EFFECT OF COLLABORATIVE AND PROBLEM BASED-LEARNING TEACHING TECHNIQUES ON STUDENTS' ACADEMIC ACHIEVEMENT IN SOIL SCIENCE PRACTICAL AMONG AGRICULTURAL EDUCATION STUDENTS IN NORTH-CENTRAL NIGERIA

Onoriode, O.[1], Tetok, N. I.[2], & Mohammed, H.[3]

[1]Joseph Sarwuan Tarka University, Makurdi,
[2]Federal University of Education, Pankshin
[3]Modibbo Adama University, Yola.

Correspondence: onoriodeovie16@gmail.com.

Abstract

Soil Science is a crucial aspect of agricultural education, requiring effective teaching techniques to enhance students' understanding and academic achievement. The study was directed by three specific objectives, address three research questions and test a single hypothesis. This study examines the impact of collaborative learning and problem-based learning (PBL) teaching techniques on academic performance. A quasi-experimental research design was adopted, involving three groups: one group was taught using collaborative learning, another using PBL, and a control group taught using the conventional Demonstration method. Pre-test and post-test instruments were administered. 239 final-year students of agricultural education were drawn from five universities in North Central Nigeria. Since the entire population was used for the study, no sampling procedure was employed. A structured 50-soil science practical academic achievement test was developed by the researchers and validated by three subject matter experts. One from the department of soil science, the department of educational foundation, and another from the department of agricultural education. A pilot test was administered to determine reliability using the Cronbach alpha techniques, yielding a coefficient of 0.872. A pre-test and a post-test were also administered to both groups at the beginning and the end of six weeks of instruction. The data for the study were collected and analyzed using mean and ANOVA. Results revealed that PBL outperformed both Collaborative Learning Techniques and the Demonstration Method, resulting in the highest student learning outcomes. Recommendation: The findings underscore the need to integrate innovative, student-centered teaching strategies into Agricultural Education to enhance learning outcomes in practical-based courses.

Keywords: Collaborative Learning, Problem-Based Learning (PBL), Teaching Techniques, Academic Achievement, Soil Science Practical, Agricultural Education and Agricultural Students

Introduction

The need to impart knowledge and skills in agriculture to the younger generation in Nigeria arose when consumer demand for agricultural produce exceeded the supply available from farmers in the market (Amonjenu, Agbulu & Onoriode, 2023). Over the years, Nigeria's growing population has resulted in an ever-increasing demand for food, which the local agricultural sector has struggled to meet. This has led to food shortages and increased reliance on agricultural products. The United Nations World Food Programme (2025) reports that

approximately 33 million Nigerians will face acute food insecurity in 2025, with the number of people facing emergency levels of need expected to double. In response, the Nigerian government has continued to advocate for integrating agriculture as a core subject throughout primary and secondary education.

Agricultural Education is a specialized form of vocational education focused on equipping learners with the necessary competencies (knowledge, skills, and attitudes) in all aspects of agricultural. production, as well as effective methods for teaching agriculture at various educational levels (Amonjenu, Agbulu & Onoriode, 2023). According to Egbule, as cited in Akpomedaye (2010), Agricultural Education is a type of education designed for the training of learners in the processes of agricultural production and the techniques of teaching the subject matter of agriculture. Similarly, the National University Commission (CCMAS, 2023) opined that Agricultural Education is a teacher education programme for producing teachers of Agricultural science for secondary schools and colleges.

Agricultural education plays crucial roles to agricultural development through, training of agricultural professionals, assist farmers to adopt modern farming techniques, enhance farm management decision making, and helps youths to take farming as a profession (Onoriode, 2025). Agricultural education plays a critical role in national development, especially in achieving food sufficiency (Amonjenu, Asogwa & Iornenge, 2016). In recognition of these benefits, the Federal Government of Nigeria, through the National University Commission (NUC), has incorporated soil education into the curriculum of the Agricultural Education programme. This curriculum aims to equip students with the competency required to manage and improve soil fertility, as well as enhance food production for human sustenance (National University Commission, CCMAS, 2023).

