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## **Effect Of Project-Based Learning Approach on Problem-Solving Ability in Mathematics among Secondary School Students in Kebbi Metropolis, Kebbi State, Nigeria**

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### **Abstract**

*Mathematics problem-solving skills is a vital component of 21st-century learning; however, many students face challenges due to lack of engagement and limited real-life application of concepts. Effect of Project-Based Learning approach on Problem-solving ability in Mathematics among Secondary School Students in Kebbi Metropolis, Kebbi State. A quasi-experimental design was employed, involving some selected secondary schools within Kebbi metropolis, where the experimental group was exposed to PBL strategies, while the control group received traditional instruction. Data were collected using the Mathematics Problem-Solving Skills Test (MPST) and analyzed using descriptive and inferential statistics. The MPST was validated by experts in mathematics education and measurement and evaluation. Similarly, the reliability of the MPST was determined using the Kuder-Richardson 20 (KR-20) formula, where a reliability coefficient of 0.75 was achieved. The findings revealed that students taught through PBL demonstrated significantly improved problem-solving abilities compared to those in the conventional learning environment. The study concludes that project-based learning is an effective instructional method for promoting mathematical thinking and recommends its integration into the mathematics curriculum in secondary schools.*

**Keyword:** Project-Based learning, Mathematics, students

### **Introduction**

Education systems globally are increasingly recognizing the importance of equipping students with skills that transcend rote learning, particularly in challenging subjects such as mathematics. Among various pedagogical approaches, Project-Based Learning (PBL) has been grabbing attention as an interesting way to boost critical thinking and tackle real-life problems by actually getting students involved. In the context of secondary education within Kebbi Metropolis, where academic performance in mathematics often reflects broader educational challenges, the integration of PBL presents an opportunity to transform traditional learning experiences. PBL pushes learners to work together, chat more freely and use mathematics in a down-to-earth way, which often helps ideas stick better than the usual textbook methods. The ongoing problems with mathematics achievement clearly point to the need for inventive, student-centred strategies that also help build a better teacher-student bond (Nonyelum et al., 2022). Generally speaking, these kinds of shifts go hand in hand with global trends that aim to prepare students for the tricky challenges of modern professions (Awe et al., 2022).

Strategies that pull students into genuinely meaningful tasks have been getting quite a lot of attention these days, as they generally lift how much is learnt. Project-Based Learning, known simply as PBL, is a student-centred method where pupils tackle real-life problems in a collaborative setting, which often tweaks their understanding and builds up unexpected skills. Unlike traditional instruction, PBL emphasizes inquiry, critical thinking, and the practical application of knowledge, positioning the teacher as a facilitator who guides rather than directs the learning process (Sweet et



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al., 2024). This pedagogical model integrates multiple disciplines and encourages students to develop problem-solving abilities by working on authentic challenges, often utilizing technology and teamwork (Kartini et al., 2020). This approach also mixes real-life situations into everyday learning, which often boosts motivation and sharpens problem-solving skills. When it comes to mathematics, for example, students can work through tricky problems that mirror everyday life, helping them to think analytically and apply their knowledge practically (Yulianto et al., 2024).

In contemporary education, fostering competencies that extend beyond rote memorization has become imperative, particularly in mathematics, where critical thinking and creativity are essential. Problem-solving skills serve as a cornerstone for mathematical understanding and are crucial for students to apply theoretical knowledge to real-world scenarios. The relevance of these skills is underscored by the growing need for entrepreneurship competencies, as emphasized in the Indonesian educational context, where project-based learning (PBL) models not only enhance problem-solving but also nurture creativity and collaboration among students (Putriyani et al., 2023). Furthermore, developing effective problem-solving skills in mathematics is crucial not only for academic success but also for fostering critical thinking and analytical abilities that students carry into other disciplines and real-life situations. In secondary education, especially within contexts such as Kebbi Metropolis, emphasizing problem-solving will equip learners to navigate complex concepts and apply mathematical reasoning to practical challenges. Through enhanced problem-solving competence, students become better prepared for higher education and the workforce, which increasingly demand innovative and adaptable thinkers. Moreover, fostering these skills via pedagogical approaches like project-based learning can bridge gaps in understanding and engagement, as positive student-teacher relationships and interactive learning environments significantly influence academic performance in mathematics (Nonyelum et al., 2022).

