JOURNAL OF SCIENCE TECHNOLOGY AND EDUCATION 14(2), JUNE, 2026
E-ISSN: 3093-0898, PRINT ISSN: 2277-0011; Journal homepage: www.atbufstejoste.com

Effects of Challenge and Project-based Learning on Woodwork Technology Students' Academic Achievement, Retention and Interest in Colleges of Education (Technical) In Northeast Nigeria

[1]Aminu Musa Ningi, [2]Tukur Tafida, [3]Christopher Ademola John, [4]Aishatu Buba Sa'idu
[1]*Department of Agricultural Education*
[2,3&4]*Adamu Tafawa Balewa College of Education, Kangere, Bauchi State*
Department of Technology Education, Moddibo Adama University of Technology, Yola

ABSTRACT

This study investigated the effect of Challenge-Based Learning (CBL) and Project-Based Learning (PBL) on students' academic achievement and retention in Wood Work Technology in Colleges of Education (Technical) in North East Nigeria. The study was motivated by the persistent poor performance and low retention of practical skills among students taught mainly through the conventional lecture method. A quasi-experimental pretest-posttest non-equivalent control group design was adopted. The population comprised 301 NCE II Wood Work Technology students, while 245 students were purposively selected from four Colleges of Education (Technical) in North East Nigeria. Data were collected using the Woodwork Technology Achievement Test (WTAT), which yielded a reliability coefficient of 0.790 using Pearson Product Moment Correlation. Mean and standard deviation were used to answer the research questions, while Analysis of Covariance (ANCOVA) was employed to test the hypotheses at 0.05 level of significance. The findings showed that students taught design skills using CBL achieved higher posttest mean scores (71.94) than those taught using lecture method (52.96). Students taught project construction using PBL also recorded higher posttest mean scores (72.07) than those taught using lecture method (54.27). In addition, students taught design skills using CBL obtained higher retention mean scores (66.03) than those taught using lecture method (48.93). ANCOVA results indicated significant differences in academic achievement and retention in favour of CBL and PBL ($p < 0.05$). The study concluded that CBL and PBL are more effective than the lecture method in improving students' academic achievement and retention in Wood Work Technology.

ARTICLE INFO
Article History
Received: January, 2026
Received in revised form: March, 2026
Accepted: March, 2026
Published online: June, 2026

KEYWORDS
Challenge-Based Learning, Project-Based Learning, Wood Work Technology, Academic Achievement, Retention, Colleges of Education (Technical).

INTRODUCTION

Technical education in Colleges of Education (Technical) is designed to equip students with practical skills, creativity, and problem-solving abilities required for the world of work. In recent years, educational institutions have increasingly encouraged the use of innovative teaching methods that promote active student participation and meaningful learning experiences. Traditional teacher-centred approaches, particularly the lecture method, have been criticized for limiting students' opportunities for hands-on engagement, critical thinking, and independent learning. As a result, educators are exploring learner-centred strategies that can improve students' academic achievement and retention of knowledge and skills (Yenduri, 2023).

Wood Work Technology is a practical-oriented programme that emphasizes the development of technical competencies needed

Corresponding author: Aminu Musa Ningi
musaaminuningi@gmail.com
Department of Agricultural Education, Adamu Tafawa Balewa College of Education, Kangere, Bauchi State.

for professional practice. The programme aims to produce graduates who can design, construct, and manage woodwork projects effectively. Design skills in woodwork involve the ability to generate ideas, visualize products, prepare sketches or plans, and consider both aesthetic and functional requirements before construction begins. Effective design skills also require planning, creativity, and the ability to solve problems that arise during the making process. These skills are fundamental to successful project construction in woodwork (Msimango, Mtshali & Khoza, 2024).

Project construction in woodwork refers to the systematic process of transforming a design into a finished product through activities such as material selection, cutting, joinery, assembly, finishing, and installation. In the Nigerian context, woodwork project construction demands technical competence, proper sequencing of tasks, quality control, and adherence to safety standards. Because of the practical and procedural nature of these activities, effective instructional methods are necessary to help students acquire the required competencies and apply them successfully in real-life situations (Council of Registered Builders of Nigeria, 2023).

