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Impact of Animated Computer-Assisted Instruction on Biology Achievement in Niger State: Post-COVID-19 Teaching Solution

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Abstract

This research explored the impact of computer-assisted instruction (CAI) with animation on the academic performance of biology students in Niger State, designed as a post-COVID-19 strategy to enhance teaching and learning. The study utilized an experimental design, focusing on Senior Secondary II (SSII) students. Participants were selected using a simple random sampling method, which included schools, class groups, and students, resulting in two equivalent groups of 30 students each (15 males and 15 females). The instrument's reliability was verified using the PPMC formula, producing a coefficient value of 0.75. Data analysis was conducted using Analysis of Variance (ANOVA) to test the hypotheses. The results revealed that the first null hypothesis was rejected, while the second was accepted. The study highlighted that incorporating CAI with animation as a teaching aid significantly improved students' academic achievements in biology. This enhancement was attributed to the integration of traditional teaching approaches with effective instructional materials, which created a more engaging and interactive learning environment. The findings recommend implementing CAI with animation software across all senior secondary schools to boost students' understanding and performance in biology and other science subjects. Such an approach addresses educational challenges exacerbated by the pandemic while fostering dynamic and effective learning experiences.

Keywords: Computer Assisted Instruction; Animation in Education; Biology Academic Performance; Interactive Learning Methods; Post-COVID-19 Teaching Strategy.

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Introduction

In the 21st century, science and technology have become essential tools in education, playing a significant role in the teaching and learning process. This era has also been marked by the emergence of various pandemic diseases such as Severe Acute Respiratory Syndrome (SARS), bird flu, Ebola, and most recently, the COVID-19 pandemic. Computer-Assisted Instruction (CAI) is an automated tool designed to facilitate teaching and learning effectively. In the context of biology, a core science subject, the use of animations has been identified as an effective teaching method (Nsofor, 2010; Sanyay, 2010).

The objectives of secondary school education in Nigeria include providing students with meaningful and relevant knowledge, enabling them to apply scientific understanding to everyday life, particularly in personal and community health, developing laboratory and fieldwork skills essential for higher education, and fostering agricultural and functional scientific attitudes (Federal Republic of Nigeria, 2009). However, many students in the 21st century opt for biology as their sole science subject, whether in the arts or science streams, which has led to widespread poor performance among students (Gambari, 2010).

To improve learning outcomes, especially during the COVID-19 pandemic, it is crucial to adopt computer-assisted instruction. This approach allows students to learn individually and at their own pace, adhering to COVID-19 safety protocols such as physical distancing. Studies by (Gana, 2013; Kareem, 2015; Akpomedaye, 2019) have shown that computer-assisted and computer-managed instruction significantly enhances student achievement. Given this, technology-mediated teaching methods are needed to support educators in classroom instruction during the pandemic.

The COVID-19 pandemic was first traced to Wuhan City in Hubei Province, China. Following extensive laboratory analyses, the virus was identified as Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) and officially

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named Coronavirus Disease 2019 (COVID-19) by the World Health Organization (Biswas et al., 2020; Ayotola et al.. 2010)). This virus has been found to cause a range of illnesses, from mild colds to severe respiratory conditions. To mitigate its rapid spread, various measures were implemented worldwide, including social distancing and the temporary closure of schools. These closures significantly impacted students' academic achievements.

Academic achievement, a psychological construct, refers to the ability to reproduce learned knowledge. It represents the outcome of learning, which is a relatively permanent behavioral change resulting from experience and training. Research has consistently shown that students' academic performance improves significantly when Computer-Assisted Instruction (CAI) is used. Studies by (Gimba et al., 2014; Abanyam & Terkuma, 2021; Gana, 2013) highlight the effectiveness of CAI in enhancing student achievement.

Gender disparities in academic achievement remain a concern among educators and researchers. While some studies, such as those by (Ige & Hlalele, 2017; Yusuf and Afolabi, 2010) found no significant differences in achievement between male and female students, others, including (Ahmed et al., 2020), observed notable disparities. (Kareem, 2015) investigated the impact of a Computer-Assisted Instructional Package (CAIP) on the academic performance of biology students in Niger State before the COVID-19 pandemic. The study revealed that students taught with CAI performed better than those in the control group. However, no significant gender differences were found among students exposed to CAI.

