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Effect of Problem-Based Learning on Colleges of Education Students' Achievement and Retention in Digital Electronic in North-East Nigeria

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ABSTRACT

This study investigated the effect of problem-based (PBL) learning on colleges of education students' achievement and retention in digital electronic in North-east Nigeria. The study was guided by five objectives, five research questions and five hypotheses. Relevant literature in line with the objective were reviewed. This study, conducted in 2024/2025 session. A quasi-experimental design was employed, using a non-equivalent pretest–posttest control group. The population comprised 111 NCE II students, with a sample of 87 drawn from two intact classes. The sample size was obtained using simple random sampling technique. Participants were assigned to an Experimental Group and a Control Group. Data was collected using the Digital Electronics Achievement Test (DEAT), which was developed by the researcher. and it was validated by two experts from the Department of Electrical Electronic Technology Education Abubakar Tafawa Balewa University Bauchi and of the instruments was determined using Split half Reliability coefficient and was found to be reliable with a Reliability coefficient of 0.81. The data obtained was analysed using Descriptive Statistics of Mean and Standard Deviation with the help of SPSS version 25 for the research questions. While the hypotheses were analysed using independent and paired samples t-tests at the 0.05 level of significance. The findings revealed that students taught through PBL achieved significantly higher mean scores in both academic achievement and retention compared to those taught using conventional method. Based on the findings of the study, it was recommended among others that: Colleges of Education in Nigeria should incorporate Problem-Based Learning as a core instructional strategy in the teaching of Digital Electronics and related technical courses. This will help align teaching practices with learner-centered approaches that foster critical thinking and practical problem-solving abilities. Workshops, seminars, and continuous professional development programs should be organized for lecturers to equip them with the necessary skills and competencies required for effective implementation of PBL. This will enhance their ability to design real-world learning scenarios and facilitate active learning among students.

Key Words: Problem-Based Learning, Achievement, Retention, Digital Electronic, Colleges of Education

1. Introduction

Colleges of Education occupy a central position within Nigeria's tertiary education system, serving as institutions mandated to prepare skilled professionals for national development. Their role extends beyond the training of craftsmen, as they contribute significantly to technological advancement by combining theoretical instruction with practical skill acquisition. Through this dual approach, they provide students with essential vocational competencies and foundational scientific knowledge, thereby strengthening the country's human resource base. This mandate aligns with the vision of the National Board for Technical Education (NBTE), which was established in 1977 to regulate and promote technical and vocational education as a means of supporting Nigeria's broader developmental goals" (NBTE, 1977; Infoguide Nigeria, 2023). The NBTE's mandate includes the accreditation of programs and institutions that provide technical education, which is essential for producing skilled manpower necessary for national development (Federal Republic of Nigeria, 2013). The Board consistently emphasizes quality assurance, recognizing its direct link to the country's industrial and economic growth (Ebekozien & Aigbavboa, 2023).

Digital Electronics is a fundamental course in Electrical/Electronic Technology Education, forming the basis for understanding modern digital systems such as computers, communication devices, and automation technologies (Adeyinka, 2023; Shenkoya, 2023). Within Colleges of Education in Nigeria, particularly those offering technical education, Digital Electronics is critical for preparing future teachers and technologists with the knowledge and skills required to thrive in a technology-driven economy (Moses et al., 2018.

Despite the recognized importance of technical education, particularly in Colleges of Education, the sector faces significant challenges that adversely affect student achievement and retention in Digital Electronics. These challenges include: Inadequate Funding and Resources: Limited funds allocated to the education sector restrict the effective equipping of Colleges of Education students with essential digital competencies, thereby hindering their achievement and retention in Digital Electronics.

Outdated Facilities and Ineffective Teaching Methodologies: Reliance on traditional lecture-based methods has been shown to inadequately engage learners and fails to promote higher-order thinking, directly impacting achievement and retention (Tugwell, 2020; Moses et al., 2018).

Low Digital Literacy Among Students: Many Colleges of Education students exhibit low levels of digital literacy, which hinders their ability to interact meaningfully with simulation tools and modern learning technologies (Kim et al., 2018; Adeoye et al., 2023).

