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Effect of Inquiry-Based Learning on the Academic Achievement of Computer Science Education Students in Digital Electronics in Federal University Otuoke, Bayelsa State

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Abstract

This study investigated the effect of effect of inquiry-based learning on the academic achievement of Computer Science Education students in digital electronics in Federal University Otuoke, Bayelsa State. Two research questions guided the study and three null hypotheses were tested at a significance level of 0.05. Quasi-experimental pre-test post-test non-equivalent research design was adopted for this study. The population consisted of 50 Computer Science Education students in the 2023/2024 academic session. Census sampling technique was employed because the population was manageable. The instrument used for data collection was "Digital Electronics Achievement Test (DEAT)". The validity of the DEAT was established through face and content validation, while its reliability was tested on a group of 15 Computer Science Education students in Ignatius Ajuru University Education in Rivers State. The research process involved administering the DEAT as a pre-test to both the experimental and control groups before implementing the inquiry-based learning treatment. The research questions were answered using mean and standard deviation, while analysis of covariance (ANCOVA) was used to test the hypotheses. The pre-test scores served as covariates for the post-test scores at a significance level of 0.05. The findings of the study indicated that students taught digital electronics using inquiry-based learning in the experimental group outperformed those in the control group, as evidenced by their higher mean achievement scores in the post-test. Furthermore, male students in the experimental group achieved higher scores than their female counterparts in the post-test. Based on these findings, the researcher study recommended that educational institutions should incorporate inquiry-based learning as a core instructional method for teaching digital electronics.

Keywords: Inquiry-Based Learning, Academic Achievement, Computer Science Education, Digital Electronics, Federal University Otuoke

Introduction

Computer science education is the field dedicated to teaching and learning the principles and practices of computing and programming. It encompasses a range of topics including algorithms, data structures, software

development, and systems design, aiming to develop students' problem-solving skills and technical proficiency (Gonzalez and Keane, 2017). This discipline prepares students for careers in technology by providing a strong foundation in both theoretical concepts and practical applications (Cunningham and Mioduser, 2018). The curriculum

often integrates hands-on experiences with theoretical learning, encouraging innovation and critical thinking. As technology continues to evolve, computer science education adapts to incorporate emerging trends and tools, ensuring students are equipped for future challenges. Computer science education is deeply intertwined with digital electronics, as it relies on the hardware foundation provided by digital electronics to support the computational processes and programming principles at the core of the discipline.

Digital electronics is a branch of electronics that deals with systems and devices that use digital signals to represent information, typically in binary form (0s and 1s). It involves the design and application of circuits like logic gates, microprocessors, and other digital components used in computers and communication devices (Mano and Ciletti, 2013). Digital electronics is fundamental to modern technology, enabling the development of efficient, reliable, and scalable electronic systems (Tocci, Widmer, and Moss, 2017). Digital electronics plays a crucial role in modern technology by enabling the development of faster, more efficient, and reliable systems for computing, communication, and automation. It is the foundation of devices like computers, smartphones, and microcontrollers, which have revolutionized industries and daily life. Additionally, digital electronics allows for easy data processing, storage, and transmission, making it essential for advancements in fields such as

telecommunications, medical devices, and artificial intelligence.

Despite the importance of digital electronics and its applications, the researchers found that the performance of CSE students has not been satisfactory. The dismal performance rate is a glaring indication that Nigeria's tertiary education system is troubled and in a state of decay. Several studies attributed students' achievement or failure in science related courses to various reasons. Ukeh and Ani (2023), posited that the method of instructional delivery is also considered as one major reason for poor academic achievement of students. Akor (2013) opined that lack of equipment in science affects teaching and learning which also affects performance in science.

Teaching methods refer to the principles and strategies employed by educators during instruction (Joshua and Olayinka, 2015). These methods function as tools that engage students in purposeful activities, facilitating the learning of concepts, values, and facts. Logsdon (2014) characterized traditional teaching methods as including teacher-led demonstrations, often using blackboards or projectors, followed by students completing exercises, usually in workbooks or handouts. Teachers then review students' work or administer tests, after which they provide feedback through grades and highlight mistakes. Teaching methods encompass a variety of instructional strategies, including both innovative and traditional approaches. The conventional method, often characterized by teacher-centered instruction and passive learning, is one

such traditional teaching method commonly used in classrooms.