Similarly, (Lovelace et al., 2010) analyzed the achievement scores of students using CAI in rural areas and found that both male and female students benefited significantly. Additionally, the study revealed that students with both high and low intelligence quotients achieved better results when taught with CAI. (Ahmed, 2011) conducted another study in Bauchi State, Nigeria, focusing on the effects of CAIP on biology students' understanding of generic concepts. The findings showed that the experimental group outperformed the control group, and gender disparities were significant when CAIP was used. Furthermore, (Ayotola and Abiodun, 2010) examined the impact of a computer animation package on the academic achievement of Nigerian senior secondary school biology students. Their study revealed a significant effect of the treatment on students' achievement in biology, emphasizing the potential of CAI and animation tools to enhance learning outcomes across diverse groups.

The outbreak of the COVID-19 pandemic compelled countries worldwide to adapt their strategies to address the challenges posed by the virus, particularly in the field of education. To curb the spread of the virus, preventive measures such as social distancing led to the adoption of various instructional strategies. Developed nations widely employed virtual classrooms, video conferencing tools like Zoom, and other advanced technological platforms for remote learning. In contrast, many developing countries, including Nigeria, primarily relied on television, radio broadcasts, and social media platforms to facilitate knowledge dissemination across different educational levels. Despite these efforts, student performance in key examinations such as the West African Examination Council (WAEC), National Examination Council (NECO), and the Joint Admission and Matriculation Examination (JAMB) in 2021 indicated a significant decline, particularly in science subjects. This trend highlighted the inadequacy of existing instructional strategies in addressing the educational needs of students during the pandemic. In Niger State, Nigeria, the poor performance in these examinations underscored the necessity for a more student-centered approach to teaching biology—one that adheres to COVID-19 protocols while effectively engaging learners.

One promising solution was the implementation of Computer-Assisted Instruction (CAI) integrated with animations, designed to facilitate learning in compliance with social distancing requirements within computer laboratories. CAI provides an interactive and individualized learning experience that accommodates varying student paces while adhering to health guidelines. Given its potential, this study sought to examine the effects of CAI with animation on students' achievement in biology during the COVID-19 pandemic in Niger State, Nigeria. The findings are expected to offer insights into effective instructional strategies that can enhance learning outcomes during public health crises.

Objectives of the study

This study aimed to explore the impact of Computer-Assisted Instruction (CAI) integrated with animation on students' academic achievement in biology during the COVID-19 pandemic in Niger State, Nigeria. Specifically, the research sought to determine the effects of CAI with animation on students' overall performance and to examine whether there were differences in achievement between male and female students exposed to this instructional method. To achieve these objectives, the study tested two null hypotheses at a 0.05 level of significance.

The first hypothesis posited that there would be no significant difference in the achievement scores of students taught biology using CAI with animation compared to those taught using the Traditional Lecture Method (TLM). The second hypothesis examined whether there was no significant difference in achievement scores between male and female students taught biology using CAI with animation. By addressing these hypotheses, the study aimed to provide insights into the effectiveness of CAI with animation not only as a pedagogical tool to enhance learning outcomes during public health crises but also in fostering gender equity in science education. The findings are expected to inform educational strategies that can be adapted to similar challenges in the future.

Method

This study employed an experimental design utilizing a randomized pretest-posttest equivalent groups approach. This design was selected to align with COVID-19 protocols, particularly the social distancing requirement. The study population comprised Senior Secondary II (SSII) students who were regularly attending school. The target population included students from two randomly sampled schools in Minna, Niger State. A simple random sampling technique was used to select schools, class arms, and participants. A total of 60 students were divided equally into experimental and control groups, with a balanced gender ratio (15 male and 15 female students in each group). Randomization was conducted considering the computer laboratory's capacity to maintain proper distancing in compliance with COVID-19 protocols.

Instruments

Two instruments were developed for data collection: a treatment tool and a test instrument. The treatment tool, designed using Research and Development (R&D) guidelines, was developed by the researcher in collaboration with a computer programmer. The test instrument, named the COVID-19 Biology Achievement Test (C-19BAT), was constructed based on the lower levels of Bloom's taxonomy: knowledge, comprehension, and application. It was structured using a test blueprint.

Validation

The treatment tool was validated by experts in computer animation and graphics, focusing on design principles, while the test instrument was validated by biology specialists and test and measurement experts from the West African Examination Council (WAEC) in Minna. Validation included face and content validity, ensuring logical sequencing and alignment with the subject matter.

