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EFFECTIVENESS OF COMPUTER-ASSISTED INSTRUCTION ON SECONDARY SCHOOL STUDENTS' ACHIEVEMENT IN BASIC SCIENCE AND TECHNOLOGY: MODERATING ROLE OF GENDER IN ZARIA, NIGERIA

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ABSTRACT
The study investigated the effectiveness of computer assisted instruction (CAI) on Secondary school student's academic achievement in Basics Science and Technology in Zaria Local Government Area of Kaduna State. A quasi-experimental Pre-test and Post-test research design was adopted. The study selected two schools from the study area in which an intact class from each school served as Experimental and the other served as control group. The experimental group students were taught using computer assisted instruction (CAI) while the control group students were taught using conventional method. The experimental class consists of sixty (60) students while the control group class had fifty-five (55) students. A researchers designed instruments called "Digestive System Computer Performance Test (DSCPT) and Excretory System Computer Performance Test (ESCPT) were used for data collection. The study found that there is significant difference in the mean scores of students taught concepts of Digestive and excretory System with t-value of -6.34 and p value of 0.00012. Also, there is no significant difference in the mean scores of both male and female students when taught Digestive and excretory System with t-value of 1.122 and p value of 0. 264.On the basis of the findings the study recommended that use of computer assisted instruction in the teaching of digestive and excretory Systems in secondary school should be encouraged as it is observed that it enhances academic performance among students. The teachers and schools should be equipped with modern facilities and instructional packages to enable the teachers/tutors carry out their lesson via computer assisted instruction method.

Keywords: Effectiveness, CAI, gender, basic science and technology

Introduction
The swift technological advancement characteristic of the 21st century has significantly transformed global educational frameworks, providing unparalleled resources to augment knowledge acquisition, pedagogical innovation, and learner engagement. Among these technological innovations, Computer-Assisted Instruction (CAI) has emerged as a fundamentally transformative approach, reconfiguring instructional delivery through interactive, learner-centered methodologies. Ranging from rudimentary drill-and-practice programs to advanced multimedia simulations and intelligent tutoring systems, CAI has demonstrated exceptional efficacy in enhancing student learning outcomes across diverse academic disciplines (Semerikov, 2021; Nwafor, 2015). In nations with advanced economies like the United States and Japan, CAI is widely integrated into educational programs,

leading to significant enhancements in students' academic achievements, enthusiasm, and ability to solve problems (Adeyemi, 2012) and (Trivena & Harisno, 2014) . These advancements are bolstered by robust digital infrastructures and policy frameworks that promote technology-driven pedagogical practices. Conversely, numerous developing nations, including Nigeria, continue to encounter systemic obstacles that impede the effective implementation of CAI, particularly in essential foundational subjects such as Basic Science and Technology. This disparity underscores a pressing necessity for educational stakeholders in Nigeria to embrace innovative instructional methodologies that can bridge the achievement gap and cultivate scientific literacy (Adepoju et al., 2023).

According to Winarno (2020), Basic Science, previously referred to as Integrated Science, constitutes the foundational pillar for scientific comprehension and technological innovation at the basic secondary school level. It encompasses a multidisciplinary curriculum derived from biology, chemistry, physics, and earth sciences, aimed at fostering students' inquiry skills, analytical reasoning, and scientific thought processes. Nevertheless, despite the critical importance of Basic Science within the framework of science education in Nigeria, student achievement in this discipline remains inadequate, often ascribed to outdated instructional methodologies, insufficient educational resources, and low levels of student involvement. The incorporation of CAI into Basic Science instruction presents a promising remedy for these challenges. Empirical investigations have substantiated that CAI not only facilitates differentiated learning but also enhances knowledge retention, encourages active engagement, and provides immediate feedback—essential components requisite for effective science education (Afuwape & Olugbuyi, 2019). However, the extent of CAI's influence within the Nigerian educational landscape, particularly in the Zaria Local Government Area of Kaduna State, remains insufficiently explored.

Consequently, this study aims to examine the impact of Computer-Assisted Instruction on the academic performance of secondary school students in Basic Science and Technology. By investigating how CAI affects learning outcomes in this pivotal subject area, the research aspires to furnish evidence-based insights that can guide educational policy, teacher training, and the strategic integration of digital technologies in science classrooms throughout Nigeria.