Soil science, which is a fundamental aspect of Agricultural Education, is conceptualized as the scientific study of soil as a natural resource on the Earth's surface including soil classification, formation, mapping and examination of the chemical, biological, physical and fertility properties of soils about soil management (James Lind Institute, 2019; Davis, 2025). Reddy (2023) submitted that soil science is a multidisciplinary field that examines the intricate and dynamic processes that take place under the Earth’s surface. In the view of Taropumps (2024), soil science is the study of soil that encompasses how soil is formed, its properties, and its management, as well as the Classification of soil types, analyzing its formation, biological properties, the fertility of soil, and how it interacts with living things. The Soil Science Society of America (2013) stated that soil science helps to address a wide range

of issues such as nutrient management, sustainable farming, global biogeochemical cycles, climate change, ecosystem dynamics, and the handling of nuclear waste disposal, and more.

Reddy (2023) noted that Soil sciences help in the assessment of soil properties, fertility, and nutrient content. Similarly, Taropumps (2024) argued that soil science helps determine soil health, which is critical for productivity, ensuring better land management practices, fostering sustainable agriculture, determining Nutrient availability, ascertaining Factors that affect soil quality, and helping manage soil degradation. Similarly, Suleiman and Kundiri (2016) asserted that understanding soil types and their suitability for different crops allows farmers to make informed decisions that enhance productivity. Soil science also contributes to sustainable agriculture through practical soil testing, pH, and other properties essential for effective soil management, as well as techniques such as crop rotation, cover cropping, and minimum tillage. Soil scientists engage in various soil practical experiments and research activities aimed at developing better disease management and prevention, and conduct tests to evaluate nutrient levels, pH, and other essential soil characteristics.

In the view of Reddy (2023), soil science practical involves hands-on experiments and field work that demonstrate and reinforce the theoretical concepts of soil science. Gautam (2012) opined that soil science practical are standardized experiments in introductory soil courses aimed at helping students acquire hands-on and theoretical knowledge of soil. The author further opined that soil science practice encompasses basic soil chemistry terms, understanding soil structure, collecting and preparing samples, and analyzing properties such as moisture content, bulk density, pH, and nutrient levels. Alexander et al (2021) asserted that engaging students in soil science practical improves students' understanding of soil science knowledge and promotes positive attitudes toward the soil-related concept. In the context of this work, soil science Practical are hands-on laboratory-based activities through which students observe, analyze and evaluate different soil types, textures, structures, composition, nutrient levels, and water-holding capacity teach students how to conduct soil tests, measure soil parameters like pH, nutrient levels, and water-holding capacity, in order to develop a practical skill for sustainable land management, environmental protection and agricultural productivity.

The University of Massachusetts Amherst (2025) submitted that soil practical testing helps diagnose plant issues, optimize crop production, protect against environmental contamination, and ensure effective fertilizer use. Al-Ismaily, et al (2023) emphasised that soil practical offer numerous benefits including enhancing student field-based experiences,

equipping them with competence for effective soil management and related fields, facilitating critical thinking, encouraging active engagement in soil science concepts, promote analysis of complex multifaceted problem, enhancing problem -solving ability, strengthens collaboration, communication and teamwork skills, necessary for achieve common goals. Through soil science practice activities, students gain practical skills in managing soil resources, protecting soil from erosion, degradation, and contamination, and promoting sustainable land use for long-term productivity and environmental health.

To effectively deliver agricultural content, particularly soil science, educational institutions are encouraged to adopt student-centered teaching strategies (Alexander et al, 2021). Learning strategies implemented in the Classroom environment, like Collaborative Learning and Problem-Based Learning (PBL), are learner-centered pedagogical approaches that have been found to foster active engagement, teamwork, and critical thinking. Cornell Center for Teaching Innovation (2025) stated that Problem-based learning (PBL) is a learner-focused approach, where students learn collaboratively, explore, and solve an open-ended problem to gain a deeper understanding of subjects. In the context of this study, it refers to instructional techniques where Agricultural Education students engage in group-based activities to complete soil science practical. The University of Ilonis Center for Innovative Training and Learning (2024) submitted that Problem-Based Learning (PBL) is an instructional strategy that uses complex real-world problems as a means of promoting student learning of concepts and principles, rather than relying on direct instructions or straightforward delivery of facts and concepts. Problem-Based Learning (PBL) has been defined as a teaching method where learner collectively work in schools together in a small group to explore and solve problems, drawn from their previous knowledge and supervisor as they learn in small teams while analyzing problems using their previous experiences with minimum guidance from the teacher, with limited a limited direction Azer, as cited by (Ogweno, et al, 2021).

