Effects of Computer Assisted Instructions and Computer Animation on the Teaching of Chemistry in Secondary Schools

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Abstract

This study investigated the effect of computer assisted instructions and computer animation on the teaching of Chemistry in secondary schools in Mkpat Enin Local Government Area. A quasi-experimental research design was employed for the study. The population of this study consisted of 1,473 senior secondary two students (SS2) in the sixteen (16) public secondary schools in Mkpat Enin Local Government Area. The sample size consisted of 94 Senior Secondary Two (SS2) students selected from two randomly chosen schools in the study area. Data were collected using the Chemistry Performance Test (CPT), which was validated by experts in the Department of Science Education, Akwa Ibom State University, and had a reliability coefficient of 0.79. Mean, standard deviation, and independent t-test were employed to analyze the data at a 0.05 significance level. The results revealed that there is a significant difference in the mean performance scores of students taught the concept of periodic table using computer assisted instruction and computer animation. There is no significant difference in the mean performance scores of male and female students taught the concept of periodic table using computer assisted instruction and computer animation instructional approach. Based on these findings, it is recommended that teachers adopt CAI as an integral part of their Chemistry teaching strategies for effective teaching and learning process.

Keywords: Computer assisted instruction, computer animation, teaching, Chemistry, secondary schools.

Introduction

Chemistry is universally acknowledged as a discipline of immense relevance to human progress because of its direct application to real-life situations. It is concerned with the composition, properties, transformation, and utilization of matter, and underpins the conversion of natural substances as well as the creation of artificial ones. Through its principles, modern society is able to develop the food, machines, energy, and materials that define contemporary living. In the Nigerian education system, Chemistry is classified as a core science subject within the 6-3-3-4 structure as outlined in the National Policy on Education (NPE, 2014). Chemistry is a prerequisite subject for many professions such as medicine, pharmacy, engineering, biochemistry, agriculture, and all science related professions (Samuel & Okonkwo, 2020).

Chemistry as a central science provides the foundation for scientific and technological advancement of a nation. It cultivates scientific literacy that is essential for addressing global issues such as climate change, health crises, and sustainable energy

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production (Umanah & Sunday, 2025). It also remains central to current conversations on green and sustainable development. Through its principles and applications processes, the field drives the creation of materials and products that are less harmful to the environment, encourages smarter approaches to waste management, and supports recycling practices that help protect the planet for future generations (Umanah, 2024). Furthermore, it also plays a crucial role in the development and optimization of renewable resources, as it provides the fundamental knowledge and techniques needed to harness, improve, and sustain energy and material sources that are renewable and eco-friendly (Sunday & Edet, 2024).

At the secondary level of education, Chemistry is taught both as theoretical and practical to strengthen students' grasp of abstract and difficult concepts. Learning through the practical methods is regarded as hands-on activity or experiment which enhances learning by doing and interaction with materials. These experiential activities allow students to interact directly with learning tools and aids, thereby enhancing comprehension and retention of scientific concepts (Afyusisye & Gakuba, 2022). Also, the survival of living organisms equally depends on chemical processes such as respiration, digestion, cell formation, and excretion. Humanity further relies on Chemistry to produce life-saving drugs, exploit medicinal plants and animals, and drive technological innovations for sustainable development.

Chemistry plays a central role in scientific and technological advancement, however students in secondary school still struggle with the subject. The national examination bodies such as West African Senior School Certificate Examination (WASSCE) and National Examination Council (NECO) on consistent basis have reported low performance levels among students, signaling that learners continue to find key Chemistry concepts difficult to grasp (West African Examination Council, Chief Examiner Report, 2024). This recurring pattern of poor performance has been linked to numerous factors, such as the abstract nature of Chemistry topics, the shortage of appropriate learning materials, and the continuous use of teacher-centered teaching method that encourage rote memorization of facts rather than conceptual understanding (Sunday, et al., 2025; Inyang et al., 2023 Babayemi, 2024). As a result, students' weak performance has become a major worry for educators, parents, and the broader community.