Reliability

To determine the reliability of the C-19BAT, the test-retest method was used. Twenty randomly selected SSII students from the study population were administered the test twice, with a one-week interval between tests. The data were analyzed using Pearson Product-Moment Correlation (PPMC), resulting in a reliability index of 0.75. This value meets the threshold set by (Yilmaz & Kabak, 2021), which states that a reliability coefficient of 0.70 or higher is acceptable for educational research.

Data Collection Procedures

The experimental group was taught using a computer-assisted animation package uploaded to computers in the laboratory. Students worked individually, seated with two computer tables between them to maintain distancing protocols. The school teacher, trained by the researcher on the package's operational guidelines, acted as a facilitator. The package included built-in evaluation mechanisms: students were allowed two attempts for each question, with immediate feedback. If a question was answered incorrectly on both attempts, the system provided the correct answer before moving to the next content. The control group received traditional classroom instruction from their teacher, following the same COVID-19 protocols. To ensure consistency, the lesson plans for the control group were prepared by the researcher to avoid variability in teaching quality.

Experimental Process

Both groups underwent a pretest to assess their baseline knowledge before treatment. After the four-week instructional period, a posttest was administered. To minimize recall bias, the posttest questions were shuffled but remained equivalent in content to the pretest. Data collected from the pretest were analyzed using Analysis of Variance (ANOVA)

to confirm no significant differences between the groups at baseline. This rigorous experimental procedure ensured that the study adhered to COVID-19 protocols while maintaining reliability and validity in its design and execution.

Results and Discussion

Result

This section presents the findings from the analysis of the collected data, organized to address the research objectives and test the formulated hypotheses. The results are structured to show the students' prior knowledge through pretest analysis, the posttest outcomes after the intervention, and gender-specific performance within the experimental group. These findings provide insights into the effects of Computer Assisted Instruction (CAI) with Animation on students' academic achievements in Biology during the COVID-19 pandemic.

Pretest Result

Analysis of Variance (ANOVA) was employed to assess the pretest scores, determining the students' prior knowledge of the subject matter before the treatment. This analysis was crucial for ensuring the groups were at an equivalent level before the intervention and to decide on the appropriate statistical tools for further analysis. It also helped identify any initial pre-experimental differences between the two groups.

Table 1. ANOVA Summary of Pretest Analysis Between the Experimental and Control Groups.

Groups	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.350	1	1.350	0.339	0.563
Within Groups	231.233	58	3.987		
Total	232.583	59			

*Not Significant at P<0.05

The pretest results, shown in Table 1, indicate no significant difference between the experimental and control groups prior to the treatment. The F-value of 0.339 and a p-value of 0.563 suggest that both groups were at an equivalent level of knowledge before the intervention, supporting the assumption that both groups were comparable at the start of the study.

Hypotheses Testing

The post-test results for both groups were analyzed to evaluate the effect of the treatment. The analysis revealed significant differences between the groups following the intervention.

Table 2. ANOVA Summary of Posttest Analysis Between the Experimental and Control Groups.

Groups	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	205.350	1	205.350	51.508	0.000
Within Groups	231.233	58	3.987		
Total	436.583	59			

*NS=Significant at p<0.05

As shown in Table 2, the posttest results reveal a significant difference in mean achievement scores between the experimental and control groups, with $F(1,59) = 51.508$ and $p < 0.05$. These findings suggest that the experimental group, which received the Computer Assisted Instruction (CAI) with Animation, outperformed the control group, which received traditional instruction. Therefore, the null hypothesis (HO1) stating that there would be no significant difference between the groups was rejected.

Table 3. ANOVA Summary Analysis of Masculine and Feminine Scores in the Experimental Group.

Groups	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.533	1	0.533	0.280	0.601
Within Groups	53.333	28	1.905		

Groups	Sum of Squares	df	Mean Square	F	Sig.
Total	53.867	29			

*NS= Not significant at P>0.05

As indicated in Table 3, the analysis of masculine and feminine achievement scores in the experimental group revealed no significant difference in mean achievement scores between male and female students. With an F-value of 0.280 and a p-value of 0.601, it is clear that gender did not significantly affect the student's performance in the experimental group. Thus, the null hypothesis (HO2) stating there would be no significant difference between male and female students' achievements was retained.

