

EFFECTIVENESS OF PROJECT BASED LEARNING (PBL) IN IMPROVING STUDENTS' LEARNING OUTCOMES AND MOTIVATION IN BASIC SCIENCE AND TECHNOLOGY IN JOS-SOUTH AREA DIRECTORATE OF EDUCATION OF PLATEAU STATE

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ABSTRACT

This study investigates the effectiveness of Project-Based Learning (PBL) in improving students' learning outcomes and motivation in Basic Science and Technology (BST) within the Jos-South Area Directorate of Education. A quasi-experimental design was employed, involving 285 Junior Secondary School II (JSS II) students. The sample was divided into an experimental group (147 students), taught using PBL, and a control group (138 students), taught using conventional teaching methods. Pre-test and post-test data were collected using a Basic Science and Technology Achievement Test (BSAT) and an Interest Inventory Scale (IIS). The results showed a significant improvement in learning outcomes and motivation among students in the experimental group. The mean achievement scores in the post-test for the PBL group were significantly higher (mean = 68.54, SD = 9.42) compared to the control group (mean = 45.89, SD = 13.71), with a mean difference of 22.65. Additionally, male students demonstrated higher interest levels (mean = 3.42, SD = 0.98) than female students (mean = 2.03, SD = 0.83), suggesting the need for gender-sensitive approaches in PBL implementation. These findings underscore the effectiveness of PBL in enhancing students' academic performance and motivation in BST, with implications for curriculum development and instructional practices.

Keywords: Project-Based Learning (PBL), Basic Science and Technology, learning outcomes, gender differences, instructional strategies.

Introduction

The increasing emphasis on Science, Technology, Engineering, and Mathematics (STEM) education has become a pivotal part of educational reform across the globe, aimed at enhancing students' competencies in these critical areas. Project-Based Learning (PBL) has emerged as a prominent pedagogical approach in Basic Science and Technology, promoting active engagement and fostering deeper understanding through hands-on, inquiry-driven experiences. In Nigeria, the need for effective Basic Science and Technology is urgent, particularly in secondary schools, where foundational knowledge and skills are developed for future academic and career pursuits (NRC, 2015; O'Brien, 2020).

PBL encourages students to engage in complex, real-world projects, enabling them to acquire knowledge and skills while collaborating with peers. This method shifts the focus from traditional rote learning to a more interactive, student-centered learning experience that emphasizes problem-solving, critical thinking, and creativity (Thomas, 2017). As students work on projects, they are encouraged to take ownership of their learning, leading to increased motivation and engagement (Bell, 2015). Studies have shown that PBL can improve students' academic performance, particularly in Basic Science and Technology, as it fosters an

environment where students apply theoretical knowledge to practical situations (Zhou et al., 2018; Chan et al., 2019).

In the context of the Jos-South Area Directorate of Education, the integration of PBL in secondary schools presents an opportunity to enhance STEM learning outcomes and cultivate a positive attitude toward learning among students. Despite its potential, the implementation of PBL in Nigerian schools has been inconsistent, with challenges including inadequate teacher training, lack of resources, and resistance to change from traditional teaching methods (Okoli & Onuoha, 2017). Understanding the effectiveness of PBL in this specific educational setting is crucial for identifying best practices, potential barriers, and strategies for successful implementation.

Furthermore, motivation is a critical component of effective learning, particularly in Basic Science and Technology, where students often face challenges in engaging with complex concepts (Ryan & Deci, 2017). By examining how PBL affects students' motivation alongside learning outcomes, this study aims to provide insights into the ways in which active learning strategies can create a more engaging and supportive educational environment. Research has indicated that when students are actively involved in their learning through PBL, their intrinsic motivation increases, leading to better retention of information and a greater willingness to tackle challenging subjects (Gonzalez, 2021; Liu et al., 2022).