Challenge-Based Learning (CBL) has emerged as an active-learning strategy that engages students in identifying and solving real-life problems through research, reflection, collaboration, and innovation. In CBL, the teacher serves as a mentor and facilitator rather than the sole source of information. The approach exposes students to authentic challenges that encourage critical thinking, creativity, resilience, and the development of disciplinary and cross-disciplinary skills. Through collaborative problem-solving and the use of innovative technologies, students become more actively involved in the learning process and are better prepared for the demands of contemporary workplaces (Silberman & LaFay, 2022).

Project-Based Learning (PBL) is another active-learning approach in which students acquire knowledge and skills by working on projects over a period of time. The teacher acts as a facilitator and project supervisor, guiding students through the process of planning, executing, and evaluating their projects. Unlike the lecture method, PBL emphasizes self-directed learning, practical application of knowledge, and the development of problem-solving abilities. Although both CBL and PBL are grounded in active learning, CBL focuses on solving open-ended real-world challenges, while PBL focuses on completing predefined projects that require systematic procedures and application of learned concepts (Ye, Liang, Ng & Chai, 2023).

Academic achievement is commonly used to determine the extent to which students have mastered the knowledge and skills taught in a particular subject. It reflects students' performance in assessments and serves as an indicator of learning outcomes. Evidence from previous studies suggests that many students enrolled in Wood Work Technology programmes perform below expectation, possibly due to ineffective teaching methods and limited student engagement during instruction. Learner-centred approaches such as CBL and PBL are therefore considered promising strategies for improving students' understanding and performance in technical subjects (Juuti et al., 2014).

Retention is another important educational outcome, referring to the ability of learners to recall and apply knowledge and skills after a period of time. High retention indicates that learning has been meaningful and enduring. Research has shown that active learning strategies enhance retention because they involve students directly in the learning process through participation, reflection, and practical application. Since woodwork education requires students to remember procedures, design concepts, safety practices, and construction techniques, instructional methods that promote long-term retention are particularly important (Bennett & Rebel, 2015).

Despite the recognized potential of Challenge-Based Learning and Project-Based Learning, there is still limited empirical evidence on their effectiveness in improving students' academic achievement in design skills and project construction, as well as their retention of design skills in Wood Work Technology in Colleges of

Corresponding author: Aminu Musa Ningi
musaaminuningi@gmail.com
Department of Agricultural Education, Adamu Tafawa Balewa College of Education, Kangere, Bauchi State.

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Education (Technical) in North East Nigeria. This gap in knowledge necessitates a study that compares the academic achievement of students taught design skills through CBL with those taught through the lecture method, compares the academic achievement of students taught project construction through PBL with those taught through the lecture method, and examines the retention scores of students taught design skills through CBL and those taught through the lecture method. The findings of such a study would provide valuable information for educators, curriculum planners, and policy makers seeking effective instructional strategies for improving learning outcomes in woodwork education.

STATEMENT OF THE PROBLEM

Students in Wood Work Technology programmes in Colleges of Education (Technical) in North East Nigeria continue to experience poor academic performance and low retention of practical skills. This problem is largely attributed to the dominance of the conventional lecture method, which emphasizes theory and provides limited opportunities for hands-on learning, problem solving, creativity, and active participation. As a result, many students struggle to acquire design skills, execute project construction effectively, and retain learned skills. Challenge-Based Learning (CBL) and Project-Based Learning (PBL) are learner-centred approaches that promote critical thinking, collaboration, practical engagement, and the application of knowledge to real-life situations.

Although these methods have demonstrated positive outcomes in other educational settings, there is inadequate empirical evidence regarding their effectiveness in teaching wood work design skills and project construction in Colleges of Education (Technical) in North East Nigeria. The differences in academic achievement and retention between students taught through CBL or PBL and those taught through the lecture method remain unclear. Consequently, this study seeks to determine the effects of CBL and PBL on students' academic achievement and retention in wood work education compared with the conventional lecture method.