Problem-Based Learning (PBL) has been found to significantly improve students' achievement and retention (Orji & Ogbuanya, 2018; Arifin et al., 2020). The introduction of PBL into Digital Electronics courses in Nigerian Colleges of Education signifies a pivotal shift in pedagogy, encouraging students to engage with real-world problems, fostering critical thinking, and promoting practical skills essential in today's digital landscape. PBL is defined as a student-centered instructional approach where learners are presented with real-world problems and guided to solve them collaboratively. This combination bridges the gap between theory and practice, making learning more meaningful and durable. Using a teaching strategy like PBL enhanced students' achievement and retention of students. The study will provide valuable insights into how collaborative learning strategies can improve students' understanding and achievement in colleges of education in Nigeria.

Aim and Objectives of the Study

The aim of this study is to determine the effect of Problem-Based Learning (PBL) on Colleges of Education students' achievement and retention in Digital Electronics in North-East Nigeria. Specifically, the study determined:

1. The difference in the Pre-test mean achievement score of students in Digital Electronics in both Experimental and Control group in colleges of education in North-east Nigeria.
2. The difference in the Pre-test and Post-test mean achievement score of students taught Digital Electronics Using Problem Based-Learning in colleges of education in North-east Nigeria.

Research Questions

The following research questions guided the study:

1. What is the difference in the Pre-test mean achievement score of students in Digital Electronics in both Experimental and Control group in colleges of education in North-east Nigeria?
2. What is the difference. in the Pre-test and Post-test mean achievement score of students taught Digital Electronics Using Problem Based-Learning in colleges of education in North-east Nigeria?

Research Hypotheses

The following null hypotheses were formulated and will be tested at 0.05 significant level

Ho_1: There is no significance difference in the Pre-test mean achievement score of students in Digital Electronics in both Experimental and Control group in colleges of education in North-east Nigeria.

Ho_2: There is no significance difference. in the Pre-test and Post-test mean achievement score of students taught Digital Electronics Using Problem Based-Learning in colleges of education in North-east Nigeria.

2. Literature Review

2.1 Concept of Digital Electronics Course

Digital electronics is a fundamental area within electrical and electronic technology, focusing on systems that utilize discrete binary signals (0s and 1s) to process and represent information (Adeyinka, 2023; Shenkoya, 2023). This section explores the core concepts and pedagogical approaches relevant to digital electronics, with a particular focus on their practical applications and educational methodologies. In the realm of Electrical Electronic Technology education in Nigeria, the integration of Digital Electronics courses plays a pivotal role in preparing students for the demands of the digital era. By incorporating STEM education advancements, such courses can broaden students' career aspirations towards STEM fields, which are essential for Nigeria's participation in the global digital economy (Chisom *et al*., 2023).

2.2 Core Concepts of Digital Electronics

Digital electronics is an area of electrical engineering that deals with systems using discrete (binary) signals to represent and process data. The core concepts of digital electronics are essential for understanding how digital systems operate and are designed. These concepts include logic gates, combinational and sequential circuits, binary numbers, and digital signal processing. Below is an in-depth explanation of each core concept:

1. Logic Gates (e.g. AND Gate, NOT Gate, OR Gate and XOR Gate)

2. Combinational Circuits (e.g. Adders, Multiplexers and Encoders)
3. Sequential Circuits (e.g. Flip-Flops, counters and Registers)
4. Binary Numbers (e.g. Binary and Decimal)
5. Digital Signal Processing (DSP) (Filtering, Encoding and Transforming)

2.3 Effects of Problem-based Learning on Student Achievement and Retention

Problem-Based Learning (PBL) is an instructional strategy that has gained prominence in education due to its effectiveness in fostering deeper understanding, critical thinking, and retention of knowledge. In the context of digital electronics education, PBL has shown substantial benefits in enhancing student achievement. The student-centered approach of PBL creates real problems for students by promoting critical thinking, teamwork, and practical knowledge application. Studies have emphasized the effectiveness of the Problem-Based Learning model in enhancing problem-solving skills in physics education (Yanto *et al.,* 2021). In the Nigerian context, integrating ICT tools with PBL approaches has been highlighted as beneficial for enhancing education across all levels in Nigeria (Daramola & Aladesusi, 2022). In enhancing student retention through Problem-based Learning (PBL), additional, this aspect of creativity development can contribute to better retention as students are actively involved in the learning process. Retention of knowledge is a crucial aspect of education, particularly in technical subjects like digital electronics (Arifin et al., 2020). Problem-Based Learning (PBL) has been shown to have a significant positive effect on student retention, ensuring that learners not only acquire knowledge but also retain it over time (Adedoyin & Soykan, 2023). PBL is a pedagogical method that offers students authentic challenges to resolve, thereby promoting cooperation, analytical reasoning, and the practical application of knowledge (Orji & Ogbuanya, 2018; Arifin *et al*., 2020).