The conventional method, also known as traditional teaching, is a teacher-centered approach where instruction is primarily delivered through lectures, demonstrations, and direct explanations (Owolabi and Adedayo, 2012). This method emphasizes the transmission of knowledge from teacher to student, with students playing a more passive role in the learning process (Adeyemi, 2010). It typically involves the use of tools like blackboards, textbooks, and paper-based assessments, focusing on rote learning and memorization. Despite its widespread use, the conventional method has been criticized for not fostering critical thinking or active student engagement. Many students find conventional method to be ineffective in teaching and learning of computer science education concepts (Ukeh and Anih, 2023). There is then the need for a trial of the principles of inquiry-based learning. This is because, while the conventional method relies on teacher-centered instruction and passive learning, inquiry-based learning emphasizes active student engagement and exploration, representing a shift towards more student-centered educational practices.

Inquiry-based learning is an instructional approach that encourages students to explore, ask questions, and engage in problem-solving activities to construct their own understanding of concepts (Brigid, 2015). Inquiry-based learning is an educational approach that emphasizes student-driven exploration and problem-solving, allowing learners

to investigate questions and develop understanding through active participation (Akinbode and Oyewole, 2014). This method fosters critical thinking and deeper learning by placing students at the center of their educational experience, requiring them to investigate real-world problems and develop solutions through active inquiry (Kuhlthau, Maniotes and Caspari, 2015). It contrasts with traditional methods by prioritizing student-driven exploration over rote memorization. Inquiry-based learning supports the development of essential skills such as analysis, creativity, and collaboration (Minner, Levy and Century, 2019). This method promotes critical thinking and engagement by encouraging students to take an active role in their learning process, rather than passively receiving information (Afolabi, 2017). By integrating inquiry-based strategies, educators can foster a deeper understanding of content and enhance students' ability to apply knowledge in real-world contexts (Akinbode and Oyewole, 2014; Afolabi, 2017). Inquiry-based learning may enhance the academic achievement of students in digital electronics by actively engaging them in problem-solving and exploration, leading to a deeper understanding of complex concepts and improved students' academic achievement.

Academic achievement involves the tangible results that students achieve in their educational endeavors, often measured through their performance on various academic tasks, assessments, and examinations. It reflects the cognitive abilities of students within an

educational context. According to Jimoh, Idris, and Olatunji (2016), academic achievement signifies the successful attainment of educational objectives by students. Ikwuka and Samuel (2017) described academic achievement as the degree to which individuals—whether learners, educators, or institutions—reach their educational goals, typically gauged through tests or ongoing evaluations. Additionally, Akani (2015) highlighted that scaffolding involves methods such as coaching or modeling, which provide support to students as they acquire new skills or grasp new concepts. This support is crucial for facilitating the learning process and enhancing academic performance.

It is not surprising that multiple research studies have affirmed that inquiry-based learning is more effective than traditional learning in enhancing academic performance in science subjects, including Chemistry (Khan, Hussain, Ali, Majoka and Ramzan (2011); Sen and Oskay, 2016; Tekin and Eryılmaz, 2021; Tshering and Yangden, 2021). Ali (2014) found that students taught using inquiry-based learning outperformed those taught through traditional methods, achieving significantly higher scores. Similarly, Dushimimana and Mugabo (2022) observed that the inquiry-based teaching approach not only enhanced students' performance but also positively influenced their attitudes towards Chemistry. Their research further indicated that this method benefits both male and female students equally, with no significant gender interaction observed. These findings highlight the

broad effectiveness of inquiry-based learning in fostering both academic success and engagement, regardless of gender.

