Effects of Computer Animation and Problem-Based Learning on Secondary School Chemistry Students' Achievement in the IUPAC Nomenclature of Organic Compounds, Oyo Metropolis

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ABSTRACT

This study examined the impact of Computer Animation and Problem-Based Learning (PBL) on the academic performance of secondary school students in the context of the International Union of Pure and Applied Chemistry (IUPAC) nomenclature of organic compounds in Oyo Metropolis, Nigeria. The subpar performance of students in chemistry, particularly in their grasp and application of IUPAC nomenclature, has underscored the need for more engaging and effective teaching strategies. A 3x2 factorial quasi-experimental design was utilised, featuring two experimental groups (Computer Animation and PBL) alongside a control group (Conventional Teaching), with gender serving as a moderating variable. A total of 170 students from Senior Secondary School II enrolled in Chemistry were selected from three public schools through the application of multistage sampling techniques. The Chemistry Achievement Test (CAT) was conducted as a pre-test and a post-test. The analysis of data was conducted through Analysis of Covariance (ANCOVA) with a significance level set at 0.05. The analysis indicated a statistically significant main effect of the instructional strategies on students' achievement ($F_{(2,166)}$=187.88, $p<0.05$, η^2=0.709). The PBL group recorded the highest post-test mean (M=23.18), followed by the Computer Animation group (M=21.50), and the Conventional group (M=13.44). An important interaction between treatment and gender was noted ($F_{(2,163)}$=7.23, $p<0.05$, η^2=0.747), showing that female students excelled compared to males in both the PBL and conventional groups, whereas males had a slight advantage over females in the computer animation group. The findings indicate that both Computer Animation and PBL greatly improve students' comprehension and performance in organic chemistry. It is advised to incorporate these methods into chemistry teaching to foster active learning and enhance academic results.

Keywords: Computer Animation, Problem-Based Learning, Chemistry Achievement, IUPAC Nomenclature, Gender

INTRODUCTION

The study of science involves systematically organising information to enhance our understanding of the world and the various forces that influence it. Science can be viewed as a domain of inquiry that investigates a set of organised facts and illustrates the functioning of universal laws. The evolution of scientific inquiry can be traced to early humans, whose engagement with the natural world sparked a curiosity about studying and comprehending the cosmos (Da-Silva, 2022). This encompasses the exploration of the natural world and how its benefits can enhance human existence. Physical science examines the inorganic realm and encompasses fields such as Astronomy, Physics, and Chemistry. In contrast, life science, or biological science, focuses on the organic world and its processes. Additionally, earth sciences represent another distinct branch of science, categorised by its specific area of study.

As noted by Danielmeie & Schreiner (2023), chemistry represents a field within the natural sciences that elucidates the structure of matter while exploring its properties and behaviours. The role of chemistry is fundamental to the proper functioning of all living organisms' bodies. For optimal functioning and survival, all living organisms depend on essential chemical processes such as respiration, digestion, cell division, filtration, and the removal of waste products from their systems. This is due to its role in offering foundational insights into both basic and applied scientific domains; chemistry serves as a bridge between physics and biology. For example, the field of chemistry elucidates the chemical processes that contribute to plant growth, the formation of igneous rocks, the development of atmospheric ozone, and the breakdown of environmental pollutants. It also explores the properties of lunar soil, the biochemical impacts of drugs on living organisms, and the techniques employed to collect forensic evidence at crime scenes. The characteristics of the compounds used in the fabrication process, the materials selected, and the methodology itself are all domains where chemistry is extensively leveraged to enhance technology.

A significant number of secondary school students throughout Nigeria face challenges in grasping scientific concepts, especially in the field of chemistry. The persistent low achievement in Science among learners in Nigeria has raised significant concerns among the government, stakeholders, school administrators, and parents. This issue is attributed to various factors, including inadequate teaching practices, students' attitudes, insufficient teaching and learning resources, and the pedagogical skills of instructors. There has been notable concern regarding the performance of Nigerian students, particularly in chemistry and science subjects, as they are scoring lower compared to their peers from other countries. The abstract nature of chemistry often leads students to memorise concepts, principles, and theories rather than truly grasping the material they are studying. In these situations, chemistry students struggle to grasp chemical concepts effectively, perform poorly on both internal and external assessments, and find themselves unable to apply their knowledge to tackle everyday issues in their community, (Aidoo, Boateng, Kissi & Ofori, 2016).