Overall, this study will contribute to the understanding of PBL as a transformative approach to teaching and learning in Basic Science and Technology within the context of Jos-South Area Directorate of Education. By analyzing the effectiveness of PBL approaches in improving learning outcomes and students' motivation, the findings will inform educators and policymakers on best practices for fostering a robust Basic Science and Technology framework that prepares students for future challenges in a rapidly evolving global landscape.

Statement of the Problem

Despite the global emphasis on the importance of Science, Technology, Engineering, and Mathematics (STEM) education, students in Nigerian secondary schools, particularly in the Jos-South Area Directorate of Education, continue to underperform in these subjects, especially, Basic Science and Technology. Emelda, Mubemba and Thelma (2024) posit that traditional teaching methods, which often emphasize rote memorization and theoretical learning, have been identified as contributing factors to students' disengagement and low achievement in Basic Science and Technology. This approach fails to stimulate critical thinking, creativity, and real-world problem-solving skills, which are essential for success in Basic Science and Technology (Okoli & Onuoha, 2017; O'Brien, 2020).

In recent years, Project-Based Learning (PBL) has emerged as an alternative pedagogical approach designed to address these issues by actively engaging students in meaningful, hands-on projects that promote inquiry, collaboration, and application of knowledge. However, the adoption and effectiveness of PBL in Nigerian schools, particularly in Basic Science and Technology, have been largely understudied. There is a need to investigate whether PBL approaches can improve learning outcomes and motivation among secondary school students in the Jos-South Area Directorate of Education, where traditional methods still dominate the classroom setting.

Given the importance of Basic Science and Technology in preparing students for future careers and addressing national development challenges, it is critical to assess the effectiveness of PBL in improving students' academic performance, motivation, and overall engagement with Basic Science and Technology. This study seeks to bridge the knowledge gap by analyzing the impact of PBL approaches on learning outcomes and students' motivation, with the goal of providing evidence-based recommendations for educators and policymakers on how to implement PBL more effectively in secondary schools. Without such intervention, the quality of Basic Science and Technology in the region may continue to decline, limiting students' opportunities and hindering the development of critical skills necessary for innovation and economic growth in Nigeria.

Objectives

The main objective of the study is to analyse the effectiveness of Project Based Learning (PBL) in improving students' learning outcomes and motivation in basic science and technology in Jos-South Area Directorate of Education. The specific objectives of the study are to:

1. Determine the mean achievement scores of students taught Basic Science and Technology using Project Based Learning and those taught using conventional method of teaching.
2. Find out the mean interest score of JSSII students taught Basic Science and Technology using Project Based Learning and those taught using conventional method of teaching.
3. Ascertain the mean achievement score of male and female JSSII students taught Basic Science and Technology using Project Based Learning.
4. Determine the mean interest score of male and female JSSII students taught Basic Science and Technology using Project Based Learning.

Research Questions

The following research questions were raised to guide the study:

1. What are the mean achievement scores of students taught Basic Science and Technologusing Project Based Learning and those taught using conventional method of teaching?
2. What is the mean interest score of JSSII students taught Basic Science and Technology using Project Based Learning and those taught using conventional method of teaching?
3. What is the mean achievement score of male and female JSSII students taught Basic Science and Technology using Project Based Learning?
4. What is the mean interest score of male and female JSSII students taught Basic Science and Technology using Project Based Learning?

Research Hypotheses

The null hypotheses were tested at a 0.05 level of significance.

H₀₁: There is no significant difference between the mean achievement scores of students taught Basic Science and Technology using Project Based Learning and those taught using conventional method of teaching.

H₀₂: There is no significant difference between the mean interest score of students taught Basic Science and Technology using Project Based Learning and those taught using conventional method of teaching.

H₀₃: There is no significant difference between the mean achievement score of male and female students taught Basic Science and Technology using Project Based Learning.

H₀₄: There is no significant difference between the mean interest scores of male and female JSSII students taught Basic Science and Technology using Project Based Learning.