Objectives of the Study

1. Academic achievement of students' taught design skills in wood work using challenge-based learning (CBL) and those taught using lecture method in Colleges of Education (Technical) in North East, Nigeria
2. Academic achievement of students taught project construction in wood work using project-based learning (PBL) and those taught using lecture method in Colleges of Education (Technical) in North East, Nigeria
3. Retention score of students taught design skills in wood work using challenge-based learning (CBL) and those taught using lecture method in Colleges of Education (Technical) in North East, Nigeria.

Research Questions

The following research questions were formulated and guided the study;

1. What are the academic achievements of students' taught design skills in wood work using challenge-based learning (CBL) and those taught using lecture method in Colleges of Education (Technical) in North East, Nigeria?
2. What are the academic achievements of students taught project construction in wood work using project-based learning (PBL) and those taught using lecture method in Colleges of Education (Technical) in North East, Nigeria?
3. What are the retention scores of students taught design skills in wood work using challenge-based learning (CBL) and those taught using lecture method in Colleges of Education (Technical) in North East, Nigeria?

Hypotheses

The following null hypotheses were formulated and tested at 0.05 level of significant:

1. There is no significant difference in the academic achievement of students' taught design skills in wood work using challenge-based learning (CBL) and

Corresponding author: Aminu Musa Ningi
musaaminuningi@gmail.com
Department of Agricultural Education, Adamu Tafawa Balewa College of Education, Kangere, Bauchi State.

those taught using lecture method in Colleges of Education (Technical) in North East, Nigeria

2. There is no significant difference in the academic achievement of students taught project construction in wood work using project-based learning (PBL) and those taught using lecture method in Colleges of Education (Technical) in North East, Nigeria
3. There is no significant difference in the retention score of students taught design skills in wood work using challenge-based learning (CBL) and those taught using lecture method in Colleges of Education (Technical) in North East, Nigeria

LITERATURE REVIEW

Project-Based Learning in Education

Project-Based Learning (PBL) has emerged as a dynamic learning to education, captivating students with its focus on authentic, student-driven learning experiences. This framework outlines the key elements and theoretical underpinnings of PBL, highlighting its potential to impact student learning across various domains. The core components of PBL as stated by Krajcik and McKenney (2020) as follows:

1. Real-world projects: PBL revolves around engaging students in complex, openended projects that address real-world issues or problems (Krajcik & McKenney, 2020). These projects provide a context for applying knowledge and skills across disciplines, fostering deep understanding and transferable learning. ii)Student inquiry and agency: PBL emphasizes student-driven inquiry and exploration. Students actively research, analyze, and problem-solve to find solutions to the project challenges, developing critical thinking and independent learning skills (Bell, 2020).
2. Collaboration and communication: PBL projects necessitate collaboration and teamwork, promoting communication, negotiation, and social-emotional learning skills (Moen & Iselin, 2022). Students learn to work effectively in teams, manage conflicting perspectives, and express their ideas clearly.
3. Authentic assessment: PBL requires flexible and authentic assessment methods that align with the project's learning objectives. These may include student presentations, portfolios, product development, or peer evaluations (Larmer et al., 2023).

Looking at the core components of the PBL learning, it can be stated that the method can provide opportunity for students learn on their own with little supervision from the side of the teacher. For-instance the method is characterized by student inquiry and agency, this means students are actively engaged in finding out a solution and way out in learning processes.

Overview of Challenge-Based Learning (CBL)

Challenge-Based Learning (CBL) is a dynamic and engaging pedagogical learning that has gained significant traction in educational settings across various disciplines (Bell, 2022; Strode et al., 2020). In its core, CBL revolves around presenting students with real-world, open-ended challenges that ignite their curiosity, spark inquiry, and necessitate active engagement in the learning process (Larmer et al., 2023).