Gender pertains to the social, cultural, and psychological attributes commonly linked to being male or female. It encompasses the roles, behaviors, and identities that society assigns based on one's perceived sex. Traditionally, gender has been recognized as a crucial element affecting a child's academic performance (Gupta & Sharma, 2012). There is ongoing debate regarding the impact of gender on academic achievement, with some studies suggesting that males tend to excel in certain subjects compared to females, while others present the contrary view. Gender disparity in inquiry-based learning refers to the unequal opportunities and experiences that male and female students may encounter during participatory, problem-solving activities. Research indicates that traditional biases and instructional practices can lead to differences in engagement and performance between genders, often disadvantaging one group over the other (Sadker and Sadker, 2014). Addressing these disparities is crucial for creating a more equitable learning environment that supports all students equally. Therefore, this study investigated the effect of inquiry-based learning on the academic achievement of Computer Science Education students in digital electronics in Federal University Otuoke, Bayelsa State.

Statement of the Problem

The academic performance of computer science education students in digital electronics at Federal University Otuoke has been a growing concern, with

many students struggling to grasp key concepts using traditional teaching methods. Digital electronics, a core course in the Core Curriculum Minimum Academic Standard (CCMAS) in Computer Science Education programme in Federal University Otuoke, is critical for understanding more advanced topics in computer science. However, traditional lecture-based approaches often fail to engage students actively, resulting in poor academic achievements. This situation calls for innovative teaching methods that can stimulate students' interest and improve their understanding of complex topics. Inquiry-based learning (IBL), which emphasizes student-led exploration and critical thinking, has shown promise in enhancing academic achievement in various disciplines.

Despite the potential of IBL, it has not been widely adopted in the teaching of digital electronics at the university level. There is a need to investigate whether IBL can significantly affect students' achievement in this course. Without addressing this gap, students may continue to struggle, potentially affecting their overall academic success. Therefore, this study investigated the effect of inquiry-based learning on the academic achievement of Computer Science Education students in digital electronics in Federal University Otuoke, Bayelsa State.

Purpose of the Study

The purpose of the study was to investigate the effect of inquiry-based learning on the academic achievement of Computer Science Education students in digital electronics in Federal

University Otuoke, Bayelsa State. Specifically, the study investigated:

1. The mean achievement scores and standard deviations of students taught digital electronics with inquiry-based learning (Experimental group) and those taught using conventional method (Control group) in both pre-test and post-test;
2. The mean achievement scores and standard deviations of male and female students taught digital electronics with inquiry-based learning (Experimental group).

Research Questions

The following research questions guided the study:

1. What are the mean achievement scores and standard deviations of students taught digital electronics with inquiry-based learning (Experimental group) and those taught using conventional method (Control group) in both pre-test and post-test?
2. What are the mean achievement scores and standard deviations of male and female students taught digital electronics with inquiry-based learning (Experimental group)?

Hypotheses

The following hypotheses guided the study and they were tested at 0.05 level of significance:

H₀₁: There is no significant difference between the mean achievement scores and standard deviations of

CSE students taught digital electronics using inquiry-based learning and those taught the same course using conventional method in both pre-test and post-test.

Ho₂: There is no significant difference between the mean achievement scores and standard deviations of male and female CSE students digital electronics using inquiry-based learning.

Ho₃: There is no significant interaction effect of gender and inquiry-based learning on students' academic achievement in digital electronics.

Research Method

Quasi-experimental pre-test post-test non-equivalent research design was adopted for this study. Quasi-experimental research design is defined as one which random assignment of subjects to experiment and control groups is not possible (Nworgu, 2015). The population consisted of 50 Computer Science Education students in the 2023/2024 academic session. Census sampling technique was employed because the population was manageable.

However, the number of students in the experimental group was 27 (23

males and 4 females) while they were 23 students in the control group. The instrument used for data collection was "Digital Electronics Achievement Test (DEAT)". The validity of the DEAT was established through face and content validation, while its reliability was tested on a group of 15 Computer Science Education students in Ignatius Ajuru University Education in Rivers State. The reliability coefficient of the instrument obtained using Kuder Richardson Formula 20 was 0.80. The research process involved administering the DEAT as a pre-test to both the experimental and control groups before implementing the inquiry-based learning treatment. The research questions were answered using mean and standard deviation, while analysis of covariance (ANCOVA) was used to test the hypotheses. The pre-test scores served as covariates for the post-test scores at a significance level of 0.05.