Statement of the Problem

Traditional pedagogical approaches, especially in scientific education, have been reinterpreted in recent decades by the incorporation of technology into classroom learning. Computer-Assisted Instruction (CAI), a method that uses computers to provide tutorial, drill-and-practice, simulation, and interactive learning experiences, is one of the most well-known breakthroughs. There is increasing interest in using CAI to enhance student performance in Basic Science and Technology since these topics form the basis for future scientific literacy and technological proficiency.

According to empirical research, CAI can improve knowledge retention, speed up learning, and raise academic

accomplishment when combined with traditional teaching techniques (Karper, Robinson, & Casado-Kehoe, 2012). Additionally, CAI has been characterized as scalable, affordable, and able to meet a variety of learner demands. Deeper comprehension of abstract scientific concepts is fostered by its multimedia components, which frequently make learning more interesting and contextually rich.

Research on the relative efficacy of CAI as a stand-alone instructional strategy vs conventional or integrated methods is still lacking, despite these encouraging claims. While some research indicates that students exposed to CAI perform better academically and show better retention, other research shows mixed or negligible differences, which are frequently impacted by contextual factors like learner motivation, infrastructure availability, teacher preparedness, and the particular design of CAI programs.

Additionally, CAI creates fresh pedagogical difficulties. Teachers may find it challenging to effectively incorporate CAI into their lesson plans, particularly in situations where access to hardware and software is restricted or technology literacy is low. Similar to this, students may abuse technology for non-academic objectives, which could divert attention from the goals of the lesson. These restrictions highlight the necessity of doing empirical research in local educational contexts.

The degree of CAI integration into the teaching of basic science and technology in Kaduna State's Zaria Local Government Area is still mostly unknown. Given the significance of preparing students with digital fluency and scientific competencies, it is necessary to look into whether CAI has a major effect on students' academic performance in this setting. Therefore, the purpose of this study is to investigate how well CAI affects secondary school students' performance in basic science and technology, offering data-driven insights to guide evidence-based teaching strategies and policy choices.

Objectives of the Study

The main purpose of this study is to determine the Impact of Computer Assisted Instruction (CAI) on the secondary school student's achievement in Basic Science and Technology. Specifically, the study explored:

i. The impact of computer assisted instruction on students' achievement in Basic Science.
ii. The impact of computer assisted instruction on achievement of male and female students in basic science.

Research Questions

The following research questions guided the study:

i. What is the impact of computer assisted instruction on the mean achievement scores of students in Basic Science?
ii. What is the impact of computer assisted instruction on the mean achievement scores of male and female students in Basic Science?

Research Hypotheses

The following null hypotheses were tested at an alpha level of 0.05

H01: There is no significant difference in the mean achievement scores of students

taught Basic Science using computer assisted instruction.
H02: There is no significant difference in the mean achievement scores of male and female students taught Basic Science using computer assisted instruction method.

Research Method

This study employed a quasi-experimental research design involving a pre-test and post-test with non-equivalent groups. The design was incorporated to evaluate the effectiveness of Computer-Assisted Instruction (CAI) on students' academic performance in selected biology topics (Digestive and excretory system). The design comprised two groups: an experimental group (EG) that received treatment through CAI and a control group (CG) that was taught using conventional (lecture) methods. Both groups were administered pre-tests and post-tests utilizing the same instruments. The target population consisted of all Junior Secondary School III (JSS III) students in government-owned basic secondary schools in Zaria Local Government Area, Kaduna State, totaling 16,495 students (8,925 males and 7,570 females). Two schools were selected using a purposive sampling technique based on the availability of ICT infrastructure. Two intact classes from each school were randomly assigned to serve as the experimental and control groups, respectively, comprising a total of 115 students (60 from School A and 55 from School B).

The data collection instruments were the Digestive System Computer Performance Test (DSCPT) and Excretory System Computer Performance Test (ESCPT). Each test consisted of 20 multiple-choice questions (MCQs) with one correct answer and three distractors. The tests were based on the JSS III Integrated Science Curriculum, focusing on the Digestive and Excretory Systems. The instruments were drawn from validated past JSS examination questions from 2018–2022.

Each question carried 5 marks, for a total of 100 marks. A Table of Specification was used to ensure content balance across cognitive levels. The instruments were validated for face and content validity by three experts—one supervisor from the Department of Biology and two senior lecturers from the Federal College of Education, Zaria. Feedback was used to revise ambiguous, irrelevant, or structurally weak items.