Lubis, et al (2022) opined that the use of the problem-based learning model improves conceptual knowledge and environmental literacy. Chang, Yan, and Lu (2022) stated that studies indicate that PBL and Collaborative Learning improve academic outcomes, student engagement, and problem-solving skills. Collaborative Learning, according to the Cornell Center for Teaching Innovation (2025), helps students develop advanced cognitive ability, effective verbal communication, self-management, and leadership competencies. CLS also enhances student-faculty interaction, boosts retention rate, self-esteem, and responsibility, broadens awareness of diverse viewpoints, and equips students with real-life social and

employment situations. The Education Endowment Foundation (EEF, 2025) noted that collaborative learning is a cost-effective way of raising academic attainment and provides students with the opportunity to work cooperatively. Similarly, Sparkrock (2025) highlighted that collaborative learning offers students a wide range of benefits, deeper engagement, and a more meaningful level of education as well as the development of higher-level thinking, self-management, oral communication, and leadership skills, Increased student retention, enhanced levels of student responsibility and self-esteem, better preparation for real-life social and employment problems, and the promotion of better student-faculty interactions. Similarly, Salma, as cited by Paulino (2024), noted that Collaborative learning strategies play a crucial role by creating an effective atmosphere where students interact actively with one another to acquire knowledge and build important skills.

According to Swargiary (2024), both Collaborative Learning and Problem-Based Learning on Academic Performance were found to significantly improve academic performance. Academic achievement, according to Tophat (2025), represents how well a student has achieved their educational learning goals. It reflects the extent to which a student or institution has met its objectives, whether in the short term or over an extended period. Ahmed (2023) states that Academic achievement refers to performance outcomes that demonstrate the extent to which an individual has advanced towards specific goals of activities in instructional settings, such as school, college, and university. Similarly, Drew (2023) defined Academic achievement as the level of success or accomplishment attained by an individual in an academic setting. Steinmayr, et al (2014), Academic achievement refers to the result of individual performance that indicates the extent to which they achieved specific objectives set within educational settings such as school, college, and university. Tophat (2025) highlighted several factors that negatively influence students' academic achievements, including students' learning competencies /skills, the home of the student, environmental causes, types of friends they keep, teacher-related factors, school factors, and sociocultural factors. Therefore, the integration of practical soil science instruction with innovative teaching approaches like problem-based strategies and Collaborative Learning represents the state-of-the-art in Agricultural Education. These approaches foster deeper understanding, greater student engagement, and improved academic outcomes. This study thus explores the effect of collaborative and problem-learning pedagogical strategies in enhancing the acquisition of practical soil science knowledge among Agricultural Education students in north-central Nigeria.

Statement of the Problem

Agricultural Education is designed to provide students with a blend of both conceptual and hand-on skills necessary for addressing real-life challenges in agriculture. Among its core subjects, Soil Science Practical is particularly vital, as it lays the foundation for understanding soil properties, management techniques, and crop production practices. Despite its importance, students in Agricultural Education programs in Nigeria—particularly in the North-Central region—often perform poorly in Soil Science practical. This is similar to the finding of Amonjenu et al. (2022) that Agricultural Education lecturers in Colleges of Education in North Central Nigeria demonstrate inadequate quality assurance in soil erosion control, manure preparation and application as well as crop rotation practices thereby enhancing the effectiveness of students instruction. This underachievement raises concern about the effectiveness of current teaching techniques being employed in delivering the course content. The researchers observe that the predominant use of the traditional demonstration method in teaching Soil Science practical has been identified as a major limitation to effective learning. This is in line with the research of Peter et al (2021) demonstrated that teaching is less effective in teaching agriculture compared the digital teaching methods. This method typically promotes rote memorization rather than active engagement, critical thinking, or real-world problem-solving skills. As a result, students often struggle to retain and apply what they have learned in practical contexts. The need for more dynamic and student-centered teaching methods has therefore become increasingly apparent.

The researchers are of the opinion that emerging pedagogical strategies such as Collaborative Learning Strategies (CLS and Problem-Based Learning Strategies (PBLS) have been widely recognized in educational research for their potential to improve academic achievement, particularly in science and technical subjects. These approaches emphasize active participation, collaborating, analytical reasoning, and ability to problem-solving—skills that are essential for success in Soil Science practical. While studies in other disciplines have demonstrated the effectiveness of these methods, there are insufficient research based evidence on their impact in Agricultural Education settings in Nigeria.