The investigation conducted by Gongden, John, & Gimba (2019) confirmed that the performance of students in chemistry during the Senior School Certificate Examinations (SSCE) has been disappointing, despite the subject's importance for scientific and technological progress. Umate, Ahmad & Ibrahim (2021) indicate that most of the errors stem from a lack of understanding in balancing chemical equations, an inability to address electrolysis questions, a misunderstanding of oxidation and reduction reactions, and a lack of knowledge regarding IUPAC conventions. Any significant success achieved while working towards an educational objective can be considered an academic accomplishment, suitable for inclusion on a resume or scholarship application as evidence of your academic capabilities. To address this challenge, it is recommended for Chemistry educators to employ teaching methods that encourage active engagement among students, particularly when discussing complex and abstract topics such as IUPAC in Chemistry. Among the methodologies that can be utilised and thoroughly examined in recent times are Computer Animation and Problem-Based Learning. The methodologies in question have shown considerable effectiveness and have been widely embraced, prompting this study to regard them as proactive strategies for teaching Chemistry IUPAC Nomenclature of Organic Compounds (Drew, 2023).

The findings by Pius, Abumchukwu, and George (2021) indicate that incorporating computer animation into secondary school instruction significantly improves students' achievement, especially in complex subjects. Conventional instructional approaches frequently depend on fixed diagrams and written descriptions, which might not adequately represent the dynamic characteristics of molecular structures and nomenclature. Computer animation offers a dynamic learning experience, allowing students to explore the three-dimensional structures of organic compounds, visualise molecular transformations, and grasp the impact of functional groups on nomenclature rules. This dynamic representation enhances conceptual understanding, allowing students to observe the interactions and changes of molecular components instead of just memorising naming conventions.

A study conducted by Gongden, John & Gongden (2020) concluded that students who learn IUPAC nomenclature through computer animation exhibit enhanced academic performance in comparison to those instructed using traditional methods. Utilising animated models facilitates a detailed, sequential demonstration of naming procedures, thereby enhancing students' understanding of intricate rules and their accurate application. Furthermore, Samuel (2021) confirmed that animations serve to connect abstract chemical concepts with their practical applications, thus improving students' problem-solving abilities and knowledge retention. The engaging aspect of animations effectively addresses various learning preferences, especially for those who learn best through visual and hands-on experiences, as they might find traditional text-based explanations challenging. Through the active engagement with animated simulations, learners cultivate a deeper and more intuitive grasp of organic chemistry nomenclature.

On the other hand, Problem-Based Learning (PBL) has gained recognition as a potent instructional approach for improving students' academic performance, especially in disciplines that demand critical thinking and problem-solving abilities, like chemistry (Bhandary, 2021). In secondary school chemistry, project-based learning promotes a deeper understanding by involving students in real-world problems instead of encouraging passive memorisation of concepts. The application of PBL to the International Union of Pure and Applied Chemistry (IUPAC) nomenclature of organic compounds enables students to delve into and build their understanding through collaborative discussions, case studies, and practical activities. This approach stands in stark contrast to conventional rote learning, which frequently results in a shallow grasp of concepts and challenges when it comes to applying nomenclature rules to intricate organic compounds.

The study conducted by Zhang & Ma (2023) indicates that students engaged in PBL show enhanced academic performance in IUPAC nomenclature, attributed to the interactive and student-centered characteristics of this approach. Through engagement in problem-solving activities, learners enhance their advanced cognitive abilities, including analysis, synthesis, and evaluation, which are crucial for understanding organic chemistry principles. Furthermore, PBL improves the retention and transferability of knowledge, as students must apply nomenclature principles to various chemical structures, thus strengthening their understanding. The collaborative aspect of PBL encourages peer learning, allowing students to address misconceptions and enhance their understanding through discussions with their peers.