Methodology

The design adopted for this study was quasi-experimental design. Specifically, the study adopted non-equivalent control group design. Quasi-experimental design was considered appropriate for the study because intact classes were used. According to Maciejewski (2020), quasi-experiment is a method that provides and compares the treatment of subjects in a group. The design is illustrated symbolically below:

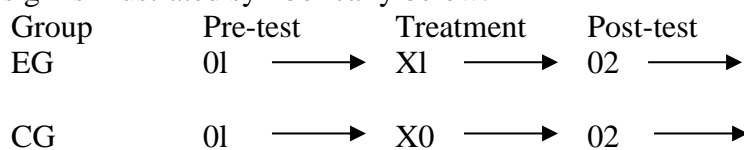


Figure 1. Pre-test Post-test Quasi Experimental Research Design Key: EG= Experimental group, CG= Control group, X1 treatment (teaching experimental group BST using PBL), X0 no treatment applied (Teaching the control group BST using conventional method), 01 = pre-test observation, 02 = post test observation

The target population for this study consists of three thousand two hundred and twenty three (3,223) Junior Secondary School two (JSSII) students in Jos South Area Directorate of Education, Plateau state. The sample for the study consists of four public schools with a sample size of 285 students which comprised of 139 males and 146 females. For a non-bias representation of the population of the schools, the researcher adopted Simple Random Sampling techniques to select the 4 schools in both the experimental and control groups because it ensures that every individual in the population has an equal chance of being included. Random sampling is the basis of all good sampling techniques and disallows any method of selection based on volunteering or the choice of groups of people known to be cooperative.

The following instruments were developed by the researcher and used for data collection.

1. Basic Science Achievement Test (BSAT) was used to get the students achievement scores.
2. Interest Inventory questionnaires (IIQ) was used to determine student’s mean interest scores.

Basic Science Achievement Test (BSAT) which was developed by the researcher consists of 20 multiple choice objective questions with four options (A, B, C and D) drawn from the BST curriculum content for JSSII students. Students were required to tick the correct answer. Interest Inventory Scale was a close ended structured questionnaire containing two sections A and B. Section A sought the bio-data of respondents while section B contains the ten (10) item BST interest inventory. The Inventory Scale was built on a four (4) point Likert scale (Strongly Agree {SA}, Agree {A}, Disagree {d} and Strongly Disagree {SD}). In scoring the items for positively framed items, Strongly Agree (SA), attracted 4 points, Agree (A), attracted 3 points, Disagree (D), attracted 2 points, while Strongly Disagree (SD) attracted 1 point. The numerical values assigned to the response modes are in accordance with the modified Likert-type scale 4,3,2,1. The interest inventory questions were drawn from literatures that discussed students’ interest in mathematics.

BSAT was subjected to content and face validity by the BST teachers with over 10 years teaching experience. The content validation ensured adherence to the table of specifications and blooms taxonomy. Interest Inventory Scale (IIS) was validated by experts in Research Measurement and Evaluation in Federal College of Education Pankshin, Plateau State. The experts scrutinizes the instrument in terms of clarity of items, proper wording of items, appropriateness and adequacy of items for the study, structure and timing. All corrections, observations and comments were reflected in the final draft. Test-retest reliability was used to establish the reliability co-efficient of the instruments. A reliability coefficient of 0.84 was obtained for IIS which implies that the instrument was reliable.

The data collected through the BSAT and IIS were carefully assembled and presented in tables. The mean and standard deviations were used to answer research questions while t-test was used for testing hypotheses using SPSS (Statistical Package for Social Science) version 25.

Results

Research Question One

What are the mean achievement scores of students taught Basic Science and Technology using Project Based Learning and those taught using conventional method of teaching?

