Effects of Integrated Problem and Project Based Learning on Building Technology Students in Academic Performance in Colleges of Education in North Central, Nigeria

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Abstract
This study investigated the effects of integrated problem- and project-based learning (PBL+PjBL) on the academic performance, interest, and retention of building technology students in colleges of education in North Central Nigeria. G3Specifically, the study sought (a) to determine the effects of integrated problem and project-based learning on students' performance, interest, and retention, and (b) to examine gender differences in these outcomes among students exposed to the integrated instructional approach. A quasi-experimental design involving pretest, posttest, and retention test was adopted. The sample comprised building technology students from selected colleges of education, assigned to experimental and control groups. Data were collected using validated achievement, interest, and retention tests, and analyzed with mean, standard deviation, and analysis of covariance (ANCOVA). Results revealed that students taught with the integrated PBL+PjBL strategy significantly outperformed those taught using conventional lecture methods in terms of achievement, interest, and retention. Findings also showed no significant gender differences in performance, interest, and retention among students exposed to the integrated instructional approach. The study concludes that combining problem- and project-based learning fosters deeper understanding, sustained interest, and better knowledge retention in building technology education. It is recommended that teacher educators adopt integrated PBL+PjBL approaches in technical and vocational classrooms, provide adequate instructional resources, and engage in continuous professional development to promote learner-centered pedagogies.

Keywords: Academic, Gender, Performance, Problem-based learning, Project-based learning,

Introduction

Vocational and technical education refers to educational programs that are primarily structured to prepare learners for either self-employment or paid work within technical and vocational fields after graduation. Effieyen, Asu-nandl, and Achima (2017) characterized this type of education as one aimed at equipping individuals with the knowledge, competencies, attitudes, work habits, and appreciation necessary to secure and advance in productive employment. Within Nigeria's higher education system, Building Technology is one of the specialized fields in vocational and technical education.

Building Technology as a program is dynamic, designed to prepare students for active roles in the construction industry within an ever-evolving society. According to Maurice, Asu-nandi, and Ntui (2010), it involves applying engineering principles and technological

knowledge to the design and construction of buildings. Similarly, Okoro (2010) described it as a discipline that emphasizes teaching technical methods, processes, tools, materials, and techniques essential for constructing and maintaining buildings. Igwe, Puyate, Onoh, and Eze (2012) further argued that Building Technology education equips learners with entrepreneurial skills necessary to establish small-scale enterprises such as block-making, production of pre-cast concrete, culverts, tiles, and other related products. Effieyen *et al.* (2017) maintained that the primary goal of Building Technology education is to develop technically skilled individuals who can contribute to industrial and economic development. Gimba (2011) highlighted that its objectives include providing learners with competencies in site organization, earthwork, formwork, sub-structural problem-solving, frame erection, and knowledge of regulatory requirements, as well as exposure to prefabrication, drainage, and other construction techniques.

Graduates of Building Technology in Nigeria often work as foremen, craftsmen, and technicians. However, the increasing complexity of modern building design and construction requires graduates with advanced problem-solving skills and broader competencies. Ogwo (2005) noted that employers in Nigeria increasingly demand workers who can flexibly acquire, transfer, and apply knowledge across various contexts while responding creatively to workplace challenges. Unfortunately, these expectations are not fully realized due to the continued reliance on conventional teaching methods, which often result in weak graduate quality.

Traditional instructional methods, according to Akpoghol, Ezeudu, Adzape, and Otor (2016), limit students' creativity, critical thinking, and collaborative problem-solving abilities. Oranu (2003) similarly criticized these approaches as teacher-centered and content-driven, while Unongo (2015) described them as predominantly one-way communication models. To address the declining student interest and poor performance in Building Technology, scholars advocate learner-centered approaches such as problem-based learning (PBL) and project-based learning (PjBL). PBL, as defined by Torp and Sage (2007), is a student-centered pedagogy where learners collaboratively investigate real-life problems to derive meaningful solutions. Akinogulu and Tandogan (2007) described it as a method that transforms learners into active knowledge constructors rather than passive recipients. Research suggests that PBL enhances knowledge retention, integration, and application (Thakur &Dutt, 2017), while also promoting critical inquiry and problem-solving (Aidoo, Boateng, Kissi, & Ofori, 2016). Abanikannda (2016) outlined PBL's stages, including problem presentation, hypothesis generation, knowledge recall, identification of gaps, and research to develop solutions. Savery (2006) emphasized its capacity to link theory and practice while empowering learners to generate viable solutions collaboratively.