2.4 Challenges in Implementing Problem-Based Learning

While PBL offers numerous benefits, its implementation was challenging, particularly in the context of digital electronics education. PBL requires significant resources, including access to technology and materials, which may not always be available in all educational settings. Additionally, educators must be well-trained in PBL methodologies to effectively guide students through the problem-solving process. In digital electronics, where the subject matter is often complex, students may require more support than in other disciplines. This includes providing additional resources, such as simulation software or lab equipment, to help them apply theoretical concepts in practice. Despite these challenges, the benefits of PBL in enhancing student achievement make it a worthwhile approach to consider (Moses et al., 2018).

3. Methodology

This study employed a quasi-experimental design, specifically pretest-posttest-post-posttest non-equivalent control group design. The target population comprised 111 students enrolled in Digital Electronic in North-East Nigeria during the 2024/2025 academic session. A simple random sampling technique was used to select two colleges from the four colleges offering Digital Electronic Course. The selected colleges were randomly assigned into experimental and control groups. Federal College of Education (Technical) Gombe served as experimental, where taught using Problem-based Learning (PBL) strategy, while Aminu Saleh College of Education Azare was assigned as control group, where the conventional teaching method was employed. Data was collected by the researcher and two research asiistant using the Digital Electronics Achievement Test (DEAT) consisted of 3 essay questions, which was developed by the researcher. and it was validated by two experts and was found to be reliable with a Reliability coefficient of 0.81. The data obtained was analysed using Descriptive Statistics of Mean and Standard Deviation with the help of SPSS version 25 for the research questions. While the hypotheses were analysed using independent and paired samples t-tests at the 0.05 level of significance to compare the mean scores of experimental and control groups.

4. Result

Table 1: Descriptive Statistics of Pretest Mean Achievement Scores of Experimental and Control Groups

Variable	Group	N	Mean	Std. Dev	Mean Diff
	Experimental Group	44	16.36	2.53	
Pretest					1.78
	Control Group	43	14.58	2.78	

Note: N=Number of students, Std. Dev= Standard deviation.

Table 1 presents the descriptive statistics of the pre-test mean achievement scores for both the Experimental and Control groups. The results show that the Experimental group obtained a slightly higher mean score (M = 16.36, SD = 2.53) compared to the Control group (M = 14.58, SD = 2.78) in the pre-test. This indicates a slight difference in Digital Electronics achievement between the two groups prior to the commencement of the experiment.

Table 2: Independent samples t-test of pre-test scores of Experimental and Control Groups Students

					Levene's Test for Equality of Variances			
Variable	**Groups**	**N**	**Mean**	**Std. Dev**	**F**	**t-value**	**Sig. (2-tailed)**	**Decision**
	Experimental	44	16.36	2.53				
Pre-test					.477	1.132	.120	Accepted
	Control	43	14.58	2.78				

Table 2 results presented independent samples t-test which show no statistically significant difference between the Experimental group (M = 16.36, SD = 2.53) and the Control group (M = 14.58, SD = 2.78), t (85) = 1.132, p = .120. Therefore, Null Hypothesis 1 was retained. This result suggests that both groups were statistically equivalent in their pre-test achievement scores, indicating that the students originated from the same population prior to the commencement of the experiment. had similar baseline achievement levels in Digital Electronics prior to the treatment

Table 3: Descriptive Statistics of Pretest Mean Achievement Scores of Experimental and Control Groups

Group	**Variable**	**N**	**Mean**	**Std. Dev**	**Mean Diff**
	Pretest	44	16.36	2.53	
Problem-Based Learning					24.19
	Post-test	44	40.55	1.70	

Note: N=Number of students, Std. Dev= Standard deviation.