Table 1: Summary of Mean and Standard deviation of BSAT Achievement Scores of Pre-test and Post-test of the Experimental and Control Groups

Group	Treatment	Number of students	Pre-Test		Post-Test		Mean Difference
			Mean (\bar{x})	Std Dev. (SD)	Mean (\bar{x})	Std. Dev. (SD)	
Control	Conventional Teaching Method	138	47.52	11.30	45.89	13.71	1.63
Experimental	Project Based Learning	147	47.29	12.08	68.54	9.42	22.65
Total		285					

Table 1 above shows that the control group had a mean achievement test score of 47.52 with a standard deviation of 11.62 in the pre-test, while the experimental group obtained a mean achievement test score of 47.29 with standard deviation of 12.08. This shows that the pre-test mean achievement scores were similar. However, after treatment was applied, the control group had a mean achievement test score of 45.89 with standard deviation of 13.71 while the experimental group had mean achievement test score of 68.54 with standard deviation 9.62. This implies that the control group had an intra-group mean difference of 1.63 while the experimental group had an intra-group mean difference of 22.65. Thus, the experimental group, achieved higher than the control group. This means that the students taught Basic Science and Technology using Project Based Learning achieved higher than those taught using conventional teaching method. This implies that students’ performance have been positively influenced by Project Based Learning.

Research Question Two

What is the mean interest score of JSSII students taught Basic Science and Technology using Project Based Learning and those taught using conventional method of teaching?

Table 2: Summary of Mean and Standard Deviation of IIS Interest Score of Pre-test and Post-test of the Experimental and Control Groups

Group	Treatment	Number of students	Pre-Test		Post-Test		Mean Difference
			Mean (\bar{x})	Std. Dev. (SD)	Mean (\bar{x})	Std. Dev. (SD)	
Control	Conventional Teaching method	138	2.31	0.66	2.23	0.91	0.08
Experimental	Project Based Learning	147	2.36	0.61	3.81	0.87	1.45
Total		285					

Table 2 above shows that the control group had a mean interest score 2.31 with standard deviation 0.66 in the pre-test, while the experimental group obtained mean interest score of 2.36 with standard deviation 0.61. This shows that the pre-test mean interest scores were similar. However, after treatment was applied, the control group had a mean interest score of 2.23 with standard deviation of 0.91 while the experimental group had mean interest score of 3.81 with standard deviation 0.87. This implies that the control group had an intra-group mean interest score difference of 0.08 while the experimental group had an intra-group mean interest score difference of 1.45. Thus, the experimental group had higher mean interest score. This means that the students taught Basic Science and Technology using Project Based Learning showed more interest in Basic Science and Technology having been exposed to Project Based Learning. This implies that Project Based Learning leads to higher interest in Basic Science and Technology.

Research Question Three

What is the mean achievement score of male and female JSSII students taught Basic Science and Technology using Project Based Learning?

Table 3: Summary of Post-test Mean and Variance of BSAT Based on Gender

Group	Treatment	Number of students	Post-Test		Mean Difference
			Mean (\bar{X})	Std. Dev. (SD)	
Male	Project Based Learning	139	72.06	6.98	21.52
Female	Project Based Learning	147	50.54	9.95	
Total		285			

Table 3 above shows that the males in the experimental group had a mean achievement score of 72.06 with variance 6.98 while the females had a mean achievement score of 50.54 with a variance of 9.95. This gives a mean difference of 21.52. Thus, the males scored higher than the

females in the post-test. However, it is pertinent to note that both males and females performed well, indicating that Project Based Learning is effective in teaching male and female students.

Research Question Four

What is the mean interest score of male and female JSSII students taught Basic Science and Technology using Project Based Learning?

Table 4: Summary of Post-test Mean and Variance IIS Based on Gender

Group	Treatment	Number of students	Post-Test		Mean Difference
			Mean (\bar{X})	Std. Dev. (SD)	
Male	Project Based Learning	139	3.42	0.98	1.39
Female	Project Based Learning	147	2.03	0.83	
Total		285			

Table 4 above shows that the males in the experimental group had a mean interest score of 3.42 with variance 0.98 while the females had a mean interest score of 2.03 with a variance of 0.83. This gives a mean difference of 1.39. Thus, the males had higher interest score than the females in the post-test.

Testing Of Research Hypotheses

The null hypotheses were tested at a 0.05 level of significance.

Hypotheses One (H₀₁): There is no significant difference between the mean achievement scores of students taught Basic Science and Technology using Project Based Learning and those taught using conventional method of teaching.