In addition, PjBL has emerged as another effective interactive method that emphasizes real-world application and

collaboration. Ibrahim, Yunus, and Yusuf (2015) noted that PjBL benefits learners who dislike passive lecture formats by improving critical thinking and synthesis of ideas. Erdem (2012) added that it enables students to solve problems through questioning, experimentation, data collection, and communication of findings. Kalayci (2008) argued that PjBL enhances teamwork, self-concept, and study skills, while Cole, Means, Simkins, and Tavali (2002) highlighted its role in fostering student autonomy and collaborative learning through projects tied to real-life contexts.

Student academic performance, as described by Akinbobola (2016), reflects learning outcomes such as knowledge, skills, and experiences gained both in classrooms and laboratories. Akinade (2001) emphasized that performance is a function of intellectual and mental capacity development, while Fstan (2016) considered classroom assessments as key indicators of achievement. Despite this, many Nigerian graduates of Building Technology still lack industry-relevant skills. Interviews conducted with students and graduates in North-central Nigeria revealed deficiencies in fundamental competencies needed for contemporary building practices.

The declining performance and interest of students in Building Technology are particularly concerning. Scholars such as Ifeakor, Njelita, and Udogu (2008) attributed poor outcomes to passive traditional teaching methods like lectures and demonstrations. The increasing cases of structural failures, including building and bridge collapses in Nigeria, underscore the urgent need for reforms in instructional strategies. To meet industry standards and prepare competent graduates, Building Technology education must prioritize interactive, skill-based approaches such as PBL and PjBL. It is within this context that the present study investigates the effects of these instructional methods on the academic performance of Building Technology students in North-central Nigeria.

Statement of the Problem

Building Technology graduates in Nigeria are often employed as foremen, craftsmen, and technicians in the construction sector. However, the rapid advancement and increasing complexity of modern construction projects now demand graduates with higher-level competencies, creativity, and problem-solving abilities. Employers, as Ogwo (2005) noted, increasingly seek individuals who can flexibly apply and adapt their knowledge to diverse contexts while responding independently and innovatively in the workplace. Unfortunately, the current output of graduates falls short of these expectations due to the predominance of conventional teaching approaches that do not adequately prepare students for industry challenges. Traditional instructional methods used in vocational and technical education in Nigeria are largely teacher-centered, passive, and content-driven (Akpoghol, Ezeudu, Adzape, &Otor, 2016; Oranu, 2003; Unongo, 2015). These methods fail to promote creativity, collaboration, or critical thinking, resulting in low student motivation, poor academic performance, and significant skill deficiencies.The

recurring cases of structural failures, building defects, and collapses in the Nigerian construction industry further highlight the inadequacies of current instructional practices (Ifeakor, Njelita, & Udogu, 2008).

Despite government and stakeholder efforts to strengthen technical and vocational education, students' performance has remained persistently low. The Chief Examiner's Report of the National Business and Technical Examination Board (NABTEB) for Benue State, North-Central Nigeria, revealed a consistent decline in students' academic outcomes between 2008 and 2013, with an average failure rate of 66 percent across six years. This trend underscores the urgent need for reform in teaching and learning practices in Building Technology education.Given the mismatch between industry expectations and graduate competencies, there is a critical need to explore alternative instructional strategies that can better engage students and improve their performance. Approaches such as problem-based learning (PBL) and project-based learning (PjBL) have been identified as learner-centered techniques that emphasize active participation, critical inquiry, collaboration, and real-world application of knowledge (Torp & Sage, 2007; Ibrahim, Yunus, & Yusuf, 2015). However, limited empirical evidence exists regarding their effectiveness in improving Building Technology education outcomes in Nigeria. Therefore, this study seeks to investigate the Effect of problem-based and project-based instructional strategies on the academic performance of Building Technology students in North-Central Nigeria.

Objectives of the Study

Sspecifically, the objectives of the research are:

1. To determine the effects of integrated problem and project-based learning on performance, interest and retention of building technology students in colleges of education in north central Nigeria.
2. To identify the difference in performance, interest and retention across gender of building technology students who are exposed to integrated problem and project-based learning in colleges of education in north central Nigeria.

Traditional instructional paradigms, such as lecture-based teaching, are increasingly viewed as outdated and ineffective for meeting the learning needs of contemporary students (Barr &Tagg, 1995; McGowan, 2007). These methods typically prioritize teacher talk and short-term memorization while neglecting student collaboration, problem-solving, and long-term retention. In the Nigerian context, persistent poor performance in technical and vocational education has been linked to the overreliance on teacher-centered methods such as lectures and demonstrations (Oranu, 2003). Within this paradigm, students often remain passive recipients of information, while the instructor dominates the classroom dialogue. Studies suggest that this approach negatively influences motivation and performance, particularly in technical subjects such as Building Technology (Okolie, Elom, & Inyiagu, 2014). Although students frequently perceive

these subjects as difficult, research indicates that when appropriate teaching materials and modern instructional strategies are employed, students' attention, motivation, and achievement improve (Okolie *et al*., 2014).