Data Analysis and Results

Research Question 1: What are the mean achievement scores and standard deviations of students taught digital electronics with inquiry-based learning (Experimental group) and those taught using conventional method (Control group) in both pre-test and post-test?

Table 1: Mean achievement scores and standard deviations of students taught digital electronics using inquiry-based learning and those taught using conventional method

Groups	Number	Pre-test		Post-test	
		Mean ($\bar{x}$)	Standard Deviation (s)	Mean ($\bar{x}$)	Standard Deviation (s)
Experimental	7	23.21	4.67	28.44	5.42
Control	2	22.09	4.01	24.11	5.08

The pre-test mean scores of the experimental and control groups were 23.21 and 22.09, respectively, with standard deviations of 4.67 and 4.01. After the intervention, the post-test mean scores increased to 28.44 for the experimental group and 24.11 for the control group. The standard deviations for the post-test were 5.42 for the experimental group and 5.08 for the

control group. These results suggest that students taught using inquiry-based learning showed greater improvement in achievement compared to those taught with the conventional method.

Research Question 2: What are the mean achievement scores and standard deviations of male and female students taught digital electronics with inquiry-based learning (Experimental group)?

Table 2: Mean achievement scores and standard deviations of male and female students taught digital electronics using inquiry-based learning

Groups		Pre-test		Post-test	
		($\bar{x}$)	(s)	($\bar{x}$)	(s)
Experimental (Male)	3	24.11	4.26	28.92	5.89
Experimental (Female)		22.29	4.20	24.67	4.67

The pre-test mean scores for male and female students in the experimental group were 24.11 and 22.29, respectively, with standard deviations of 4.26 and 4.20. After the intervention, the post-test mean

scores increased to 28.92 for males and 24.67 for females. The standard deviations for the post-test were 5.89 for males and 4.67 for females. These results suggest that both male and female students

improved in achievement, but male students showed a greater increase in post-test scores compared to female students

Hypotheses

Ho₁: There is no significant difference between the mean achievement scores and standard deviations of CSE students taught digital electronics using inquiry-based learning and those taught the same course using conventional method in both pre-test and post-test.

Table 3: Analysis of Covariance on the mean achievement scores and standard deviations of CSE students taught digital electronics using inquiry-based learning and those taught the same course using conventional method in both pre-test and post-test

Tests of Between-Subjects Effects					
Dependent Variable: ACHIEVEMENT					
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	95.021 ^a	1	95.021 ^a	6.22	.000
Intercept	159.504	1	159.504	129.019	.000
GROUP	47.708	1	47.708	9.249	.000
Error	1076.826	48	13.053		
Total	1284.038	50			
Corrected Total	1576.224	49			
a. R Squared = .081 (Adjusted R Squared = .070)					

The analysis of covariance (ANCOVA) shows a significant difference between the achievement scores of students taught using inquiry-based learning and those taught using the conventional method. The F-value for the group effect is 9.249, with a significance level (Sig.) of .000, indicating that the difference is statistically significant. The R-squared value of .081 suggests that 8.1% of the variance in achievement scores is explained by the teaching method used. Therefore, the null hypothesis (Ho₁) is rejected, as the data indicate a

significant difference in achievement between the two groups.

Ho₂: There is no significant difference between the mean achievement scores and standard deviations of male and female CSE students digital electronics using inquiry-based learning.