A pilot test was conducted using 35 students from the Federal College of Education, Kontagora (outside the study area). The Cronbach's Alpha reliability coefficient obtained was 0.82, indicating a high level of internal consistency. The intervention lasted for four weeks, with each group receiving a 40-minute lesson per session on the Digestive and Excretory Systems. The Experimental Group (EG) received instruction using Computer-Assisted Instruction (CAI). Digital content—including PowerPoint slides, video clips, and simulations was delivered via desktop computers. Students worked in small groups based on the number of available computers. The Control Group (CG) was taught using the conventional lecture method, involving oral explanations and note-taking without multimedia support. The CAI Steps for Experimental Group included ICT equipment and

materials were set up in advance, teaching content was delivered using PowerPoint presentations and pre-recorded video clips, students viewed the content on screens and engaged in discussions and finally, lessons were summarized, followed by administration of the post-test. Pre-tests (DSCPT & ESCPT) were administered to both groups before instruction to assess baseline equivalence. After the four-week treatment, the same tests with answer options rearranged to avoid recall bias were re-administered as post-tests. Data collection was supported by two trained research assistants. Informed consent was obtained from school authorities, and ethical approval was granted by the Department of Biology, Faculty of Education, Ahmadu Bello University, Zaria. Participation was voluntary, and data confidentiality was ensured. Data were analyzed using both descriptive and inferential statistics. Descriptive statistics (mean, standard deviation, frequency, and percentage) were used to summarize demographic data and pre-/post-test scores. Independent samples t-tests were used to test hypotheses and compare mean performance scores between the experimental and control groups at a 0.05 level of significance. All analyses were conducted using SPSS statistical software.

Results

Research Question One: What is the impact of computer assisted instruction on the mean achievement scores of students in Basic Science?

Table 2: Analysis of pre and post-test control group mean achievement scores of students in Basic Science

Variable	N	Mean	S.D	Mean diff.
Pre-test performance control	115	26.64	8.06	
				10.09
Post-test performance control	115	36.73	13.09	

In Table 2, the result shows the computation mean scores and standard deviation of pretest and post group of conventional method (control) groups respectively. The result revealed that students in the pre group have mean performance of 26.64 and standard deviation of 8.06 while the post group have mean performance of 36.73 and standard deviation of 13.09. The mean difference between the two groups is about 10.09. This result reveals slightly difference in the performance of post control group compared with pre control group.

Table 3: Analysis of pre and post-test experimental mean of students' achievement scores of students in Basic Science

Variable	N	Mean	S.D	Mean diff.
Pre-test performance Experimental	115	26.00	9.83	
				21.59
Post-test performance Experimental	115	47.59	2.87	

In Table 3 the result revealed that students in the pre-experimental group have mean performance of 26.00 and standard deviation of 9.83 while the post experimental group have mean performance of 47.59 and standard deviation of 2.87. The mean difference between the two groups is about 21.59. This result reveals out performance of post experimental group compared with pre-experimental group.

Table 4: Analysis of difference in the mean scores of students' achievement scores of students in Basic Science using conventional and computer aided method

Variable	N	Mean	S. D	Mean diff.
Post control performance (conventional method)	115	36.73	13.09	10.86
Post experimental performance (computer aided method)	115	47.59	2.88	

In Table 4 the result shows revealed that students in the post control performance (conventional method) have mean performance of 36.73 and standard deviation of 13.09 while the Post experimental performance (computer aided method) have mean performance of 47.59 and standard deviation of 2.88. The mean difference between the two groups is about 10.86. This result reveals student in post experimental performance (computer aided method) out performed those in the post control group.

Research Question Two: What is the impact of computer assisted instruction on the mean achievement scores of male and female students in Basic Science?

Table 5: Analysis of difference in the mean scores of both male and female students mean achievement scores of male and female students in Basic Science

Variable	N	Mean	S.D	Mean diff.
Post male performance in the experimental group	45	46.89	2.88	1.39
Post female performance in the experimental group	70	48.28	2.68	

In Table 5 the result shows revealed that students in the post male experimental method have mean performance of 46.89 and standard deviation of 2.883 while the Post female experimental performance (computer aided method) have mean performance of 48.28 and standard deviation of 2.68. The mean difference between the two groups is about 1.39. This result reveals students in female post experimental performance (computer aided method) slightly out performed male in post experimental group.

Test of Hypotheses

Research Hypothesis One: There is no significant difference in the mean achievement scores of students taught Basic Science using computer assisted instruction.