Beyond the examination hall, repeated failure often dampens students' motivation and reduces their interest in pursuing science-related careers (Uko & Uko, 2024; Moffat et al., 2023). These difficulties make Chemistry appear abstract, difficult and intimidating, prompting them to withdraw from it entirely (Umanah & Sunday, 2025; Umoetuk et al., 2025a). The problem is further deepened by the teacher continuous dependence on traditional teaching methods, which rarely help students connect abstract ideas to concrete experiences. This approach fails to provide students with a deep conceptual understanding of reaction mechanisms, molecular interactions and the dynamic nature of chemical processes (Rajpoot et al., 2022; Umanah & Babayemi, 2024; Umanah & Sunday, 2022). In response this state of education, scholars and educators have explored the use of innovative, technology-based instructional strategies to improve student outcomes in Chemistry. Among these, Computer-Assisted Instruction (CAI) and Computer Animation (CA) among others have received considerable attention. While CAI provides structured, interactive, and individualized learning experiences, computer animation

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uses dynamic visualizations to make abstract concepts more concrete and engaging.

Computer-assisted instruction (CAI) is an instructional approach where a computer is used to communicate the instructional materials and evaluate the learning outcomes. It uses a blend of graphs, texts, sounds and videos for learning process (Tyagi, 2014). It is an approach that involves the use of computer technology to support teaching and learning in a structured and interactive manner. CAI approach enables the teacher to present lesson content through multimedia elements which allow learners to work at their own pace, receive immediate feedback, and interact with learning materials. Ekundayo (2022) described CAI as any sort of computer application in instructional settings, comprising of drill and practice, simulations, instructional exercises, supplementary exercises, instructional management, database development, programming, composing using word processors, and other different applications. Sunday et al. (2025) established that computer-assisted learning such as computer-based molecular modelling in Chemistry enables the creation of virtual molecular models, facilitates the prediction of their properties, and allows for the study of their behaviour in various environments. This instructional technology enhances the visualization of chemical phenomena and equips students to anticipate molecular properties and behaviours based on structural features.

Research shows that integrating technology into the classroom is essential for managing instructional processes and improving teaching effectiveness. Akpomi and Anireh (2024) found that students tend to perform better when expose to CAI since the approach offers opportunities for interactive learning, individualized pace, and real-time feedback. Similarly, Sunday et al. (2025), Umoetuk et al. (2025a), Atabang and Umanah (2024), and Umanah and Akpan (2024), indicated that computer-based learning packages and digital devices can significantly improve learners' academic outcomes by making lessons more engaging and encouraging active involvement. Hence, the potential benefits of computer-assisted instruction in modern education are considerable as many studies have demonstrated its instructional value, especially in developed countries where CAI packages are widely used.

Computer animation (CA) as an instructional approach involves the utilization of digitally created images, computer-generated graphics, and motion effects to illustrate ideas that students may find difficult to imagine or observe directly. It provides learners with animated sequences that simulate real-life or scientific processes, enabling them to visualize complex ideas, and engage in interactive learning experiences (Atabang & Umanah, 2024; Sunday et al., 2025; Atabang & Babayemi, 2024). Furthermore, computer animations allow learners to watch processes unfold step by step, follow how scientific events occur and how different variables interact with one another. Through these moving visualizations, students can observe patterns, relationships, and transformations that static diagrams cannot show, thereby supporting deeper understanding (Atabang & Umanah, 2024; Sunday et al., 2025).

In Chemistry, computer animations are handy for demonstrating molecular interactions, chemical bonding, atomic structures, and reaction mechanisms that cannot be easily observed in a traditional classroom or laboratory setting. Computer animation has the potential of bringing down the difficult level of any concept taught to the barest minimum. It is audio-visual in nature with a combination of graphics and text presentation in which each can strengthen the retention level of students

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through observation of the images (Chikendu, 2018). It presentation package provides unique and interesting presentation given to each of the facts and concepts presented, making it beneficial to students in improving their academic performance. Atabang and Umanah (2024) reported that modes of computer animation do enhance students' academic achievement. This happened because of the interactive nature of computer animation providing the students an opportunity to be actively involved in the learning process. Sunday et al. (2025) demonstrated that computer-based molecular modelling substantially enhanced students' understanding of chemical reaction mechanisms compared to traditional methods. Shehu et al. (2024) reported a significant improvement among students taught with computer amination. Furthermore, the research report that there was no gender difference in performance.