Given the essential role that hand-on skills play in advancing agricultural development and the persistent academic challenges faced by students in Soil Science, it is necessary to explore alternative teaching strategies that can enhance learning outcomes. Therefore, this study seeks to investigate the effect of Collaborative and Problem-Based Learning teaching

techniques on students' academic achievement in Soil Science practical among Agricultural Education students in North-Central Nigeria. The findings are expected to inform instructional practices and contribute to the development of more effective teaching strategies in Agricultural Education.

Purpose of the study

1. To investigate the effect of collaborative learning techniques on students' academic achievement in soil science practical among agricultural education students in north-central Nigeria.
2. To examine the impact of Problem-Based Learning techniques on students' academic achievement in soil science practical among agricultural education students in north-central Nigeria.
3. To compare the academic achievement of students taught using collaborative learning techniques and those taught using Problem-Based Learning techniques in soil science practical.

Research Question

1. What is the effect of collaborative learning techniques on students' academic achievement in soil science practical among agricultural education students in north-central Nigeria?
2. How do Problem-Based Learning techniques influence students' academic achievement in soil science practical among agricultural education students in north-central Nigeria?
3. What is the difference between the academic achievement of students taught using collaborative learning techniques and those taught using Problem-Based Learning techniques in soil science practical?

Research hypotheses

1. There is no significant difference in the academic achievement of students taught using collaborative learning techniques, Problem-Based Learning techniques and lecture methods on students' academic achievement in soil science practical among agricultural education students in north-central Nigeria.

Methodology

The study was directed by three specific objectives, address three research questions and test single one hypothesis. These guided the structure for data collection, analyses and

interpretation of results. A quasi-experimental research design involving a pre-test and post-test control group design. This research design was suitable as it allowed for comparison among groups while accounting for initial differences in students' academic abilities. The study was conducted in North Central, Nigeria allowing for contextual importance and accessibility. The target population comprised all final students of Agricultural Education students offering agricultural Education in North-Central Nigeria. A total of 239 students were selected from five institutions using stratified random sampling. Each institution was assigned one of the three teaching techniques: Group A: Collaborative Learning. Group B: Problem-Based Learning (PBL), Group C: Traditional Demonstration Method TDM (Control Group). The Agricultural Achievement Test (AAT) was developed by the researcher from the 200-level CCMASS curriculum. A structured 50 structured multiple-choice questions (MCQs) were marked over 100 %. 200-level soil science laboratory practical manual adopted from the CCMAS Curriculum was utilized during the development of the achievement test. To ensure internal validity, a table blue print was employed during the construction of the test. The table enable the researcher to align the sub-topic within the main subject under study against the corresponding learning domain. A pilot study was conducted in Enugu using 10, two-level students of the Agricultural Education University of Nigeria Nsukka. Using test-rested methods, yielding a coefficient of 0.87 indicates reliability of the instrument for the study. The students were separated into Groups A, B and C. depending on the types of instructional strategies received. Group A (collaborative learning) Students, were organized into small groups and engaged in cooperative tasks related to soil classification, texture analysis, and land evaluation. They work collaboratively discussing and presenting findings. Group B (Problem-Based Learning) Students were given practical agricultural problems (e.g., soil fertility management for different crops) to solve in guided inquiry sessions. The teacher facilitates learning but allows students to explore solutions independently or in groups. In Group C (Demonstration Methods) Students were taught using conventional demonstration instructional methods where the teacher explained and demonstrated soil science concepts without active participation. All the groups received a six-week instructional period, Pre-test scores were collected before the intervention to establish a baseline knowledge, and a post-test was conducted after the instruction to assess student achievement. To minimize biases and increase the internal validity of the study, the researchers didn't consider the script of students who sat for the pretest and later missed the posttest coupled with those who sat for the posttest but later missed the pretests. More so, the same set of instructional objectives, content, test items, and

marking guides were used across the board, the research assistant followed standardized procedures in the delivery of content based on the assigned instructional strategy, and Institutional differences were also taken cognizance during the random assignment of teaching strategies. Mean and standard deviation were used to analyze the research question while the Analysis of variance (ANOVA) was adopted to determine the effect of teaching techniques on academic achievement, controlling for pre-test scores. The Schaffer post hoc test was adopted to test the significance that may exist between the group comparisons.