Table 6: Analysis of significant difference in the mean scores of students taught concepts in Biology using YouTube and those taught using conventional teaching methods

Variable	N	Mean	S.D	Mean diff.	d.f	t_{cal}	p-value	Remark
Conventional method	115	36.73	13.09	10.86	115	-6.34	0.00012	Significant
Computer aided method	115	47.59	2.88					

Table 6 reveals the t-test analysis of significant difference for post experimental and control group performance. The significance value of the statistic is 0.000012. The t equals -6.34, is not in the 95% critical value accepted range: [-1.9704:1.9704]. Since the calculated t-value (-6.34) is greater than the tabulated t-value at a 95%confidence interval, there is significant difference between the groups**. x1-x2=-10.86, is not in the 95% accepted range: [-3.3700: 0.004256]. The** statistic S' equals 1.712. The observed standardized effect size is large (0.84). That indicates that the magnitude of the difference between the average and average is large. The study rejects the null and accepted that there is significant difference in the mean achievement scores of students taught Basic Science using computer assisted instruction.

Research Hypothesis Two: There is no significant difference in the mean achievement scores of male and female students taught Basic Science using computer assisted instruction method.

Table 7: Analysis of significant differences of mean scores of male and female students 'taught Basic Science using computer assisted instruction method

Variable	N	Mean	S.D	Mean diff.	d.f	t_{cal}	p-value	Remark
Male computer aided method	45	46.89	2.88	1.39	113	1.122	0.264	Not Significant
Female computer aided method	70	48.28	2.68					

In Table 7, the result revealed mean scores and standard deviation of the male and female students. The result shows that male students have mean of 46.89 while female have mean of 48.28 with mean differences of 1.39. The t-value calculated (1.122) is less than the tabulated value of 1.67 at 95% confidence interval. The study therefore, concludes that there is no significant difference in the mean scores of both male and female students when taught using computer aided method.

Summary of Findings

The major findings from the data analysis are summarized as follows:

1. There is significant difference in the mean achievement scores of students taught Basic Science using computer assisted instruction with those taught using lecture methods with t value of -6.34 and p value of 0.00012.

2. There is no significant difference in the mean achievement scores of male and female students taught Basic Science using computer assisted instruction method with t-value of 1.122 and p value of 0.264.

Discussion of Findings

The study found significant difference in the mean achievement scores of students taught Basic Science using computer assisted instruction methods with t-value of -6.344 and p value of 0.00012. This is consistent with the findings of Adeyemi (2012) findings which revealed that Computer Assisted Instruction (CAI) enhanced higher students' achievement in Basic Science, Similarly, the finding correlated with that of Ordeniza and Ali (2024) who opined that, students exposed to CAI demonstrate significantly higher post-test scores compared to those who received traditional instruction. For instance, a study reported a 14% increase in mean percent scores among students using CAI. Additionally, Dap-og and Orongan (2022) highlighted that CAI led to fairly satisfactory results in post-test while non-CAI students showed the need for improvement.

There is no significant difference in the mean achievement scores of male and female students taught Basic Science using computer assisted instruction method with t-value of 1.122 and p value of 0.264. This is similar to the studies of Asubiojo (2023) who found no significant difference in the mean scores of physics achievement scores of males (68.90) and female (67.60). However, a contrast was observed in the study of Julius et al. (2018), who revealed a significant gender difference in chemistry academic achievement in favour of girls.

Conclusion

On the basis of the findings of the study the following conclusions were drawn: -

(i) There is significant difference in the mean achievement scores of students taught Digestive and excretory System using computer assisted instruction and that taught using with conventional methods

(ii) There is no significant difference in the mean achievement scores of male and female students taught Basic Science using computer assisted instruction method.

Recommendations

On the basis of the findings arising from the study, the following recommendations were made:

1. The use of computer assisted instruction concept of Digestive and excretory System in secondary school should be encouraged as it is empirically established that it enhances academic performance among students.
2. The teachers and schools should be equipped with modern facilities and instructional packages to enable the teachers/tutors carry out their lesson via computer assisted instruction method.
3. All science teachers and particularly Basic Science and Technology should be encouraged or facilitated to use of Computer aided Instructions. All science teachers, Basic Science in particular, should learn how to use modern instructional materials; models, media technology, ICT, among others. This is to enable them carry-

out teaching digestive and excretory system using computer aided instruction method effective in combating students' misconception of concepts.

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