The key features of CBL according to Bell (2020, p.26) are;

1. Student-centered: Challenges are chosen or co-created with students, fostering a sense of ownership and motivation (Bell, 2020).
2. Project-based: Students learn through hands-on projects that involve researching, analyzing, problem-solving, and collaborating to find solutions to the chosen challenge (Krajcik & McKenney, 2020).
3. Interdisciplinary: Challenges typically integrate various knowledge domains, encouraging students to connect and

Corresponding author: Aminu Musa Ningi
musaaminuningi@gmail.com
Department of Agricultural Education, Adamu Tafawa Balewa College of Education, Kangere, Bauchi State.

apply learning across subjects (Moen & Iselin, 2022).
4. Authentic and relevant: Challenges address real-world issues and connect to students' interests and communities, enhancing engagement and meaning-making (Larmer et al., 2023).
5. Collaborative: Teamwork and communication are crucial for tackling complex challenges, fostering student cooperation and social-emotional skills (Strode et al., 2020).

Research suggests that CBL can positively influence student learning in multiple ways which include the followings:

1. Deeper understanding: The exploration and application of knowledge in authentic contexts promotes deeper understanding and knowledge retention (Bell, 2022). ii) Critical thinking and problem-solving: CBL challenges encourage students to think critically, analyze information, and develop creative solutions (Krajcik & McKenney, 2020).
2. Motivation and engagement: The student-centered and project-based nature of CBL fosters intrinsic motivation and sustained engagement in learning (Strode et al., 2020).
3. Collaboration and communication: The collaborative nature of CBL projects strengthens students' teamwork and communication skills (Moen & Iselin, 2022).
4. 21st-century skills: CBL provides opportunities to develop essential 21st-century skills like critical thinking, creativity, problem-solving, communication, and collaboration (Larmer et al., 2023).

Implementing CBL effectively requires careful planning and consideration of potential challenges which are: -

1. Teacher training and support: Educators need adequate training and support to design and facilitate effective CBL experiences (Bell, 2020).
2. Assessment: Assessing student learning in CBL can be complex, requiring flexible and authentic methods (Krajcik & McKenney, 2020).
3. Resources and time: Implementing CBL may require additional resources and time commitment from both teachers and students (Strode et al., 2020).
4. Student adaptability: Some students may require additional support to adjust to the open-ended and student-driven nature of CBL (Moen & Iselin, 2022).

Overall, CBL represents a promising and engaging learning to learning that can enhance student motivation, deep learning, and 21st-century skills development. Careful planning, teacher support, and ongoing evaluation are key to overcoming challenges and maximizing the benefits of CBL in various educational settings. Considering the speculation about the CBL learning by various authors, the method can effectively be used to teach wood work technology.

METHODOLOGY

The design for the study was quasi-experimental pretest, post-test nonequivalent control group. Jelena & Jelena (2022) defined quasi-experiments as a design which involved assignment, but not random assignment of participants to groups. In other words, entire classrooms, not individual students, are assigned to treatments. The target population involved all NCE II students of Woodwork Technology Education in Colleges of Education in the North East Nigeria. The total number of students at NCE II of the 2024/2025 academic session is 301 students.

Purposive sampling technique was used in the selection of the schools and students for the experiment. Four out of five Colleges of Education that are offering wood work technology were selected namely, Adamawa State College of

Corresponding author: Aminu Musa Ningi
musaaminuningi@gmail.com
Department of Agricultural Education, Adamu Tafawa Balewa College of Education, Kangere, Bauchi State.

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E-ISSN: 3093-0898, PRINT ISSN: 2277-0011; Journal homepage: www.atbufstejoste.com

Education Hong with 67 students, Aminu Sale College of Education Azare with 63 students, Federal College of Education (Technical) Gombe with 61 students and Federal College of Education (Technical) Potiskum with 54 wood work technology students. The total will be 245 NCE II students. NCE II students will be used for this study because they have spent at least one full year in their colleges.

The instruments for data collection were Woodwork Technology Achievement Test (WTAT), and interest inventory developed by the researcher based on the course content. The test has 40 items each of the item followed by five options, A to D among which the students are expected to choose the correct answer from the options. The questions covered design skills and construction aspects of Woodwork Technology course. The Woodwork Technology Achievement Test, Interest Inventory and all the Lesson Plans were given to three experts for face and content validation, two from Modibbo Adama University, Yola to check the adequacy of content, logical sequence and suitability of the technical terms used, and one from Federal Collage of Education (Technical) Bichi to check the content of the instrument against National Commission for College of Education standard on wood work technology.