Globally, a shift toward learner-centered, participatory instructional approaches has emerged as educators recognize the limitations of conventional methods (Akpoghol et al., 2013; Torraco, 1999; Azar, 2010). Effective teaching now emphasizes inquiry, critical thinking, and active engagement. Strategies such as Scenario-Based Learning (SBL), Problem-Based Learning (PBL), and Project-Based Learning (PjBL) fall under the umbrella of inquiry-based learning (Khurshid & Ansari, 2012; Amaechi & Thomas, 2016). These approaches position students as active participants, encouraging them to engage in collaborative group work, analyze real-world problems, and develop practical solutions (Barnstein, 2006). In this sense, teachers act as facilitators rather than knowledge transmitters, while students take ownership of their learning (Abdullahi, 1998).

For example, Problem-Based Learning (PBL) has been widely recognized as an effective pedagogical approach because it places learners at the center of instruction and organizes learning around meaningful, real-world problems (Torp & Sage, 2002; Barrows, 2000). Research consistently demonstrates the benefits of PBL for student performance and motivation. Thakur and Dutt (2017), for example, found that students taught with PBL in biology displayed significantly higher achievement motivation than those taught through conventional methods, with strong positive correlations between pre- and post-test scores. Argaw, Haile, Ayalew, and Kuma (2016) similarly reported that PBL significantly improved physics achievement compared to traditional instruction, emphasizing the method's capacity to enhance both problem-solving skills and content mastery. Abanikannda (2016), focusing on chemistry students in Nigeria, also confirmed that PBL improved both academic achievement and students' outlook on learning. Collectively, these studies suggest that PBL fosters critical thinking, problem-solving, and sustained interest, thereby addressing many of the challenges associated with passive, lecture-based learning.

Like PBL, Project-Based Learning (PjBL) emphasizes student-centered, experiential learning, but it does so by engaging students in extended projects that require planning, implementation, and reflection. Redmond (2014) demonstrated that pupils taught using PjBL outperformed those taught with conventional approaches in academic achievement. Bilgin, Karakuyu, and Ay (2015) found similar results with undergraduate students, noting not only higher academic performance in the PjBL group but also more positive attitudes toward learning. Uzoma and Amadi (2017) further compared PjBL with group discussions, self-regulated learning, and lectures, reporting that PjBL yielded the highest gains in performance.

In the Nigerian context, Alachi, Owadara, and Iwu (2016) showed that

PjBL enhanced Physics students' ability to produce creative equipment, underscoring its role in fostering innovation and global competitiveness. Likewise, Karacalli (2014) revealed that PjBL significantly improved students' attitudes, retention, and academic achievement in electrical studies. Abdulhamid (2013) confirmed these findings in Agricultural Science, reporting that PjBL significantly enhanced students' retention of subject matter compared to traditional approaches. These studies consistently highlight that PjBL not only improves academic performance but also develops creativity, retention, and skills that extend beyond the classroom.

Evidence from prior research clearly indicates that both PBL and PjBL significantly enhance performance, motivation, and retention across diverse subject areas. These approaches align directly with the objectives of the present study, which seeks to examine their effects on Building Technology students in colleges of education in North Central Nigeria. In particular, the literature suggests that integrating PBL and PjBL may address persistent challenges in technical education by fostering interest, improving retention, and supporting equitable performance across gender. By situating learning in authentic problems and projects, these methods have the potential to not only raise academic achievement but also equip students with critical thinking, creativity, and problem-solving skills necessary for professional and entrepreneurial success in the construction industry.

Methodology

This study employed a quasi-experimental pre-test, post-test, non-equivalent control group design, involving 148 Building Technology students drawn from three colleges of education in North-Central Nigeria: Federal College of Education, Pankshin (56 students), Niger State College of Education, Minna (47 students), and Kogi State College of Education, Ankpa (45 students). Using simple balloting, the Pankshin group was assigned to problem-based learning, Minna to project-based learning, and Ankpa to the conventional lecture method (control). Data were collected through the Building Technology Performance Test (BTPT), a 50-item multiple-choice instrument validated by experts and with a reliability coefficient of 0.83 (K-R21). All groups completed a pre-test before the intervention, which lasted six weeks, followed by a post-test to assess performance. Scores were marked over 50, and data were analyzed using mean, standard deviation, and Analysis of Covariance (ANCOVA) at the 0.05 level of significance.