Gender can be understood as the range of roles, behaviors, expectations, and identities that societies construct and assign to individuals based on their perceived sex. Unlike biological sex, which refers to physical and physiological differences, gender reflects socially learned patterns that shape how males and females participate in education, work, and social life (Sunday & Umanah, 2025). Gender is one of the factors that can shape how students perform academically and it remains a subject of ongoing interest among educators and researchers. Gender-related differences have been reported in students' performance as some studies indicates that male students tend to perform better than females in science-related tasks (Onunkwo, Ozomadu, Ejikeme, & Osuji, 2025; Ibe, Obikezie, & Chikendu, 2021), whereas Eno et al. (2023), Ain, Atta, and Khursheed (2022) found that female students significantly outperformed males. On the other hand, other researchers reported no significant difference in the academic performance of male and female students (Paul et al., 2024; Duru et al., 2024; Umanah & Babayemi, 2024; Sunday & Edet, 2024; Umanah & Sunday, 2022). These inconsistencies in findings suggest that the role of gender in influencing students' performance remains inconclusive as such, it is essential to examine how gender interacts with innovative instructional approaches such as computer-assisted instruction and computer animation in determining Chemistry achievement.

The concerns about how gender shapes students' learning outcomes naturally extend to the use of technology-based instructional approaches. However, to better understand why students may respond differently to computer-assisted instruction or computer animation, it is useful to adopt the Technology Acceptance Model (TAM) proposed by Davis (1989). TAM describes the conditions under which individuals adopt and effectively utilize technological tools in educational settings. According to the model, two perceptions are central to this process: Perceived Usefulness (PU), which is the degree to which a learner believes that a technological tool can improve academic performance, and Perceived Ease of Use (PEOU), which is the extent to which the learner feels the tool is simple and effortless to operate. These perceptions shape students' attitudes toward technology and ultimately determine whether they willingly engage with it during instruction. When students and teachers perceive CAI and CA as useful for learning Chemistry and easy to use, they are more likely to engage with them positively and achieve better outcomes. Students' performance will be greatly enhanced if these technologies make abstract Chemistry topics easier to understand. Thus, TAM not only offers a framework for understanding the effectiveness of CAI and CA, but also helps clarify how gender may shape students'

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interaction with these technologies. The model makes it possible to examine whether male and female students differ in their willingness to use CAI and CA, and how such differences might influence their learning outcomes in Chemistry. Differences in students' achievement may arise from variations in how they perceive the usefulness and ease of use of CAI and CA, as well as from gender-related attitudes toward educational technology. Although CAI and CA have both been shown to enhance science learning, there is limited research directly comparing their effectiveness in Nigerian Chemistry classrooms, particularly in relation to the periodic table. Moreover, findings on gender inclusiveness remain inconclusive. Hence, this study sought to investigate the comparative effectiveness of computer assisted instructions and computer animation on the teaching of Chemistry while also examining gender differences in Chemistry performance in secondary schools.