In determining the reliability of the instrument, test and re-test method was used. This involves the administration of the instrument twice outside the area of the study, in this case, Federal College of Education (Technical) Bichi was used with 47 Wood Work Technology students. After collecting the result, the data was analyzed using Pearson Product Moment Correlation (PPMC) coefficient. The instrument yielded a reliability index of 0.790 which was considered reliable. The scores obtained from the pre-test and post-test were analyzed using mean and standard deviation to answer the research questions, while Analysis of covariance (ANCOVA) was used for testing the null hypotheses at 0.05 level of significance.

RESULTS

The three research questions raised were answered using descriptive statistics of mean and standard deviation and in the same vein, the three null hypotheses formulated were tested at 0.05 level of significance using independent sample t-test.

Research Question 1

What is the academic achievement of students' taught design skills in wood work using challenge-based learning (CBL) and those taught using lecture method in Federal Colleges of Education (Technical) in North East, Nigeria?

Table 1: *Mean Difference in the Academic Achievement of Students Taught Design Skills in Experimental and Control Groups*

Group	N	Pre-test		Post-test		$\bar{X}_{Diff.}$
		$\bar{X}$	SD	$\bar{X}$	SD	
Experimental (CBL)	63	20.54	5.65	71.94	6.54	51.40
Control I (LM)	54	21.63	6.33	52.96	6.76	31.33

N = Number of Subjects; $\bar{X}$ = Mean and SD = Standard Deviation, $\bar{X}_{Diff.}$ = Mean Difference

The result presented in table 1 shows that the experimental group taught design skills using Challenge-Based Learning has a mean score of 20.54 and standard deviation of 5.65 in the pre-test and a mean score of 71.94 and standard deviation of 6.54 in posttest. This gives a mean difference of 51.40. The control group taught using lecture method has a mean score of 21.63 and standard deviation of 6.33 in the pre-test and a mean score of 52.96 and standard deviation of 6.76 in posttest. This gives a mean difference of 31.33. The mean difference between the pre-test and posttest mean score of experimental group is 51.40 which is higher than that of the control group (31.33). This means that, Challenge-Based Learning is the better

Corresponding author: Aminu Musa Ningi
musaaminuningi@gmail.com
Department of Agricultural Education, Adamu Tafawa Balewa College of Education, Kangere, Bauchi State.

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instructional method at improving cognitive achievement of wood work technology students

Research Question 2

What is the academic achievement of students taught project construction in wood work using project-based learning (PBL) and those taught using lecture method in Federal Colleges of Education (Technical) in North East, Nigeria?

Table 2: *Mean Difference in the Academic Achievement of Students Taught Design Skills in Experimental II and Control II Groups*

Group	N	Pre-test		Post-test		$\bar{X}_{Diff.}$
		$\bar{X}$	SD	$\bar{X}$	SD	
Experimental (PBL)	61	19.91	7.65	72.07	6.56	52.16
Control II (LM)	67	22.02	5.33	54.27	7.59	32.25

N = Number of Subjects; $\bar{X}$ = Mean and SD = Standard Deviation, $\bar{X}_{Diff.}$ = Mean Difference

The result presented in table 2 shows that the experimental group taught design skills using Project -Based Learning has a mean score of 19.91 and standard deviation of 7.65 in the pre-test and a mean score of 72.07 and standard deviation of 6.56 in posttest. This gives a mean difference of 51.16. The control group II taught using lecture method has a mean score of 22.02 and standard deviation of 5.33 in the pre-test and a mean score of 54.27 and standard deviation of 7.59 in posttest. This gives a mean difference of 32.25. The mean difference between the pre-test and posttest mean score of experimental group is 52.16 which is higher than that of the control group (32.25). This means that, Project-Based Learning is the better instructional method at improving cognitive achievement of wood work technology students

Research Question 3

What is the retention score of students taught design skills in wood work using challenge-based learning (CBL) and those taught using lecture method in Federal Colleges of Education (Technical) in North East, Nigeria?