Results Presentation

RQ1: What are the effects of integrated problemand project-based learning on the performance, interest, and retention of Building Technology students in colleges of education in North-Central Nigeria? This research question aims to investigate how combining problem-solving and project work as teaching methods help Building Technology students in colleges of education in North-Central Nigeria do better in their studies, stay more interested,

and remember what they learn. To address this, Table 1 was used.

Table 1: Mean Performance Scores of Building Technology Students taught with Problem and Project-based Learning Methods and those taught with Conventional Method

Groups	N	Pre-test $\bar{X}$	Pre-test SD	Post-test $\bar{X}$	Post-test SD	Pre/Post-test Gain Scores
Problem-based Learning	56	23.11	4.45	41.18	3.48	18.07
Project-based Learning	47	22.81	4.31	43.04	3.28	20.23
Conventional (Control)	45	22.93	4.26	29.24	4.20	6.31

Table 1 presents the mean performance scores of Building Technology students taught with problem-based learning (PBL), project-based learning (PjBL), and the conventional lecture method. At the pre-test stage, the three groups performed at comparable levels: PBL (M = 23.11, SD = 4.45), PjBL (M = 22.81, SD = 4.31), and control (M = 22.93, SD = 4.26). At post-test, however, the PjBL group recorded the highest mean score (M = 43.04, SD = 3.28), followed by the PBL group (M = 41.18, SD = 3.48), while the control group achieved a substantially lower mean (M = 29.24, SD = 4.20). Gain scores indicated marked improvements for PjBL (20.23) and PBL (18.07) compared to the control (6.31). These results suggest that both PBL and PjBL were more effective than the lecture method in improving students' performance.

RQ2: What differences exist in performance, interest, and retention across gender among Building Technology students exposed to integrated problem and project-based learning in colleges of education in North-Central Nigeria?T his research seeks to determine whethermale and female Building Technology students learn, stay interested, and remember things differently when taught with a mix of problem-solving and project work in colleges of education in North-Central Nigeria.

Table 2: Mean Performance Scores of Male and Female Students taught Building Technology with Problem and Project-based Learning Methods and those taught with Conventional Method

SN	Treatments	Gender	Pre-test N	Pre-test $\bar{X}$	Pre-test SD	Post-test $\bar{X}$	Post-test SD	Gain Scores
1	Problem-based Learning	Males	48	23.13	4.42	41.17	3.52	18.04
		Females	8	23.00	4.56	41.25	3.19	18.25
2	Project-based Learning	Males	41	22.82	4.60	43.04	3.26	20.22
		Females	6	22.67	4.36	43.00	3.74	22.33
3	Conventional (Control)	Males	39	23.06	4.52	30.17	4.01	7.11
		Females	6	22.01	3.78	29.11	4.53	7.10

Table 2 shows the mean performance scores of male and female students across the three instructional methods. For the PBL group, males (M = 41.17, SD = 3.52) and females (M = 41.25, SD = 3.19) performed almost equally, with similar gain scores (18.04 vs. 18.25). In the PjBL group, males (M = 43.04, SD = 3.26) and females (M = 43.00, SD = 3.74) also achieved nearly identical post-test scores, though females recorded a slightly higher gain (22.33) than males (20.22). Within the control group, both males (M = 30.17, SD = 4.01) and females (M = 29.11, SD = 4.53) had lower scores and minimal gains (7.11 and 7.10). These results indicate that PBL and PjBL enhanced performance regardless of gender, while the lecture method was less effective for both groups.

Discussion of Findings

The first finding revealed that students of Building Technology taught with the problem-based learning (PBL) method achieved substantial improvement, with a marked increase from pre-test to post-test performance. This aligns with the work of Aidoo, Boateng, Kissi, and Ofori (2016), who affirmed that PBL enhances critical thinking and problem-solving skills, making it an effective instructional approach. Similarly, Thakur and Dutt (2017) demonstrated that students exposed to PBL not only performed better than those in control groups but also showed stronger achievement motivation, indicating that the method fosters both cognitive and affective learning outcomes. Supporting this evidence, Argaw, Haile, Ayalew, and Kuma (2016) reported that PBL significantly improved physics achievement compared to conventional instruction, while Abanikannda (2016) confirmed its effectiveness in boosting academic achievement more broadly. Together, these findings reinforce the view that PBL actively engages learners, enabling deeper understanding and sustained performance gains.