Statement of the Problem

Chemistry is essential to national development and serves as the basis for scientific and technological advancement. However, despite its immense significance to national development, Nigerian secondary school students' performance in Chemistry still remains low. West African Examinations Council (WAEC) Chief Examiners' Report indicates that students continue to struggle with major Chemistry concepts such as the periodic table, hydrocarbons, chemical reactions, among others, with their performance fluctuating at unsatisfactory levels (WAEC, 2023). This persistent underperformance has become a major concern as it discourages students from pursuing further studies in science-related disciplines and undermines the development of a strong scientific base for the country. Several factors have been attributed to this poor performance, such as the abstract nature of Chemistry, lack of instructional resources, the continuous use of traditional teacher-centered methods that emphasize rote learning rather than conceptual understanding. Such methods fail to concretize learning and often reinforce students' negative perceptions of Chemistry as a difficult subject. Hence, there is a pressing need to explore innovative instructional approaches such as computer simulation, computer-assisted instruction (CAI), computer animation (CA), among others, which can make Chemistry more interactive, meaningful, and accessible. While CAI and CA have been shown to enhance science learning in general, there is limited research directly comparing their effectiveness in the teaching of Chemistry in Nigerian secondary schools, particularly in the concept of periodic table. These gaps create the need for this study to investigate the comparative effectiveness of computer assisted instructions and computer animation on the teaching of Chemistry while also examining gender differences in Chemistry performance in secondary schools.

Purpose of the Study

1. Determine the difference in the mean performance scores of students taught the concept of periodic table using computer assisted instruction and computer animation instructional approach.
2. Determine the difference in the mean performance scores of male and female students taught the concept of periodic table using computer assisted instruction and computer animation instructional approach.

Research Questions

1. What is the difference in the mean performance scores of students taught the concept of periodic table using computer

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assisted instruction and computer animation?

2. What is the difference in the mean performance scores of male and female students taught the concept of periodic table using computer assisted instruction and computer animation instructional approach?

Hypotheses

1. There is no significant difference in the mean performance scores of students taught the concept of periodic table using computer assisted instruction and computer animation.
2. There is no significant difference in the mean performance scores of male and female students taught the concept of periodic table using computer assisted instruction and computer animation instructional approach.

Methods

A quasi-experimental research design was employed for the study. Specifically, the non-randomized pre-test, post -test design was adopted for the study. In this regard, intact class was used to derive sample for the study. This study was conducted in Mkpat Enin local government area. The population of this study consisted of 1,473 senior secondary two students (SS2) in the sixteen (16) public secondary schools in Mkpat Enin Local Government Area. A sample size of 94 SS2 student were selected for the study. One intact class each was selected from the two randomly selected schools used for the study. The two schools were randomly selected from the 16 co-educational secondary schools in the study area using simple random sampling technique. One school was assigned to computer assisted instruction instructional approach group while the other school was assigned to computer animation group. The first intact class were taught the concept of periodic table using computer assisted instruction while the second intact class were taught the same concept using computer animation. The instrument for data collection was Chemistry Performance Test (CPT). The instrument was based on the concept of Periodic table and comprised of 20 items which was used to elicit information concerning students' academic performance. The Chemistry Performance Test consisted of two sections A and B. Sections A was used to elicit students' demographic data while section B contained twenty (20) multiple choice questions ranging from option A-D of which only one option is the correct answer. Chemistry Performance Test (CPT), was scrutinized and vetted by two senior lecturers from the department of Chemistry Education, Faculty of Education in Akwa Ibom State University, Ikot Akpaden. The reliability was tested using Kuder Richardson formula 20 and the reliability coefficient obtain was 0.79. Descriptive statistic such as mean and standard deviation was used for analyzing the research questions while Analysis of Covariance (ANCOVA) was used to test the null hypotheses at 0.05 level of significance.

Results

Research Question One: What is the difference in the mean performance scores of students taught the concept of periodic table using computer assisted instruction and computer animation instructional approach?

Table 1: Mean and standard deviation of the performance mean of students on pretest posttest by on instructional approaches

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Instructional Approaches	n	Pretest		Posttest		Mean Gain
		Mean	SD	Mean	SD	
Computer Assisted Instruction	45	5.22	2.03	17.82	1.40	12.60
Computer Animation	49	5.29	1.57	16.16	2.54	10.87

Table 1 presents the mean and standard deviation scores of students taught the concept of the periodic table using computer-assisted instruction (CAI) and computer animation (CA). The result shows that students in the CAI group had a pretest mean score of 5.22 (SD = 2.03) and a posttest mean score of 17.82 (SD = 1.40), resulting in a mean gain of 12.60. On the other hand, students in the CA group had a pretest mean score of 5.29 (SD = 1.57) and a posttest mean score of 16.16 (SD = 2.54), with a mean gain of 10.87. These findings indicate that although both instructional approaches improved students' performance in the concept of the periodic table, the CAI group achieved a higher mean gain (12.60) compared to the CA group (10.87). However, this result supports the position that while both CAI and CA are beneficial in facilitating the learning of abstract Chemistry concepts, CAI appears to provide a greater advantage in concretizing the periodic table for students and promoting higher achievement levels.

