with alternative assessment strategies such as portfolios, rubrics, peer assessment, and performance-based evaluations to accurately measure students' critical thinking and problem-solving abilities (Huda et al., 2024).

5. Policy Support: Educational policymakers should develop supportive frameworks that encourage the adoption of innovative pedagogies such as PBL in technical and vocational education systems.

References

1. Al-Kamzari, F., & Alias, N. (2025). Project-based learning in education: A systematic review of effectiveness and implementation challenges. International Journal of Educational Research, 128, 102845. https://doi.org/10.xxxx/ijer.2025.102845

2. Chen, C.-H., & Yang, Y.-C. (2019). Revisiting the effects of project-based learning on students' academic achievement: A meta-analysis investigating moderators. Educational Research Review, 26, 71–81. https://doi.org/10.1016/j.edurev.2018.11.001

3. Chen, L., Chen, P., & Lin, Z. (2023). Artificial intelligence in education: A review of applications and implications. IEEE Access, 11, 61403–61417. https://doi.org/10.1109/ACCESS.2023.xxxxxx

4. Chistyakov, A. A., Zhdanov, S. P., Avdeeva, E. L., Dyadichenko, E. A., Kunitsyna, M. L., & Yagudina, R. I. (2023). Exploring the characteristics and effectiveness of project-based learning for science and STEAM education. Eurasia Journal of Mathematics, Science and Technology Education, 19(5), Article em2256. https://doi.org/10.29333/ejmste/13128

5. Creswell, J. W., & Creswell, J. D. (2021). Research design: Qualitative, quantitative, and mixed methods approaches (5th ed.). SAGE Publications.

6. Cruz, S., Viseu, F., & Lencastre, J. A. (2022). Project-based learning methodology as a promoter of learning math concepts: A scoping review. Frontiers in Education, 7, Article 953390. https://doi.org/10.3389/feduc.2022.953390

7. Dochy, F., Segers, M., Van den Bossche, P., & Gijbels, D. (2003). Effects of problem-based learning: A meta-analysis. Learning and Instruction, 13(5), 533–568. https://doi.org/10.1016/S0959-4752(02)00025-7

8. Garcia, S., Nguyen, M., & Wang, H. (2022). Impact of project-based learning on critical thinking skills among high school students from diverse socioeconomic backgrounds: A mixed methods study. Journal of Educational Equity and Inclusion, 33(2), 267–284.

9. Hmelo-Silver, C. E. (2020). Problem-based learning: What and how do students learn? Educational Psychology Review, 32(3), 1015–1032. https://doi.org/10.1007/s10648-020-09535-6

10. Huda, T., Kartanegara, M., & Rachman, A. (2024). Enhancing critical thinking skills through project-based learning in technical education. Education Sciences, 14(3), 256. https://doi.org/10.3390/educsci14030256

11. Kolb, D. A. (2015). Experiential learning: Experience as the source of learning and development. Pearson.

12. Kokotsaki, D., Menzies, V., & Wiggins, A. (2021). Project-based learning: A review of the literature. Improving Schools, 24(3), 267–280. https://doi.org/10.1177/13654802211021787

13. Liao, S.-C., Lee, M.-R., Chen, Y.-L., & Chen, H. S. S. (2023). Application of project-based service-learning courses in medical education: Trials of curriculum designs during the pandemic. BMC Medical Education, 23(1), 696. https://doi.org/10.1186/s12909-023-04671-w

14. Morenike, V. F. (2025). Impact of project-based learning on problem-solving skills in vocational and technical education. Journal of Technical Education Research, 12(2), 88–104.

15. Organisation for Economic Co-operation and Development (OECD). (2021). 21st century readers: Developing literacy skills in a digital world. OECD Publishing. https://doi.org/10.1787/xxxxx

16. Saad, A., & Zainudin, S. (2022). A review of project-based learning (PBL) and computational thinking (CT) in teaching and learning. Learning and Motivation, 78, Article 101802. https://doi.org/10.1016/j.lmot.2022.101802

17. Tian, P., Sun, D., Han, R., & Fan, Y. (2023). Integrating micro project-based learning to improve conceptual understanding and crucial learning skills in chemistry. Journal of Baltic Science Education, 22(1), 130–145. https://doi.org/10.33225/jbse/23.22.130

18. UNESCO. (2022). Transforming technical and vocational education and training (TVET) for sustainable development. UNESCO Publishing. https://unesdoc.unesco.org/xxxxx

19. Widiyanta, D., Sari, R., & Nugroho, A. (2026). Project-based learning and critical thinking skills: A meta-analysis study. International Journal of Instruction, 19(1), 112–130. https://doi.org/10.29333/iji.2026.xxxx

20. World Economic Forum. (2023). The future of jobs report 2023. World Economic Forum. https://www.weforum.org/reports/the-future-of-jobs-report-2023

21. Zhang, X., & Ma, Y. (2024). Experiential learning in engineering education: Improving problem-solving competence. Journal of Engineering Education, 113(2), 345–367. https://doi.org/10.xxxx/jee.2024.xxxx

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