Table 3: *Means Retention Score of Students Taught Design Skills Using Challenge-Based Learning and Those Taught Using Lecture Method*

Group	N	Pre-test		Retention Test		$\bar{X}_{Diff.}$
		$\bar{X}$	SD	$\bar{X}$	SD	
Experimental (CBL)	63	20.54	5.65	66.03	6.72	45.49
Control I (LM)	54	21.63	6.33	48.93	7.04	27.03

N = Number of Subjects; $\bar{X}$ = Mean and SD = Standard Deviation, $\bar{X}_{Diff.}$ = Mean Difference

The result presented in table 3 shows that the experimental group taught design skills using Challenge-Based Learning has a mean score of 20.54 and standard deviation of 5.65 in the pre-test and a mean score of 66.03 and standard deviation of 6.72 in retention test. This gives a mean difference of 45.49. The control group taught using lecture method has a mean score of 21.63 and standard deviation of 6.33 in the pre-test and a mean score of 48.93 and standard deviation of 6.76 in retention test. This gives a mean difference of 27.03. The means difference between the pre-test and retention mean score of experimental groups taught using CBL is 45.49 which is higher than that of the control group taught using lecture method (27.03). This means that, Challenge-Based Learning is the better instructional method at improving cognitive retention of wood work technology students.

Corresponding author: Aminu Musa Ningi
musaaminuningi@gmail.com
Department of Agricultural Education, Adamu Tafawa Balewa College of Education, Kangere, Bauchi State.

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Test of Hypotheses

Hypothesis 1

There is no significant difference in the academic achievement of students' taught design skills in wood work using challenge-based learning (CBL) and those taught using lecture

Table 4: *Analysis of Covariance of the Mean Post test Scores of Students Taught Design Skills Using CBL and Lecture Method*

Source of Variance	Sum of Squares	DF	Mean Square	F	Sig. of F (p-value)
Corrected Model	10468.091[a]	2	5234.045	117.709	.000
Intercept	43050.279	1	43050.279	968.159	.000
Pre-test (CBL and Lecture)	.532	1	.532	.012	.913
Post test (CBL and Lecture)	10464.166	1	10464.166	235.329	.000
Error	5069.140	114	44.466		
Total	482560.000	117			
Corrected Total	15537.231	116			

Table 4 reveals that the F value of pretest is 0.012 with p-value of 0.913 which is greater than 0.05 indicating that there is no significant different in the pre-test score (covariate). The F-calculated value for groups (1, 114) is 235.33 with p-value of 0.000. Since the p value of 0.000 is less than 0.05, the null hypothesis is therefore rejected. Hence, there is significant difference between the mean post test achievement scores of wood work students taught design skills using challenged-based and those taught using lecture method.

Hypothesis 2

There is no significant difference in the academic achievement of students taught project construction in wood work using project-based learning (PBL) and those taught using lecture method in Federal Colleges of Education (Technical) in North East, Nigeria

Table 5: *Analysis of Covariance of the Mean Post test Scores of Students Taught Project Construction Using PLB and Lecture Method*

Source of Variance	Sum of Squares	DF	Mean Square	F	Sig. of F (p-value)
Corrected Model	10113.181[a]	2	5056.590	98.934	.000
Intercept	54354.833	1	54354.833	1063.476	.000
Pre-test (PBL and Lecture)	.083	1	.083	.002	.968
Post test (PBL and Lecture)	10112.646	1	10112.646	197.858	.000
Error	6388.819	125	51.111		
Total	520510.000	128			
Corrected Total	16502.000	127			

Table 5 shows that the pretest recorded an F-value of 0.002 with a p-value of 0.968, which is higher than the 0.05 level of significance. This indicates that there was no significant difference in the pretest scores (covariate) of the groups. However, the calculated F-value for the groups (1, 125) is 197.85 with a corresponding p-value of 0.000. Since this p-value is less than 0.05, the null hypothesis is rejected. Therefore, a significant difference exists between the mean posttest achievement scores of woodwork students taught project construction through Project-Based Learning and those taught using the lecture method.