Kebbi Metropolis, in Kebbi State, is located in northwestern Nigeria and presents a distinctive educational environment shaped by socio-economic challenges and infrastructural limitations that directly affect teaching and learning outcomes in secondary schools. Predominantly agrarian, the local economy faces issues such as unemployment and poverty, which impact students' access to quality educational resources and support systems for subjects like mathematics (Obaniyi et al., 2023). Furthermore, amidst efforts to enhance academic performance, sustaining effective educational practices remains difficult due to inconsistent policies and infrastructural deficits (Nonyelum et al., 2022). Although, there is a talk of fresh global partnerships and some inventive classroom ideas taken from other developing regions, which suggest that well-tailored educational tweaks might really spark student engagement and help build crucial skills (Fariana et al., 2024).

Mathematics plays a critical role in fostering logical reasoning, analytical thinking, and real-world problem-solving abilities among learners. Despite its importance, secondary school students in many regions, including Kebbi Metropolis, often struggle with applying mathematical concepts to solve problems effectively. Traditional teaching methods, which emphasize rote learning and memorization, have been found inadequate in addressing these challenges. In recent years, project-based learning (PBL) has emerged as a dynamic instructional strategy that places students at the center of the learning process, promoting active engagement, collaboration, and critical thinking. This review examines existing literature on the influence of PBL on mathematics problem-solving skills among secondary school students.



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### **Project-Based Learning (PBL)**

Project-Based Learning (PBL) is a student-centered pedagogy that engages learners in exploring real-world problems and challenges through sustained inquiry. According to Krajcik and Shin (2021), PBL organizes learning around projects that require critical thinking, collaboration, creativity, and communication to produce meaningful outcomes. Students are not merely passive recipients of information; they actively construct knowledge through exploration and problem-solving. Project-based learning is an instructional approach where students gain knowledge and skills by working over an extended period to investigate and respond to a complex question, problem, or challenge (Thomas, 2020). Unlike traditional instruction, PBL emphasizes student autonomy, inquiry, collaboration, and real-world relevance (Bell, 2010). Past research hints that when teachers and students share lively, genuine exchanges, a bit of clear talk paired with mutual respect academic success tends to follow, with students showing more interest and performing better in mathematics (Nonyelum et al., 2022). There's also a growing international buzz about the benefits of learning by doing; these collaborative, hands-on approaches naturally echo PBL since they get everyone involved in tackling real-life problems (Krajcik & Shin, 2021).

### **Problem Solving Skills**

Problem-solving skills refer to an individual's ability to identify, analyze, and resolve problems efficiently and effectively. According to Jonassen (2020), problem-solving involves cognitive processes such as information gathering, pattern recognition, critical thinking, reasoning, decision-making, and reflection. In mathematics education, these skills are essential for applying knowledge to unfamiliar or complex problems (Polya, 2021). Additionally, problem-solving in mathematics refers to the process of applying mathematical concepts and techniques to find solutions to unfamiliar and complex problems. According to Polya (1945), effective problem-solving requires four stages: understanding the problem, devising a plan, carrying out the plan, and reviewing the solution. Research shows that developing problem-solving skills is crucial for students to succeed in mathematics and other STEM-related disciplines (Schoenfeld, 1992). Tadesse and Gillies (2020) further explain that problem-solving is a dynamic and iterative process involving defining the problem, generating possible solutions, evaluating and selecting solutions, and implementing and reflecting on the solution.