Result and Discussion

Research Question 1

To investigate the effect of Collaborative Learning Techniques on students' academic achievement in Soil Science Practical among Agricultural Education Students in North-Central Nigeria.

Table 1: Mean Score of Academic Achievement test of Students taught using Collaborative Learning Techniques (CLT) in Soil Science Practical.

Group	Teaching Methods		N	Mean	Standard Deviation
Experimental	Collaborative learning techniques	Pre-test	87	46.46	4.685
		Post-test	87	65.84	9.984
Control	Demonstrative Teaching methods	Pre-test	68	44.12	6.916
		Post-test	68	58.94	10.461

Table 1 displays the average scores of the pre-test and post-test for both the experimental and the control groups. The test indicates that students exposed to Collaborative Learning Techniques achieved better results, with a post-test mean of 65.84, compared to a mean score of 57.94 under Demonstration Teaching Methods (DTM). The computed mean difference between CLT and DTM was 6.9. At the same time, the mean gain from pre-test and post-test within the Collaborative Learning Techniques group was 19.38. This indicates that CLT had a notable effect on enhancing students' academic performance. This implies that Collaborative Learning Techniques are a more effective teaching method, as they produce higher student achievement compared to the Demonstration Teaching Method.

Research Question 2

How do Problem-Based Learning techniques influence students' Academic Achievement in soil science practical among Agricultural Education Students in North-Central Nigeria?

Table 2: mean score of Academic Achievement test of students taught using Problem-Based Learning Techniques (PBLT) in Soil Science Practical and Collaborative Learning Techniques (CLT).

Group	Teaching Methods	Test	N	Mean	Standard Deviation
Experimental	Problem-Based Learning Techniques	Pre-test	83	47.27	5.182
		Post-test	83	67.69	9.040
Control	Demonstrative Teaching methods	Pre-test	68	44.12	6.916
		Post-test	68	58.94	10.461

Table 2 displays the average scores of the pre-test and post-test for both the experimental and the control groups. The test indicates that students exposed to Problem-Based Learning Techniques achieved better results, with a post-test mean of 67.69, compared to a mean score of 65.84 under Demonstration Teaching Methods (DTM). The computed mean difference between PBL and DTM was 8.75. At the same time, the mean gain from pre-test and post-test within the Problem-Based Learning techniques group was 20.42. This indicates that Problem-Based Learning techniques had a notable effect in enhancing students' academic performance. This implies that Problem-Based Learning techniques are a more effective teaching method, as they produce higher student achievement compared to the Demonstration Teaching Method.

Research Question 3

What is the difference between the academic achievement of students taught using collaborative learning techniques and those taught using Problem-Based Learning techniques in soil science practical?

Table 3: mean score of Academic Achievement Test of students taught using Problem-Based Learning Techniques (PBLT) in Soil Science practical and Collaborative Learning Techniques CLT).

Group	Teaching Methods	Test	N	Mean	Standard Deviation
Experimental	Problem-Based Learning techniques	**Pre-test**	83	47.27	5.182
		Post-test	83	67.69	9.040
Experimental	Collaborative learning techniques	Pre-test	87	46.46	4.685
		Post-test	87	65.84	9.984

Table 3 displays the average scores of the pre-test and post-test for both the experimental and the control groups. The test indicates that students exposed to Problem-Based Learning Techniques achieved better results, with a post-test mean of 65.69, compared to a mean score of 65.84 under Collaborative Learning Techniques (CLT). The computed mean difference between PBL and CLT was 1.85. While the mean gain from pre-test and post-test within the Problem-Based Learning techniques group was 47.27, this indicates that Problem-Based Learning techniques had a notable effect in enhancing students' academic performance compared to Collaborative Learning Techniques. This implies that Problem-Based Learning techniques are a more effective teaching method, as they produce higher student achievement compared to Collaborative Learning Techniques.

Hypotheses Test.

There is no significant difference in the academic achievement of students taught using collaborative learning techniques, Problem-Based Learning techniques and lecture methods on students' academic achievement in soil science practical among Agricultural Education Students in North-Central Nigeria.

Table 4: ANOVA analysis of the post-test result of mean score of Academic Achievement test of students taught using Problem-Based Learning Techniques (PBLT) and Collaborative Learning Techniques (CLT) in soil Science Practical.