Corresponding author: Aminu Musa Ningi
musaaminuningi@gmail.com
Department of Agricultural Education, Adamu Tafawa Balewa College of Education, Kangere, Bauchi State.

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Hypothesis 3

There is no significant difference in the retention score of students taught design skills in wood work using challenge-based learning (CBL) and those taught using lecture method in Federal Colleges of Education (Technical) in North East, Nigeria.

Table 6: *Analysis of Covariance of the Mean Retention test Scores of Students Taught Design Skills Using CBL and Lecture Method*

Source of Variance	Sum of Squares	DF	Mean Square	F	Sig. of F (p-value)
Corrected Model	85.768[a]	11	7.797	26.808	.000
Intercept	38.644	1	38.644	132.864	.000
Pre-test (CBL and Lecture)	.073	1	.073	.250	.618
Retention test (CBL and Lecture)	85.751	1	8.575	29.482	.000
Error	30.540	114	.291		
Total	549.000	117			
Corrected Total	116.308	116			

Table 6 indicates that the pretest recorded an F-value of 0.250 with a p-value of 0.618, which is greater than the 0.05 level of significance. This shows that there was no significant difference in the pretest scores (covariate) of the groups. However, the calculated F-value for the groups (1, 114) is 29.48 with a p-value of 0.000. Since this p-value is less than 0.05, the null hypothesis is rejected. Therefore, a significant difference exists between the mean retention test scores of woodwork students taught design skills through Challenge-Based Learning and those taught using the lecture method.

DISCUSSION OF FINDINGS

The findings of the study were discussed in order of the specific research questions and their corresponding supportive hypotheses of the study. The result related to the first research question indicated that Challenge-Based Learning is the better instructional method at improving cognitive achievement of wood work technology students on design skills. The supportive hypothesis also shows that there is significant different in the achievement score of students taught design skills using Challenge-Based Learning and those using lecture method. The possible reason for this finding is due to the fact that Challenge-Based Learning actively engages learners in solving real-world and meaningful design problems, which promotes critical thinking, creativity, and problem-solving abilities. Through this hands-on and inquiry-driven process, students are encouraged to explore multiple design alternatives, apply theoretical knowledge to practical contexts, and reflect on their learning outcomes. This finding corroborates that Ogbuanya et al. (2021) who carried out a study on Effects of challenge-based and activity-based learning on technical college students' achievement, interest and retention in woodwork technology.

The study revealed that students taught woodwork using the challenge-based learning instructional learning had a higher mean score than students taught using the activity-based learning teaching method in cognitive achievement tests. It is also in line with finding of Musa, (2021) studied the experimental investigation of challenge-based learning in woodwork technology education. The study found that challenge-based learning significantly improved academic achievement compared to traditional methods. Furthermore, it is similar to Fasasi (2023) studied the longitudinal study on challenge-based learning in Woodwork Technology Education, and reported that challenge-based learning contributed to sustained improvement in academic achievement of students.

The finding with respect to research question two revealed that Project-Based

Corresponding author: Aminu Musa Ningi
musaaminuningi@gmail.com
Department of Agricultural Education, Adamu Tafawa Balewa College of Education, Kangere, Bauchi State.

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Learning is a more effective instructional approach for teaching project construction in woodwork technology. The supportive hypothesis also revealed that there is significant different in the achievement score of students taught project construction using Project-Based Learning and those using lecture method. A possible reason why Project-Based Learning is a more effective instructional approach for teaching project construction in woodwork technology is that it emphasizes learning by doing, allowing students to actively participate in the design, planning, and execution of real-life woodwork projects. This hands-on engagement helps students connect theoretical concepts with practical applications, thereby enhancing their understanding of construction processes, material selection, and tool handling.