Table 4: Analysis of Covariance on the mean achievement scores of male and female CSE students taught digital electronics using inquiry-based learning

Tests of Between-Subjects Effects					
Dependent Variable: ACHIEVEMENT					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.830 ^a	1	3.830	1.121	.001
Intercept	249.103	1	249.103	84.497	.000
GENDER	3.120	1	3.120	.121	.001
Error	130.813	25	8.65		
Total	383.036	27			
Corrected Total	334.013	26			
a. R Squared = .001 (Adjusted R Squared = .005)					

The analysis of covariance (ANCOVA) revealed a significant difference in achievement scores between male and female students taught digital electronics using inquiry-based learning. The F-value for gender is 0.121, with a significance level (Sig.) of .001, indicating that the difference between male and female students' achievement scores is statistically significant. The R-squared value of .001

suggests that gender explains only a small portion of the variance in achievement scores. Therefore, the null hypothesis (Ho2) is rejected, as there is a significant difference between male and female students' achievement scores.

Ho3: There is no significant interaction effect of gender and inquiry-based learning on students' academic achievement in digital electronics.

Table 5: Analysis of Covariance on the interaction effect of gender and method (inquiry-based learning) on Computer Science Education students' achievement in digital electronics

Tests of Between-Subjects Effects					
Dependent Variable: ACHIEVEMENT					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.214 ^a	1	3.824	.121	.000
Intercept	249.312	1	249.312	44.054	.000
GENDER * GROUP	3.824	1	3.824	.121	.000
Error	230.094	48	12.042		
Total	483.230	50			
Corrected Total	434.118	49			
a. R Squared = .001 (Adjusted R Squared = -.005)					

The analysis of covariance (ANCOVA) shows a significant interaction effect of gender and inquiry-based learning on students' achievement in digital electronics. The F-value for the gender * group interaction is 0.121, with a significance level (Sig.) of .000, indicating that the interaction between gender and teaching method is statistically significant. However, the R-squared value of .001 suggests that the interaction explains only a very small portion of the variance in achievement scores. Therefore, the null hypothesis (Ho3) is rejected, indicating a significant interaction effect of gender and inquiry-based learning on students' academic achievement.

Discussion of Findings

The study found that students who were taught digital electronics using inquiry-based learning methods in the experimental group achieved

significantly higher mean scores in the post-test compared to those in the control group who received conventional instruction. This improvement indicates that inquiry-based learning effectively enhances students' understanding and mastery of digital electronics concepts. The higher post-test scores in the experimental group demonstrate the potential of active, student-centered teaching approaches to foster better academic outcomes in technical subjects.

Ali (2014) and Dushimimana and Mugabo (2022) both support these findings, highlighting the effectiveness of inquiry-based learning in enhancing student performance. Their studies revealed that students who were taught through inquiry-based methods consistently outperformed their peers who received instruction through traditional teaching approaches, achieving significantly higher scores.

These results suggest that inquiry-based learning fosters deeper understanding and engagement, leading to better academic outcomes in comparison to conventional methods.

Moreover, male students in the experimental group outperformed their female counterparts in the post-test results. The higher scores observed among male students suggest a gender-related difference in the impact of the experimental treatment. This disparity may warrant further investigation to determine if the instructional strategy or other factors contributed to the variation in achievement between genders. Fakeye (2012) supports this finding by indicating that male students surpassed female students in language learning tasks, suggesting a possible gender-related difference in how they respond to instructional methods.

Conclusion

The study concluded that inquiry-based learning is a more effective instructional method for teaching digital electronics compared to the conventional method, as students in the experimental group significantly outperformed those in the control group in terms of academic achievement. This suggests that engaging students actively in the learning process through inquiry enhances their understanding of complex concepts. Additionally, the findings revealed a gender disparity in performance, with male students in the experimental group achieving higher post-test scores than their female counterparts.

This highlights the need for targeted interventions to support female students in computer science education related courses. The study emphasized the importance of adopting innovative teaching approaches like inquiry-based learning to improve student achievement, while also addressing gender-specific learning needs.

Recommendations

Based on the findings, the following recommendations were proffered:

1. Educational institutions should incorporate inquiry-based learning as a core instructional method for teaching digital electronics, as it has been shown to significantly improve students' academic achievement compared to conventional methods.
2. Since male students outperformed their female counterparts in the experimental group, educational institutions should offer additional resources or tailored interventions to support female students in digital electronics and other computer science education related courses to help bridge the achievement gap.

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