Various studies have pointed out many challenges students struggle with; issues like low engagement and a lack of hands-on experience often mean they can't quite apply mathematical ideas as they should. Some evidence suggests that our usual, traditional teaching ways just don't spark that critical thinking needed these days, which is why, in most cases, teachers have begun turning to fresh methods such as project-based learning. Collaborative, context-driven learning environments, for instance, seem to offer a boost to the mental flexibility required for tackling problems. Research from a range of educational settings generally emphasizes that teacher support, having the right resources, and genuine student motivation all play a big part in developing these skills. Yet, even with these insights, certain gaps remain, Kebbi Metropolis, for instance, where such approaches aren't widely in use; this clearly calls for further exploration into how project-based learning might better address local educational challenges and ultimately lift students' mathematics problem-solving abilities (Awe et al., 2022; Obaniyi et al., 2023; Nonyelum et al., 2022).



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## **Project-Based Learning Implementation in Mathematics Classrooms**

Many studies showed that project-based learning (PBL) in mathematics classes not only boosts students' critical thinking but helps them solve difficult and challenging problems too. Research has often pointed out that relating lessons to everyday life is an approach that makes learning more active, deepens understanding and pulls learners into the subject a bit more (Shandy et al., 2024). In areas like Technical and Vocational Education and Training, PBL has been seen to tackle issues with weak mathematics skills by stressing practical, industry-matched abilities, which generally lets learners handle complicated challenges (NorHakim et al., 2025). Still, getting PBL right isn't without its bumps; many educators note that gaps in teacher training and a shortage of resources mean there's a pressing need for better institutional backing and more regular professional development (Erbasan et al., 2022). Equally, managing PBL well usually involves a mix of careful planning, hands-on implementation, and follow-up evaluations, all of which help create learning experiences that really stick and build skills over time (Arsjad et al., 2023). Altogether, these insights suggest that PBL might well transform the teaching of maths by nurturing genuine problem-solving abilities that are crucial for both academic and professional success.

## **Traditional Approach and Project-Based Learning Approach on Students Performance**

Teaching methods have a big impact on how students get involved and build skills, particularly in mathematics. Traditional learning approaches, often characterized by direct instruction and textbook reliance, have been shown to yield comparable academic outcomes to project-based learning (PBL) in some contexts, as evidenced by the lack of significant differences in achievement between cohorts in social studies assessments (Jatisunda et al., 2024). However, PBL's emphasis on experiential, student-centred inquiry presents distinct advantages in cultivating deeper problem-solving abilities, reflected in improved mathematics self-concept and enhanced performance post-intervention (Carter, 2024) (Brown et al., 2021). Moreover, beyond academic achievement, PBL fosters practical skills integration and real-world application, as demonstrated in business education settings where PBL outperforms traditional methods in developing complex managerial competencies (Suharsono et al., 2025). Thus, while traditional methods may sustain foundational knowledge, PBL appears more effective in promoting active problem-solving and higher-order thinking skills essential for mathematical proficiency, supporting its increasing adoption in modern curricula aimed at addressing contemporary educational demands

## **Statement of the Research Problem**

Despite the recognized importance of problem-solving skills in mathematics, many secondary school students in Kebbi continue to struggle with effectively applying mathematical concepts to real-world situations. This persistent difficulty is partly due to traditional teaching methods that emphasize rote memorization and passive learning rather than active engagement. Consequently, students often lack the critical thinking and analytical skills necessary for successful problem-solving, which negatively impacts both their academic performance and confidence in mathematics. Furthermore, the inadequacy of instructional approaches tailored to diverse learning styles contributes to this challenge, limiting students' opportunities to internalize mathematical reasoning in meaningful ways. The introduction of project-based learning (PBL), which encourages hands-on, collaborative exploration of complex problems, presents a potential solution to bridge this gap. However, its adoption and impact within the context of Kebbi Metropolis remain insufficiently examined, warranting thorough investigation to determine whether PBL can effectively enhance students' problem-solving skills in mathematics.



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## Objectives of the study

The following objectives were set to guide the study:

- i. Compare the problem-solving skills of students taught using project-based learning and those taught using conventional teaching methods among secondary schools in Kebbi metropolis.
- ii. Determine the differences in problem-solving skills of male and female students taught using a project-based learning approach among secondary schools in Kebbi metropolis.