Between Groups	Sum of Squares	df	Mean Square	F	Sig.
Within Groups	1794.412	236	897.206	8.844	.000
Total	25735.448	238	101.445		

Table 4 displays the achievement test result of the three instructional groups, revealing a p-value of 0.00, which is below the alpha value of 0.05. Consequently, the null hypothesis, which

posited no significant difference in the academic achievement of students taught using Collaborative Learning Techniques (CLT), Problem-Based Learning Techniques (PBLT), and Demonstration Methods (DM) on students' academic achievement in soil science practical among Agricultural Education Students in North-Central Nigeria, was rejected. This outcome implies that there are statistically significant differences in performance among the three groups of agricultural education students in North Central Nigeria.

Post-Hoc -Test

Table 5: Pair-wise comparisons between Post-Hoc -Test results of mean scores of Academic Achievement test of students taught using Problem-Based Learning techniques and collaborative learning techniques in soil science practical

Methods/Groups	Mean Different	Sig	Remark
PSB vs. CLT	1.976	.478	Problem-Based and collaborative
PSB vs. DMC	6.611*	.000	Problem-Based and Demonstration
CLT vs. PSB	-1.976	.478	collaborative & Problem-Based
CLT vs. DMC	4.635*	.012	Collaborative& Demonstration
DMC vs. PSB	-6.611*	.000	Demonstration& Problem-Based
DMC vs. CLT	-4.635*	.012	Demonstration & Collaborative

Table 5: shows the Scheffe post hoc test result for the three groups of teaching methods. The pairwise comparisons indicate that there were significant differences between PBLT and DMC as well as between PBLT and DMC. This is because Scheffe's test result for these group comparisons shows p-values less than 0.05. Hence, Problem-Based Learning Techniques (PBLT) performed significantly better followed by Collaborative Learning Techniques (CLT). Therefore, PBLT is the most effective in teaching soil science practical among Agricultural Science Students in North-Central Nigeria.

Finding of the Study

The following are the findings of the study

1. Collaborative Learning Techniques are superior teaching compared to demonstration teaching method methods because they produce higher student learning outcomes in soil science practical
2. Problem-Based Learning techniques are superior teaching methods because it has produced higher student learning outcomes as compared to demonstration teaching methods.

3. Problem-Based Learning techniques are superior teaching methods because they produce higher student learning outcomes as compared to Collaborative learning techniques and demonstration teaching methods.

Discussion of the Finding

This study aimed to assess the effects of three instructional strategies, Collaborative Learning Techniques (CLT), Problem-Based Learning Techniques (PBLT), and the Demonstration Method (DM), on students' academic achievement in Soil Science practical among Agricultural Education students in North-Central Nigeria.

A quasi-experimental design was used to ensure adequate control of internal validity threats because group assignment was randomly assigned, and pre-test measures were used to account for initial academic differences. The removal of students who missed tests or multiple classes further minimized the impact of extraneous variables, ensuring that observed effects could be the result of the instructional interventions.

The first issues raised in Tables 1,2,3, and 4 show differences between the pre-test and post-test achievement performance of students in the Agricultural Soil Science practical. These differences in scores can be attributed to the treatment administered to the students since the pre-test was designed to assess their entry behavior. Therefore, this study concludes that treatment had a significant effect on student learning. This finding aligns with the findings of Yamikani and Mbaraka (2023), who reported that pre-test and post-test instruments significantly influence students' academic performance.

The results in Table 1 indicate that students exposed to Collaborative Learning Techniques (CLT achieve better results, with a post-test score of 65.84 compared to a mean score of 57.94 for students taught using Demonstration Teaching Methods. The computed mean difference between CLT and DTM was 6.9. While the mean gain from pre-test and post-test within the Collaborative Learning Techniques group was 19.38. This indicates that CLT had a notable effect on enhancing students' academic performance. This implies that Collaborative Learning Techniques are a more effective teaching method, as they produce higher student achievement in soil science practical compared to the Demonstration Teaching Method. This is consistent with the finding of Abbey-Kalio (2023), who reported that the collaboration teaching strategies improve both academic achievement and retention among chemistry students when compared to the demonstration method of teaching. Similarly, Kabir (2024) found that demonstration and collaborative teaching methods have a more significant effect on students' academic achievement in biology than traditional lecture methods.