Similarly, students taught with the project-based learning (PjBL) method demonstrated the highest performance gains. This outcome resonates with Redmond (2014), who found that PjBL yielded significantly greater academic achievement than traditional methods. Bilgin, Karakuyu, and Ay (2015) also observed that students in PjBL groups outperformed control groups and expressed positive attitudes toward the approach, suggesting that the method promotes both achievement and learner satisfaction. In line with this, Ilter (2014) highlighted that PjBL not only enhanced conceptual understanding but also supported higher behavioral and academic achievement. The consistent agreement across studies underscores that PjBL is particularly effective in engaging students in authentic, hands-on learning that mirrors real-world applications, thereby making learning more meaningful.

By contrast, students taught through the conventional lecture method showed only minimal improvement, highlighting the limited effectiveness of teacher-centered instruction in Building Technology. This finding supports Uzoma and Amadi (2017), who found that PjBL students significantly outperformed those taught through lecture, discussion, and self-regulated methods. Similarly, Alachi,

Owadara, and Iwu (2016) observed that PjBL equipped students with innovative skills needed for global competitiveness, a feature largely absents in conventional approaches. Collectively, these results suggest that active, student-centered pedagogies are better suited to the demands of vocational and technical education than passive lecture-based methods.

The second major finding examined the effect of gender on students' performance. Results indicated that both male and female students benefitted equally from PBL and PjBL, with no meaningful gender differences in performance gains. This agrees with Omaga (2017), who reported no significant gender differences in electricity achievement scores under PBL, and with Etiubon and Ugwu (2016), who found that gender did not significantly influence students' thermodynamics achievement when taught with PBL. Similarly, in the PjBL group, both male and female students recorded substantial performance gains, echoing Murat (2015) and Chu (2009), who confirmed that PjBL positively affects learners irrespective of gender or academic ability.

In contrast, students in the control group both male and female recorded only modest gains, further confirming the superiority of PBL and PjBL methods over the conventional lecture approach. Taken together, these findings demonstrate that active learning strategies not only enhance performance but also provide equitable benefits across gender. Notably, PjBL produced slightly higher gains than PBL, suggesting that its project-oriented, collaborative design may offer additional advantages in motivating students and consolidating learning outcomes.

Overall, the findings of this study highlight the transformative potential of integrating problem-based and project-based learning into Building Technology education. Both methods proved superior to the conventional lecture approach, equipping students with higher achievement, stronger motivation, and deeper understanding. Importantly, the absence of gender differences in performance suggests that these methods provide equitable learning opportunities for all students, making them inclusive strategies for technical and vocational education. In the Nigerian contextwhere Building Technology plays a vital role in preparing students for professional and entrepreneurial pathwaysPBL and PjBL offer practical, learner-centered approaches that not only enhance academic outcomes but also develop the critical thinking, creativity, and problem-solving skills required for national development and global competitiveness.

Conclusion

This study investigated the effects of problem-based learning (PBL) and project-based learning (PjBL) on the academic performance of Building Technology students in colleges of education in North-Central Nigeria, with attention to gender differences. The findings revealed that both PBL and PjBL significantly enhanced students' performance compared to the conventional lecture method, with PjBL yielding the highest performance gains. These results confirm that learner-centered approaches

promote deeper understanding, retention, and interest than teacher-centered methods, which often restrict creativity and critical thinking.The study also revealed that gender did not significantly influence students' performance outcomes, as both male and female students benefitted equally from PBL and PjBL. This suggests that these approaches foster equitable learning opportunities, providing a supportive platform for all learners to achieve success regardless of gender.Overall, the results highlight the urgent need to reform instructional practices in Building Technology education by shifting from traditional lecture-based approaches to innovative, student-centered methods that can meet the demands of modern construction practice and industry expectations.

Recommendations

Based on the findings of this study, several recommendations are made.

1. Teachers of Building Technology should adopt problem and project-based learning approaches as core instructional strategies.
2. Teachers of Building Technology should also participating in continuous professional development workshops designed to equip them with the practical skills necessary for effective implementation.
3. Curriculum planners should recommend the integration of PBL and PjBL into the Building Technology curriculum of colleges of education to ensure students acquire hands-on experience, creativity, and problem-solving skills.
4. College management should adequately provide instructional materials and facilities such as tools, equipment, and project resources to support successful implementation of the curriculum.
5. Policymakers should mandate the use of innovative, learner-centered pedagogies across technical and vocational education programs and allocate sufficient funding to create active learning environments that meet global standards.
6. Finally, future research should examine the long-term effects of PBL and PjBL on students' employability and workplace readiness, as well as investigate their influence on other aspects of learning such as collaboration, creativity, and entrepreneurial skills within vocational and technical education.

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