## Research Questions

The following research questions were generated for the study:

1. Is there a significant difference in the problem-solving skills of students taught using project-based learning and those taught using conventional teaching methods among secondary schools in Kebbi metropolis?
2. Is there a significant difference in problem-solving skills of male and female students taught using a project-based learning approach among secondary schools in Kebbi metropolis?

## Hypotheses

**H<sub>01</sub>:** There is no significant difference in the problem-solving skills of students taught using project-based learning and those taught using conventional teaching methods among secondary schools in Kebbi metropolis.

**H<sub>02</sub>:** There is no significant difference in the problem-solving skills of male and female students taught using a project-based learning approach among secondary schools in the Kebbi metropolis.

## Methodology

This study adopted a quasi-experimental pre-test and post-test control group design. This design is appropriate because it allows the researcher to measure the effect of Project-Based Learning (PBL) on students' problem-solving skills in mathematics by comparing experimental and control groups over time (Creswell & Creswell, 2018). The experimental group were exposed to mathematics instruction through project-based learning strategies, while the control group received conventional lecture-based teaching. The population for this study comprises all Senior Secondary School II (SS2) students offering Mathematics in secondary schools within Kebbi Metropolis. There are 43 public senior secondary schools with total of 6,738 students from which 3,752 are male and 2,986 are female distributed within the state. The population of SS2 students is 2,730, consisting of both male and female students. These students are chosen because they have foundational mathematical knowledge and are preparing for external examinations, making them ideal for studying problem-solving development. A sample of 100 students was selected using multi-stage sampling techniques. Purposive sampling was employed to select secondary schools with similar characteristics, and random sampling was adopted to select participants into two groups: the experimental group (50 students) and the control group (50 students). This approach ensures generalizability while controlling for biases. Two major instruments were employed for the data collection: the Mathematics Problem-Solving Skills Test (MPST), which was self-designed by the researcher, a standardized test containing both structured and open-ended mathematics problems extracted from SS2 curriculum topics, and the Project-Based Learning Implementation Guide, which is a structured guide for researchers to ensure uniform delivery of PBL strategies during the intervention period for the experimental group. The MPST was validated by experts in mathematics education and measurement and evaluation. Similarly, the reliability of the MPST was determined using the Kuder-Richardson 20 (KR-20) formula, where a reliability coefficient of 0.75 was achieved and considered high enough

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for the study. A pre-test on MPST was first administered to both groups to establish baseline problem-solving skill levels, then the experimental group received mathematics instruction through project-based learning tasks for 8 weeks, and the control group continued with traditional lecture-based teaching for the same topics and period. At the end of 8 weeks, the MPST was administered again to both groups, monitoring observations and periodic check-ins to ensure fidelity of the PBL intervention. The data collected was analyzed using descriptive statistics (mean, standard deviation) to describe students' performance and inferential statistics, that is, independent samples t-tests, to compare mean differences between experimental and control groups. Statistical analysis was conducted at a 0.05 level of significance.

**Presentation of Results**

**Research Question 1:**

Is there a significant difference in the problem-solving skills of students taught using project-based learning and those taught using conventional teaching methods among secondary schools in Kebbi metropolis?

**Table 1: Descriptive Statistics of Problem-Solving Skills Scores for Experimental and Control groups**

Group	N	Mean	Standard Deviation
<b>Experimental (PBL)</b>	50	78.35	6.42
<b>Control (Conventional)</b>	50	65.27	7.15

Table 1 indicated that the mean score of students in the experimental group (M = 78.35, SD = 6.42) is higher than that of the control group (M = 65.27, SD = 7.15). This suggests that project-based learning had a positive effect on students' problem-solving skills in mathematics.