Table 5: Summary of Independent Sample t-test Based on Groups

Group	N	Mean (\bar{X})	Variance (S ²)	Df	t-cal	t-crit	p-value	Remark
Control	138	45.89	68.92					
Experimental	147	68.54	74.59	124	3.31	1.713	0.05	Significant
Total	285							

The analysis in table 5 above shows that the calculated t-value was 3.31 and critical t-value 1.713 at $\alpha = 0.05$ with 124 degree of freedom (df). Since the calculated t-value of 3.31 is greater than the critical t-value of 1.713. Then the null hypothesis (H₀₁) is rejected and the alternative hypothesis is accepted that there is a significant difference between the mean achievement score of students taught Basic Science and Technology using Project Based Learning and those taught using conventional method of teaching. This implies that the experimental group taught Basic Science and Technology using Project Based Learning performed significantly better than the control group taught using conventional method.

Hypotheses Two(H₀₂): There is no significant difference between the mean interest score of students taught Basic Science and Technology using Project Based Learning and those taught using conventional method of teaching.

Table 6: Summary of Independent Sample t-test for Mean Interest Scores Based on Group

Group	N	Mean (\bar{X})	Variance (S^2)	Df	t- cal	t- crit	P - value	Remark
Control	138	2.23	0.82					
Experim ental	147	3.81	0.76	124	4.34	1.713	0.05	Significa nt
Total	285							

The analysis in table 6 above shows that the calculated t-value was 4.34 and critical t-value 1.713 at $\alpha = 0.05$ with 124 degree of freedom (df). Since the calculated t-value of 4.34 is greater than the critical t-value of 1.713. Then the null hypothesis (H_{02}) is rejected and the alternative hypothesis is accepted that there is significant difference between the mean interest score of students taught Basic Science and Technology using Project Based Learning and those taught using conventional method of teaching. This implies that the experimental group taught Basic Science and Technology using Project Based Learning had higher mean interest rating in Basic Science and Technology than the control group taught using conventional method.

Hypotheses Three (H_{03}): There is no significant difference between the mean achievement score of male and female students taught Basic Science and Technology using Project Based Learning.

Table 7: Summary of Independent sample t-test for Mean Achievement Test Score Based on Gender

Group	N	Mean (\bar{X})	Variance (S^2)	Df	t-cal	t-crit	p- value	Remark
Male	134	72.06	61.76					
Female	151	50.54	66.67	124	5.40	1.713	0.05	Significant
Total	285							

The analysis in table 7 above shows that the calculated t-value was 5.40 and critical t-value 1.713 at $\alpha = 0.05$ with 124 degree of freedom (df). Since the calculated t-value of 5.540 is greater than the critical t-value of 1.713. Then the null hypothesis (H_{03}) is rejected and the alternative hypothesis is accepted that there is significant difference between the mean interest score of students taught Basic Science and Technology using Project Based Learning and those taught using conventional method of teaching. This implies that the experimental group taught Basic Science and Technology using Project Based Learning had higher mean interest in Basic Science and Technology than the control group taught using conventional method.

4.2.4: Hypotheses Four (H_{04}): There is no significant difference between the mean interest scores of male and female JSSII students taught Basic Science and Technology using Project Based Learning.

Table 8: Summary of Independent Sample t-test for Mean Interest Score Based on Gender

Group	N	Mean (\bar{X})	Variance (S^2)	Df	t- cal	t- crit	P - value	Remar k
Male	118	3.42	0.96					
Femal e	134	2.03	0.69	124	2.69	1.711	0.05	Signific ant

Total 252

The analysis in table 8 above shows that the calculated t-value was 2.69 and critical t-value 1.711 at $\alpha = 0.05$ with 124 degree of freedom (df). Since the calculated t-value of 2.69 is greater than the critical t-value of 1.711. Then the null hypothesis (H_{04}) is rejected and the alternative hypothesis is accepted that there is significant difference between the mean interest scores of male and female JSSII students taught Basic Science and Technology using Project Based Learning. This implies that the male students taught Basic Science and Technology using Project Based Learning had higher mean interest in Basic Science and Technology than the female taught using conventional method.