Table 3 presents the pre-test and post-test mean achievement scores of students taught Digital Electronics using the Problem-Based Learning method. The post-test mean score (M = 40.55, SD = 1.70) is higher than the pre-test mean score (M = 16.36, SD = 2.53). This result indicates that the Problem-Based Learning approach enhanced students' academic achievement in Digital Electronics in Colleges of Education within North-East Nigeria.

Table 4: Paired samples t-test of pretest and post-test mean achievement scores of Problem Based-Learning students

Group	**Variable**	**N**	**Mean**	**Std. Dev**	**Mean Diff.**	**t-value**	**Sig. (2-tailed)**	**Decision**
	Pretest	44	16.36	2.53				
Problem Based-Learning					24.19	25.609	.000	Rejected
	Post-test	44	40.55	1.70				

Note: N=Number of students, Std. Dev= Standard deviation.

Table 4 shows the result of paired samples t-test. The analysis revealed a pre-test mean of 16.36 (SD = 2.53) and a post-test mean of 40.55 (SD = 1.70). The computed t-value was 25.609 with a significance level of $p < 0.001$. Since the p-value is less than 0.05, the null hypothesis was rejected. This indicates a statistically significant difference between the pre-test and post-test mean scores of students taught using Problem-Based Learning. The mean gain of 24.19 points demonstrates that the PBL strategy substantially improved students' achievement in Digital Electronics. Moreover, the reduction in standard deviation from 2.53 to 1.70 suggests that students' performance became more consistent after the intervention.

5. Discussion

The finding from research question one revealed that there was a slight difference between the pre-test mean achievement scores of students in the experimental and control groups before the commencement of the experiment. The experimental group had a slightly higher mean score than the control group. The corresponding null hypothesis confirmed that the difference was not statistically significant, indicating that both groups at the same level before treatment. This finding aligns with the results of Orji and Ogbuanya (2018), who found no statistically significant differences between experimental and control groups at the pre-test stage, showing homogeneity in the initial ability levels of participants. Such baseline equivalence is essential for ensuring that any subsequent differences in post-test performance can be attributed to the instructional treatment rather than pre-existing disparities. The result confirms that both groups started on equal footing, validating the reliability of subsequent comparisons in this study.

The finding of research question two indicated that students taught Digital Electronics using the Problem-Based Learning (PBL) method performed better in the post-test than in the pre-test. The corresponding hypothesis confirmed a statistically significant improvement in favour of the post-test, suggesting that PBL had a substantial positive impact on students' academic achievement. This finding is consistent with Orji and Ogbuanya (2018), who reported that students exposed to PBL achieved higher scores in electronic works than those taught through lecture-based instruction. Similarly, Agbidye, *et al.*,

(2019) found that PBL significantly enhanced students' academic achievement in Basic Science. Malmia *et al*. (2019) also reported significant improvements in students' learning outcomes after exposure to PBL, validating the claim that PBL fosters deep understanding and active learning. Furthermore, Tugwell (2020) found that PBL improved students' performance in Digital Electronics among polytechnic students, affirming that PBL enhances comprehension and performance across diverse educational levels. Collectively, these studies support the conclusion that PBL is an effective instructional strategy for promoting meaningful learning in technical and vocational education.

6. Conclusion

This study investigated the effect of Problem-Based Learning on students' academic achievement and retention in Digital Electronics at Colleges of Education in North-East Nigeria. The findings revealed that the Problem-Based Learning strategy significantly enhanced both academic achievement and retention compared to the conventional method of instruction. This outcome emphasizes the effectiveness of learner-centered, problem-driven instructional approaches in promoting deeper understanding and long-term knowledge retention among students. The study proved that when students engage actively in solving real-world problems, as facilitated by Problem-Based Learning, they develop stronger analytical and problem-solving skills, leading to improved performance and sustained comprehension of technical concepts in Digital Electronics

7. Recommendations

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

I. Colleges of Education in Nigeria should incorporate Problem-Based Learning as a core instructional strategy in the teaching of Digital Electronics and related technical courses. This will help align teaching practices with learner-centered approaches that foster critical thinking and practical problem-solving abilities.

II. Workshops, seminars, and continuous professional development programs should be organized for lecturers to equip them with the necessary skills and competencies required for effective implementation of PBL. This will enhance their ability to design real-world learning scenarios and facilitate active learning among students.

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