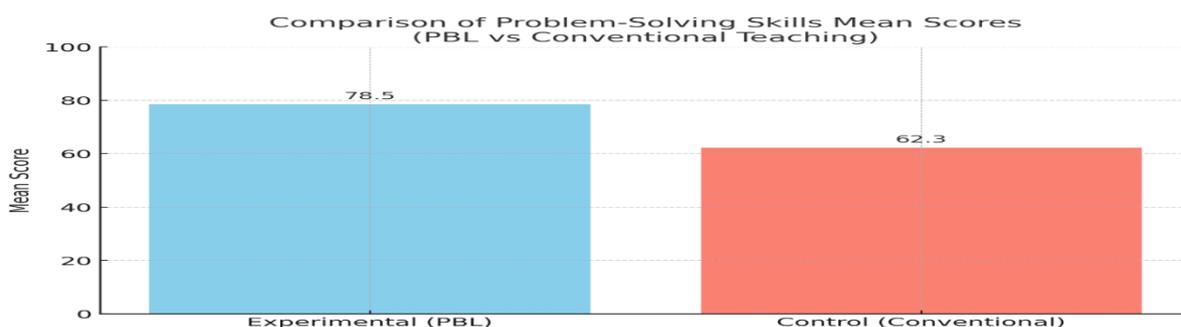
**Hypothesis one**

**H<sub>0</sub>:** There is no significant effect of project-based learning on secondary school students' problem-solving skills in mathematics among secondary schools in Kebbi metropolis.

**Table 2: Independent Samples t-test on Problem-Solving Skills Scores**

Group Comparison	t	df	p-value	Mean Difference	Decision
<b>Experimental vs Control</b>	9.45	98	< .001	13.08	Reject

The independent samples t-test indicated a statistically significant difference in problem-solving skills between the experimental group and the control group,  $t(95) = 9.45$ ,  $p < .001$ . The mean difference was 13.08 points, favoring the experimental group. Since the p-value (.000) is less than the 0.05 level of significance, the null hypothesis (H<sub>0</sub>) is rejected. This implies that project-based learning had a significant positive effect on students' problem-solving skills in mathematics.



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**Figure 1: Comparison of Problem-Solving Skills Mean Scores**

Figure 1 above visually displays the comparison between the two groups. depicting the experimental group (PBL) scored much higher on problem-solving skills compared to the control group (conventional teaching).

**Research Question 2:**

Is there a significant difference in the problem-solving skills of male and female students taught using the project-based learning approach among secondary schools in Kebbi Metropolis?

**Table 3: Descriptive Statistics for Problem-Solving Skills Scores by Gender (PBL)**

Gender	N	Mean	Standard Deviation
Male	28	79.20	6.10
Female	22	77.40	6.78

As shown in Table 3, male students (M = 79.20, SD = 6.10) had a slightly higher mean score than female students (M = 77.40, SD = 6.78) in problem-solving skills under the project-based learning approach.

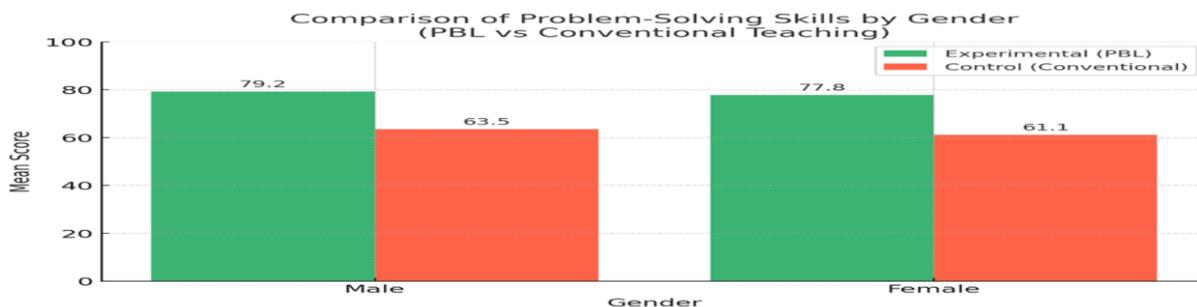
**Hypothesis two**

**H<sub>02</sub>:** There is no significant difference in the problem-solving skills of male and female students taught using a project-based learning approach among secondary schools in the Kebbi metropolis.