Discussion

The results of this study highlight the significant impact of Computer Assisted Instruction (CAI) with Animation on students' achievement in Biology, as well as the equitable effectiveness of the intervention across genders. The findings align with and expand upon previous studies in the field.

The analysis of the posttest results in Table 2 reveals a significant difference in mean achievement scores between the experimental and control groups, with $F(1,59) = 51.508$ and $p < 0.05$. This indicates that the experimental group, which was exposed to CAI with Animation, outperformed the control group that received traditional lecture-based instruction. The rejection of the null hypothesis (HO1) demonstrates the effectiveness of CAI with Animation as a learning tool. The improvement in achievement scores can be attributed to the integration of multimedia instructional aids, which enhance engagement, understanding, and retention of knowledge. These findings are consistent with the studies conducted by (Gana, 2013; Kareem, 2015; Akpomedaye, 2019), which similarly reported higher gains in achievement scores for experimental groups compared to control groups using traditional teaching methods. The current study reinforces the idea that CAI with Animation is a valuable complement to traditional classroom instruction, particularly in enhancing student learning outcomes.

Furthermore, the analysis of gender differences in the experimental group, as shown in Table 3, indicates no significant disparity in achievement scores between male and female students after exposure to CAI with Animation ($F(1,29) = 0.280$, $p > 0.05$). The retention of the null hypothesis (HO2) confirms that the intervention is equally effective for both genders. This finding aligns with the studies of (Lovelace et al., 2010; Ahmed, 2011; Ayotola and Abiodun, 2010), which advocate for the adoption of CAI with Animation as an effective instructional strategy in Biology. These studies also emphasized its gender-neutral influence, suggesting that such interventions can bridge gaps in educational outcomes between male and female students.

Overall, the results of this study support the integration of CAI with Animation as a pedagogical tool in Biology instruction. The significant improvements in achievement scores in the experimental group underscore its potential to enhance learning outcomes, while the equitable performance across genders highlights its inclusive benefits. These findings contribute to the growing body of evidence supporting the use of technology-enhanced learning solutions in addressing the challenges of traditional education systems, particularly in the context of pandemic-related disruptions.

Conclusions and Suggestions

Conclusions

This study demonstrated that Computer Assisted Instruction (CAI) with Animation significantly enhanced students' achievement in Biology compared to traditional classroom instruction. Furthermore, the findings revealed that CAI with Animation was equally effective for both male and female students, eliminating gender disparities in academic performance. These outcomes underline the importance of integrating innovative instructional strategies like CAI with Animation into the educational system, particularly in scenarios requiring adherence to pandemic protocols. The results highlight the potential of such technology-driven approaches to transform Biology teaching and learning in Senior Secondary Schools.

study revealed that, CAI with animation enhanced the achievement of students in Biology better than normal classroom instruction and it also revealed that CAI with animation improved the achievement of the Masculine and Feminine students in Biology. Recommendations were made to improve the application of CAI with animation software in our Senior Secondary Schools.

Suggestions

1. Encouraging the Use of CAI with Animation
   The implementation of CAI with Animation software should be widely promoted in Senior Secondary Schools. This approach can serve as a robust alternative to traditional methods, ensuring continuous learning and improved academic performance in Biology, particularly during pandemics or other emergencies when physical classrooms are inaccessible.
2. Provision of Functional Computer Equipment
   Adequate and functional computer gadgets should be made available to students, not only within schools but also at their homes. This will enable students to access and practice instructional packages effectively, ensuring uninterrupted learning regardless of the operational status of schools.
3. Capacity Building for Teachers
   Teachers should be trained in the use of CAI with Animation software to enhance their instructional delivery. Capacity-building programs should focus on integrating digital tools into their teaching methods to optimize the effectiveness of the technology.
4. Collaboration with Stakeholders
   Schools should collaborate with educational stakeholders, including government agencies, non-governmental organizations, and technology providers, to ensure the successful implementation of CAI with Animation. This includes funding for hardware acquisition, software development, and teacher training.
5. Periodic Assessment and Updates
   Regular evaluation of CAI with Animation programs should be conducted to assess their effectiveness and relevance. Updates to the software should be made to align with curriculum changes and advancements in educational technology, ensuring sustained improvements in student outcomes.

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