Discussion

The data presented in Table 1 reveals a clear distinction between the academic performance of students taught Basic Science and Technology (BST) using Project-Based Learning (PBL) and those taught using conventional teaching methods. The findings suggest that PBL had a far more positive impact on students' academic achievement in Basic Science and Technology than the conventional teaching method. This result aligns with several studies that have demonstrated the effectiveness of PBL in improving students' understanding, engagement, and retention of knowledge. For instance, Thomas (2015) asserts that PBL promotes deeper learning and enhances students' problem-solving skills by allowing them to engage in real-world tasks. Similarly, a study by Demirel and Dağyar (2016) found that students taught using PBL exhibited better academic performance and greater enthusiasm toward learning science subjects compared to those taught using traditional methods.

The findings also support the conclusion of Kokotsaki, Menzies, and Wiggins (2016), who noted that PBL increases student motivation and fosters active learning, resulting in improved academic outcomes. The significant improvement seen in the experimental group's post-test scores can be attributed to the interactive and hands-on nature of PBL, which likely engaged students more deeply in the learning process and helped them to better grasp key concepts in Basic Science and Technology. In contrast, the slight decline in the control group's performance could be reflective of the limitations of conventional teaching methods, which often rely on passive learning and may fail to actively engage students. Studies by Johnson and Delawsky (2017) show that traditional methods, while effective in certain contexts, often do not provide the same level of student involvement and critical thinking opportunities as PBL.

The table provides a summary of the mean and standard deviation of interest scores from pre-test and post-test for both the experimental and control groups. The experimental group was taught Basic Science and Technology (BST) using Project-Based Learning (PBL), while the control group was taught using the conventional teaching method. The results indicate that PBL is more effective in increasing students' interest in Basic Science and Technology than the conventional teaching method. The significant increase in interest scores for the experimental group can be attributed to the hands-on, student-centered nature of PBL, which engages students in real-world problem-solving tasks, making learning more relevant and exciting for them. This finding is consistent with several studies. For instance, Hmelo-Silver (2015) argues that PBL encourages active participation, collaboration, and critical thinking, which are key factors in boosting students' interest and motivation to learn. Similarly, a study by Gijbels, Dochy, Van den Bossche, and Segers (2016) emphasizes that PBL creates an interactive

learning environment where students can relate scientific concepts to real-life applications, thereby fostering greater interest in STEM subjects.

Furthermore, Kokotsaki, Menzies, and Wiggins (2016) found that PBL not only enhances academic performance but also stimulates students' intrinsic motivation, as they are more invested in tasks that require exploration and creativity. This aligns with the results in the current study, where the experimental group's interest scores increased significantly after being taught using PBL. The slight decline in the control group's interest score may be due to the limitations of conventional teaching methods, which are often characterized by passive learning and teacher-centered instruction. According to Van Der Vleuten et al. (2018), traditional methods may not provide sufficient opportunities for students to actively engage with the content, which can lead to disengagement and reduced interest over time.

The data presented in Table 3 examines the mean achievement scores of male and female Junior Secondary School II (JSSII) students taught Basic Science and Technology (BST) using Project-Based Learning (PBL). The analysis highlights notable differences between the performance of male and female students after the PBL intervention. These findings suggest that PBL had a significantly greater positive impact on the academic performance of male students in Basic Science and Technology compared to female students. The observed disparity in achievement scores between male and female students is consistent with several studies that have explored gender differences in academic performance, particularly in science and technology subjects. According to Stoet and Geary (2018), gender differences in academic achievement can be influenced by various factors, including cultural, cognitive, and social elements. Their research suggests that boys often perform better in science and technology subjects, particularly in problem-solving and hands-on activities such as those involved in PBL. This may explain the higher post-test scores observed for male students in this study.