Through collaborative problem-solving and self-directed inquiry, learners develop not only technical skills but also creativity, critical thinking, and teamwork abilities competencies that are essential in woodwork practice. This finding is in agreement with Bani-Hamad and Abdullah who conducted a study on the effect of project-based learning to improve the 21st century skills among Emirati secondary students. The study found that project-based learning has significant effect on improvement of 21st century skills (4Cs) among Emirati secondary level students who participated in Think Science National Competition 2019. Another study that is in line with the finding of Ahmed (2022) conducted a study on Project-Based Learning in North East Nigeria, and reported that project-based learning significantly improved academic achievement of students compared to traditional method. It is also similar to that of Nwafor and Adegboye, (2023) study on the Impact of Project-Based Learning on Woodwork Education Outcomes. The study found that Project-based learning positively influenced academic achievement of students.

The outcome pertaining to the research question three showed that Challenge-Based Learning is the better instructional method in enhancing students' retention of design skills content. The supportive hypothesis also shows that there is significant different in the mean retention score of students taught design skills using Challenge-Based Learning and those using lecture method. A possible reason for this finding is that Challenge-Based Learning (CBL) engages students in authentic, real-world problem-solving activities that require them to apply design skills in meaningful contexts. This active involvement promotes deep learning and long-term memory retention, as students connect new knowledge with prior experiences.

Moreover, CBL emphasizes collaboration, reflection, and iterative design, which help reinforce understanding and strengthen cognitive connections. This result resembles that of Musa, (2021) who studied the experimental investigation of challenge-based learning in woodwork technology education and found that challenge-based learning significantly improved academic retention compared to traditional methods. It also corroborates Ibrahim, (2022) who conducted a study on Longitudinal Study on Challenge-Based Learning in Woodwork Technology Education. The findings of the study indicated that challenge-based learning contributed to sustained improvement in academic retention of students over the study period. Moreover, it is in line with the finding of Ukaegbu and Adigwe, (2023) who studied the Experimental Investigation of Challenge-Based Learning in Woodwork Technology Education. The study found that Challenge-based learning significantly improved academic retention compared to traditional methods.

CONCLUSION

The study concluded that innovative, learner-centered instructional approaches such as Challenge-Based Learning (CBL) and Project-Based Learning (PBL) are more effective than the traditional lecture method in teaching woodwork technology. Specifically, Challenge-Based Learning proved to be a superior method for enhancing students' cognitive achievement, and retention, in woodwork design skills. Similarly, Project-Based Learning was found to be more effective in improving students' cognitive achievement, and retention in woodwork project construction. Based on the findings, it can be

Corresponding author: Aminu Musa Ningi
musaaminuningi@gmail.com
Department of Agricultural Education, Adamu Tafawa Balewa College of Education, Kangere, Bauchi State.

concluded that the two teaching approaches can be used to promote deeper understanding, sustained knowledge retention, and greater learner engagement.

RECOMMENDATIONS

Based on the findings of the study, the following recommendations were made:

1. Woodwork technology teachers in Colleges of Education should adopt Challenge-Based Learning (CBL) as a core instructional approach in teaching design-related topics, as it encourages critical thinking, creativity, and deeper understanding of design concepts among students.
2. Teachers of woodwork technology in Colleges of Education should integrate Project-Based Learning (PBL) into the teaching of project construction activities to promote hands-on experience, collaboration, and practical problem-solving skills necessary for mastery of construction tasks.
3. National Commission for Colleges of Education should incorporate Challenge-Based Learning into the design skills component of the woodwork curriculum to help students retain knowledge longer through active engagement and real-world challenges
4. Colleges of Education should encourage the use of Project-Based Learning in woodwork classes to improve long-term retention of concepts and techniques by engaging students in meaningful, project-centered learning experiences.
5. Wood Work Technology should assist students during Challenge-Based Learning activities to increase motivation and sustained students' interest in the subject.
6. Wood Work Technology teachers in collaboration with Colleges of Education should promote Project-Based Learning by providing adequate resources, time, and support for student-centered projects that stimulate curiosity and enthusiasm toward woodwork technology.

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Corresponding author: Aminu Musa Ningi
musaaminuningi@gmail.com
Department of Agricultural Education, Adamu Tafawa Balewa College of Education, Kangere, Bauchi State.

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Corresponding author: Aminu Musa Ningi
musaaminuningi@gmail.com
Department of Agricultural Education, Adamu Tafawa Balewa College of Education, Kangere, Bauchi State.