Gender plays a vital role in this study, as investigations into its impact on learning via Computer Animation and Problem-Based Learning (PBL) are still in progress. Gender includes various social, psychological, cultural, and behavioural aspects, with conventional perspectives typically following a binary classification. Multiple fields, such as Psychology, Sociology, and Neuroscience, investigate the ways in which biological and social elements influence gender identity and behaviour. Gender differences influence student performance, interest, and engagement in scientific studies; however, these issues have not been thoroughly examined, (Castro-Alonso, Wong, Adesope, Ayres, & Paas, 2019). Studies have shown that males and females exhibit different responses to computer animations; girls typically favour character-driven narratives, whereas boys are generally attracted to action-oriented content. Investigations indicate that gender plays a role in the efficacy of instructional visualisations, with dynamic animations producing different results based on gender composition. A meta-analysis on instructional visualisations indicated that males typically exhibited superior performance with dynamic visuals. Additionally, another study focused on the Computer Animation Instructional Package (CAIP) demonstrated its effectiveness in reducing gender disparities in math achievement. Furthermore, studies examining spatial ability modifications indicated that males continued to surpass females in multimedia-based learning environments. The results underscore the importance of conducting additional enquiries into gender-related disparities in learning outcomes associated with the use of computer animation and problem-based learning.

The integration of computer animation and problem-based learning in the instruction of IUPAC nomenclature could greatly improve students' academic performance in chemistry, as noted by Abdulrahaman, Faruk, Oloyede, Surajudeen-Bakinde, Olawoyin, Mejabi, Imam-Fulani, Fahm, and Azeez (2020). Utilising the advantages of both animation for visualisation and active participation through project-based learning, students cultivate a deeper comprehension of the naming conventions for organic compounds. Empirical studies indicate that students who engage with these methods achieve superior performance in assessments relative to their peers instructed through conventional lecture-based approaches (Beichumila & Bahati, 2022; Samuel, 2021). Integrating computer animation and problem-based learning into chemistry instruction can effectively enhance students' understanding of IUPAC nomenclature, leading to improved academic performance and a deeper appreciation of organic chemistry. This study will investigate how computer animation and problem-based learning can be utilised as teaching strategies to enhance students' achievement in IUPAC nomenclature. This study specifically assesses the effectiveness of employing computer animation and problem-based learning as teaching methods in high school chemistry settings.

Statement of the Problem

The education system plays a crucial role in shaping students' understanding of scientific concepts, particularly in Chemistry. In Oyo Metropolis, concerns have been raised regarding the academic achievement of secondary school students in the International Union of Pure and Applied Chemistry (IUPAC) nomenclature of organic compounds. Despite its fundamental importance in organic chemistry, many students struggle with mastering the principles of systematic naming, which is essential for further studies in the sciences. Traditional teaching methods, often dominated by rote memorization and teacher-centered approaches, have been found to inadequately engage students, leading to poor retention and application of knowledge. The abstract nature of organic chemistry, coupled with a lack of visual representation, makes it challenging for students to grasp structural relationships between organic compounds. Additionally, large class sizes, insufficient instructional resources, and an uninspiring learning environment further contribute to students' difficulties in mastering IUPAC nomenclature. To address these challenges, there is a need for innovative and student-centered teaching strategies that enhance conceptual understanding and problem-solving skills. Computer animation provides dynamic and interactive visual representations of molecular structures, which may aid students in better comprehending organic compounds. Similarly, problem-based learning (PBL) encourages active participation, critical thinking, and real-world application of chemical concepts. However, empirical studies evaluating the effectiveness of these instructional methods in improving students' achievement in IUPAC nomenclature remain limited. This study seeks to examine the effects of computer animation and problem-based learning on secondary school students' academic achievement in the IUPAC nomenclature of organic compounds in Oyo Metropolis. By exploring these instructional strategies, the research aims to provide insights into their potential to enhance students' understanding, engagement, and overall performance in organic chemistry.