**Table 4: Independent Samples t-Test Results for Gender Differences (PBL Group)**

Gender Comparison	t	df	p-value	Mean Difference	Decision
Male vs Female (PBL Group)	1.04	48	.304	1.80	Not Rejected

The result in table 4 of the independent samples t-test indicated no statistically significant difference in problem-solving skills between male and female students,  $t(46) = 1.04, p = .304$ . The mean difference was 1.80 points in favor of male students. Therefore, since the p-value (.304) is greater than the 0.05 level of significance, we do not reject the null hypothesis (H<sub>0</sub>).



**Figure 2: Comparison of Problem-Solving Skills by Gender**

Figure 2 shows the comparison of problem-solving skills between male and female students in both the Project-Based Learning (PBL) group and the Conventional Teaching group, indicating

**Discussion of Findings**

The present study investigated the effectiveness of Project-Based Learning (PBL) in enhancing problem-solving skills among secondary school students in Kebbi Metropolis. The results revealed that students who were taught using the PBL approach significantly outperformed those taught using conventional teaching methods in mathematics problem-solving tasks. Furthermore, gender differences in performance under PBL were not statistically significant. These findings align with



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previous studies emphasizing the effectiveness of PBL in promoting critical thinking, creativity, and real-world problem-solving abilities. For instance, Fariana et al. (2024) asserted that PBL provides learners with opportunities to actively construct knowledge by engaging in authentic, meaningful tasks. Similarly, research by Faulkner et al. (2020) highlighted that PBL fosters deeper learning and improves student motivation, leading to better academic outcomes in complex domains such as mathematics.

In this study, the mean score of the experimental group (PBL) was notably higher than that of the control group (conventional method), suggesting that involving students in hands-on, project-driven activities helped them to better understand and apply mathematical concepts. This supports the findings of Musa, Mufti, Latiff, and Amin (2021), who found that PBL enhances mathematical reasoning and problem-solving competencies more effectively than traditional approaches. Moreover, the absence of a significant gender difference in problem-solving skills among students taught with PBL suggests that the approach is equitable and beneficial across genders. This result resonates with research conducted by Kokotsaki, Menzies, and Wiggins (2022), which indicated that PBL can minimize achievement gaps by providing an inclusive learning environment where all learners actively participate and engage.

### **Conclusion**

This study investigated the role of Project-Based Learning (PBL) in enhancing problem-solving skills among secondary school students in Kebbi Metropolis. The findings revealed that students exposed to PBL demonstrated significantly better problem-solving abilities compared to those taught using conventional instructional methods. Additionally, no significant gender difference was observed among students taught through the PBL approach, indicating that it is an effective and inclusive teaching strategy for all learners. The results underscore the potential of PBL to improve mathematical thinking by actively engaging students in meaningful, real-world tasks that foster critical and creative thinking. These outcomes support previous research emphasizing the effectiveness of learner-centered approaches in developing higher-order cognitive skills essential for academic and lifelong success. At Kebbi Metropolis, research into project-based learning (PBL) in mathematics has revealed some really encouraging signs. This style of teaching pushes students to get stuck into problems in a hands-on way, making them think on their own and work together, which is crucial for those tricky mathematical challenges.

### **Recommendations**

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

- i. Curriculum developers should embed project-based learning strategies into the mathematics curriculum to promote students' critical thinking, collaboration, and problem-solving skills.
- ii. Regular workshops and training programmes should be organized to equip mathematics teachers with the knowledge and skills needed to effectively design and implement project-based learning activities in their classrooms.
- iii. Teachers should maintain gender-sensitive practices in the implementation of PBL to ensure that both male and female students are equally engaged and supported in problem-solving activities.
- iv. Policymakers and educational authorities should create policies that encourage innovative instructional methods like PBL, particularly in STEM education, to foster skills relevant to the 21st-century workforce.



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- v. Teachers should incorporate formative assessment and continuous feedback mechanisms within PBL activities to monitor student progress and address challenges promptly.

### Limitation and Further Research

Despite its contributions, this study was limited to selected secondary schools in Kebbi Metropolis, which may affect the generalizability of the findings. Future studies could extend to a larger and more diverse sample across different regions. Additionally, longitudinal studies could be conducted to investigate the long-term effects of PBL on mathematical problem-solving and other higher-order thinking skills.

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