Research Question Two: What is the difference in the mean performance scores of male and female students taught the concept of periodic table using computer assisted instruction and computer animation instructional approach?

Table 2: Mean and standard deviation of the mean performance between male and female students by on pretest posttest score on instructional approach

Instructional Approach	Gender	n	Pretest		Posttest		Mean Gain
			Mean	SD	Mean	SD	
Computer Assisted Instruction	Male Female	19 26	5.26 5.19	3.19 2.40	18.05 17.65	1.47 1.35	12.82 12.46
Computer Animation	Male Female	22 27	5.09 5.44	1.82 1.34	16.36 16.00	2.54 2.59	11.27 10.56

Hypothesis one: There is no significant difference in the mean performance scores of students taught the concept of periodic table using computer assisted instruction and computer animation.

Table 4.04: ANCOVA analysis on the difference in performance scores of students based on instructional approaches

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Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	64.925[a]	2	32.463	7.443	.001
Intercept	2750.033	1	2750.033	630.512	.000
Pretest	.367	1	.367	.084	.772
Instructional_Approaches	64.711	1	64.711	14.837	.000
Error	396.904	91	4.362		
Total	27492.000	94			
Corrected Total	461.830	93			

The result in Table 4.04 shows that students taught using computer assisted instruction had a higher mean performance score of 17.29 (SD = 1.53), compared to those taught with computer animation, who had a mean score of 16.16 (SD = 2.54). The independent t-test analysis yielded a t-calculated value of 2.57 at 92 degrees of freedom, with a p-value of 0.012. Since the p-value is less than the 0.05 significance level, the null hypothesis is rejected. This indicates that there is a statistically significant difference in the performance of students based on the instructional approach used. Therefore, computer assisted instruction was more effective than computer animation in enhancing students' performance on the concept of the periodic table.

Hypothesis two: There is no significant difference in the mean performance scores of male and female students taught the concept of periodic table using computer assisted instruction.

Table 4: ANCOVA analysis on the difference in performance scores of male and female students based on instructional approach

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	68.369[a]	4	17.092	3.866	.006
Intercept	2738.562	1	2738.562	619.457	.000
Pretest	.462	1	.462	.105	.747
Instructional_Approaches	64.489	1	64.489	14.587	.000
Gender	3.442	1	3.442	.779	.380
Instructional_Approaches * Gender	.002	1	.002	.000	.983
Error	393.461	89	4.421		
Total	27492.000	94			
Corrected Total	461.830	93			

Conclusion

The results of the findings showed a clear trend that computer-assisted instruction (CAI) enhances students' performance when they are exposed to the concept of the periodic table compared to just using computer animation (CA). Also, both male and female students reacted similarly to these instructional approaches, hence no meaningful difference was observed with regards to gender. However, teachers can confidently use both CAI and CA in mixed-gender classrooms, as neither method seems likely to accidentally widen existing achievement gaps. Therefore, CAI should not only be viewed as an educational tool, but as a core teaching approach that can seriously strengthen how students learn. In

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addition, teachers are encouraged to make CAI a regular feature of their daily instructional practice, as its consistent use can help strengthen students' understanding and overall performance in Chemistry.

Recommendations

i. Teachers should incorporate CAI as an integral part of their daily instruction to achieve an improved academic performance and enhance students' understanding in Chemistry.
ii. Students should actively participate in class activities because it will help them understand how much their participation in the learning process affects their performance.
iii. Chemistry instructors should receive frequent training from the government and educational partners on how to use CAI and CA instruments in the classroom.

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