Table 2. Revealed that students who were exposed to Problem-Based Learning Techniques (PBLT) achieved a higher post-test mean score of 67.69 compared to the mean score of 65.84 for those taught using demonstration teaching methods. The computed mean difference between PBL and DTM was 8.75. At the same time, the mean gain from pre-test and post-test within the Problem-Based Learning techniques group was 20.42. This indicates that Problem-Based Learning techniques had a notable effect in enhancing students' academic performance. This implies that Problem-Based Learning techniques are a more effective teaching method, as they produce higher student achievement in soil science practical compared to the Demonstration Teaching Method. This agrees with the finding of Ogweno, Nephat, and. Nkurumwa (2021) who opined that PBL teaching techniques were found to be more effective in teaching the agriculture concept.

Table 3 shows that students exposed to Problem-Based Learning Techniques (PBLT) scored 65.69, while those taught Collaborative learning techniques 65.84. The computed mean difference between PBL and CLT was 1.85. While the mean gain from pre-test and post-test within the Problem-Based Learning techniques group was 47.27, this indicates that Problem-Based Learning techniques had a notable effect in enhancing students' academic performance in soil science practical compared to Collaborative Learning Techniques. This implies that Problem-Based Learning techniques are a more effective teaching method, as they produce higher student achievement in soil science practical compared to the Collaborative Learning Techniques. This finding is synonymous with those of Yew, and Goh (2016), who observe that PBL consistently demonstrates greater efficacy in promoting longer-term knowledge retention and application.

Table 4 display the achievement test result of the three instructional groups, revealing a p-value of 0.00, which is below the alpha value of 0.05. Consequently, the null hypothesis, which posited no significant difference in the academic achievement of students taught using Collaborative Learning Techniques (CLT), Problem-Based Learning Techniques (PBLT), and Demonstration Methods (DM) on students' academic achievement in soil science practical among Agricultural Education Students in North-Central Nigeria, was rejected. This outcome implies that there are statistically significant differences in performance among the three groups of agricultural education students in north central Nigeria.

Scheffe Post hoc posttest indicates that Problem-based learning Techniques (PBT) performed significantly higher, followed by collaborative techniques. Therefore, PBT Techniques are the most effective in teaching soil science practical among agricultural science

students in North Central. This finding is supported by Cindy (2014), who stated that PBL fosters deep learning, problem-solving, and integration of knowledge more effectively than collaborative models. Similarly, this finding is similar to the finding of Abbas and Mohammad (2015), who found that the students involved have improved learning and acquisition of problem-solving skills, including communication, teamwork, and high-order thinking skills, due to effective collaborative learning activities among them. Abbas and Mohammad (2015) found that students who are taught using both Problem-Based Learning and Collaborative Learning approaches possess better skills, including communication, teamwork, and high-order thinking skills, due to effective collaborative learning activities.

Recommendation

Based on the light of the findings, the following recommendations were made

1. Government and Curriculum planners should adopt Problem-Based Learning (PBL) as a primary instructional strategy in teaching soil science practical and other applied agricultural subjects in higher institutions in North Central, Nigeria.
2. Government and Curriculum planners should Incorporate Collaborative Learning Techniques alongside PBL to foster teamwork, communication, and peer-supported learning, especially in large or diverse classes in higher institutions in North Central, Nigeria.
3. Stakeholders in education should Train teachers and lecturers in the effective design and implementation of PBL and CLT strategies to maximize student engagement and learning outcomes.
4. Curriculum planners should revise curriculum guidelines to encourage the integration of active, student-centered learning methods such as PBL and CLT in agricultural education programs.
5. Further research should be conducted to explore the long-term retention and practical skills development associated with PBL and CLT across different agricultural domains.

Conclusion

This study examined the comparative effects of Problem-Based Learning (PBLT), Collaborative Learning Techniques (CLT), and Demonstration Method (DM) on students' academic achievement in soil science practical among Agricultural Education students in North-Central Nigeria. The findings revealed that: Collaborative Learning Techniques (CLT) were more effective than the Demonstration Method, as students in the CLT group achieved

higher post-test scores, Problem-Based Learning Techniques (PBLT) outperformed both Collaborative Learning Techniques(CLT) and the Demonstration Method (DM), resulting in the highest student learning outcomes. Statistical analysis (ANOVA and Scheffé post hoc test) confirmed a significant difference among the three instructional methods, with PBL being significantly superior. The evidence supports the conclusion that PBL is the most effective instructional approach for improving students' academic achievement in soil science practical. That demonstrated the superior impact of PBL on critical thinking, retention, and application of knowledge.

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