Additionally, research by Aina and Olabisi (2015) found that boys tend to be more engaged in active learning environments, such as those fostered by PBL, where practical tasks and experiential learning are emphasized. This engagement may have contributed to the higher achievement scores among the male students. However, the lower performance of female students should not be interpreted as a lack of ability. Studies by Mensah, Okyere, and Kuranchie (2017) indicate that female students often face barriers, such as lower confidence levels and societal stereotypes, which may affect their performance in science subjects. These barriers may have influenced the lower mean score for female students in the current study. Additionally, the higher standard deviation for female students suggests greater variability in their performance, which could indicate that some female students benefitted from PBL, while others may have struggled. The findings of this study are supported by literature on the effectiveness of PBL in science education. Kokotsaki, Menzies, and Wiggins (2016) found that PBL is highly effective in engaging students in deep learning and improving academic outcomes across various subjects, including science and technology. However, they also noted that gender differences in learning preferences and experiences could influence how students respond to PBL.

The data presented in Table 4 compares the post-test mean interest scores of male and female JSSII students taught Basic Science and Technology using Project-Based Learning (PBL). It reveals significant differences in the levels of interest between male and female students. The findings suggest that male students were more positively influenced by the PBL approach than female students in terms of interest in Basic Science and Technology. This gender-based disparity in interest could be attributed to various factors, including gender socialization and

different attitudes toward science subjects among male and female students. These findings align with studies that have examined the impact of PBL on students' interest in science subjects. For instance, a study by Hmelo-Silver (2016) found that PBL can increase interest and motivation, particularly among students who enjoy hands-on, inquiry-based learning experiences, which are often favored by male students. Similarly, Hattie and Donoghue (2016) emphasized that PBL encourages active participation, which may resonate more with male students, who are typically more engaged in practical, problem-solving activities.

However, the relatively lower interest scores for female students could be reflective of broader gender-related issues in science education. For example, Nugent et al. (2015) highlighted that female students often face societal and cultural barriers that discourage them from pursuing interest in STEM fields, despite the potential benefits of approaches like PBL. It may also reflect that the PBL activities were not as aligned with female students' learning preferences, as supported by the work of Wang et al. (2019), who suggested that different instructional strategies may be required to engage female students more effectively in science subjects. The gender disparity observed in this study indicates the need for instructional designs that are sensitive to the learning preferences of both male and female students. While PBL is effective in fostering interest, especially among male students, efforts should be made to ensure that female students also benefit equally. This can include tailoring PBL activities to address the specific interests and learning styles of female students in science education, as suggested by Archer et al. (2016), who emphasized the importance of gender-responsive teaching methods in STEM fields.

Conclusion

The results clearly indicate that Project-Based Learning is more effective in improving students' academic achievement in Basic Science and Technology compared to conventional teaching methods. This finding reinforces the need to adopt PBL as a pedagogical strategy for teaching science subjects in secondary schools, as it not only enhances students' knowledge but also increases their engagement and motivation to learn. Also, the findings clearly demonstrate that Project-Based Learning is more effective in fostering student interest in Basic Science and Technology than conventional teaching methods. The significant increase in the experimental group's post-test interest score supports the growing body of literature that highlights the benefits of PBL in enhancing student motivation, engagement, and overall interest in STEM subjects. As educators continue to seek innovative ways to improve learning outcomes and student engagement, PBL presents itself as a promising pedagogical approach for fostering long-term interest in science and technology education.

Furthermore, the findings of the study suggest that PBL significantly improves the academic performance of male students in Basic Science and Technology, while female students may not experience the same level of benefit without additional support. These findings highlight the need for educators to consider gender-specific strategies when implementing PBL in science education to ensure that both male and female students can achieve optimal learning outcomes. In conclusion, the results indicate that male students had a significantly higher interest in Basic Science and Technology when taught using PBL compared to female students. This gender gap in interest underscores the importance of adopting gender-sensitive pedagogical approaches to ensure that both male and female students can equally benefit from innovative teaching strategies like PBL.

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