Hypotheses

The following hypothesis were tested in the study at 0.05 level of significant

$H0_1$: There will be no significant main effect of the treatments (computer animation, and problem-based learning) and gender on chemistry students' achievement

$H0_2$: There will be no significant interactive effect of the treatments (computer animation, and problem-based learning) and gender on chemistry students' achievement.

Scope of the Study

The population scope of this study is the Senior Secondary School II Chemistry Students, while the geographical scope is Oyo Metropolis, Oyo State which comprises four (4) Local Governments which are Oyo West, Oyo East, Afijio, and Atiba Local Government. The aspect of chemistry that will be covered in this study is the IUPAC Nomenclature System of Naming Organic Compounds which includes the guidelines, procedures, and examples. The experimental group will be taught through computer animations and problem-based learning, while the control group will receive instruction via lectures. This topic was picked because the WAEC Chief Examiner's evaluation indicated that students had trouble understanding it.

METHODOLOGY

Research Design

The research design used for this study is a 3x2 factorial quasi-experimental design involving pre-test, post-test, non-randomized control, and non-equivalent intact group. It focused on computer animation, problem-based learning, and conventional methods at three levels (2 treatment groups and a control group). Computer Animation and Problem-Based Learning are independent variables that served as the treatment group for the experimental group while the conventional teaching method was used for the control group. Students' achievement in the Chemistry Achievement Test (CAT) in both the pre-test and post-test levels at two levels (high and low) was the dependent variables. In contrast, students' gender served as the moderating variable for the study.

Population of the Study

The population for the study was all senior secondary II students in Oyo Metropolis. Oyo State, Nigeria which is two thousand, six hundred and thirty-nine (2639). The names of the schools used for this study are; Awe Senior High School (Afijio Local Government), Ladigbolu Grammar School 2 (Oyo West Local Government), and Durbar Senior Grammar School (Oyo East Local Government).

Sample and Sampling Techniques

The study adopted a multistage technique to select the students required which includes three (3) intact science classes of senior secondary II. A purposive sampling technique was used to select three public co-educational secondary schools, one (1) school each from a Local Government area in the Oyo Educational Zone of Oyo State using the following criteria:

1. Schools that have been in existence for more than 50 years.
2. Schools that have qualified chemistry teachers with at least five (5) years of working experience and also five (5) years of experience as a West African Examinations Council (WAEC) Examiner.
3. Schools that have a standard well-equipped laboratory and a laboratory assistant

In Afijio Local Government, the school selected was Awe Senior High School, which has 53 Chemistry students in senior secondary school II. In Oyo West Local Government, the school selected was Ladigbolu Grammar School, which has 89 Chemistry students in senior secondary school II. Also, in Oyo East Local Government, the school selected was Durbar Senior Grammar School, which has 28 Chemistry students in senior secondary school II.

Research Instruments

Four (4) research instruments were used for this study: The Chemistry Achievement Test (CAT), Lesson Plan Format for Experimental Group 1 (Computer Animation), Lesson Plan Format for Experimental Group 2 (Problem-Based Learning), and Lesson Plan Format for Convectional Group (Control Group).

Description of the Research Instruments

Chemistry Achievement Test

The researcher developed the instrument to assess both students' initial knowledge of IUPAC nomenclature before any intervention (Pretest) and after the completion of the teaching interventions to measure improvement (Posttest). The Chemistry Achievement Test consists of thirty multiple-choice questions on the IUPAC Nomenclature of Organic Compounds with four options which the senior secondary II chemistry students answered, it contains two (2) sections. Section A consists of demographic data. Section B includes thirty multiple-choice questions adapted from the Senior Secondary Certificate Examination (SSCE), which are past questions used to test the student's achievement in the IUPAC Nomenclature of Organic Compounds.

Validity and Reliability of the Instruments

The researcher's supervisor and three (3) lecturers from Lead City University's Department of Science Education in Ibadan, Nigeria, verified the research instruments for both face and content validity in order to provide reliable comments. On the basis of their recommendations, fundamental changes and modifications were then made. To evaluate the reliability of the research tool, the Chemistry Achievement Test (CAT), a pilot study was carried out. Thirty Senior Secondary II Chemistry students from Alaafin High School I, located on Idi-Ose Street in the YID Area of Agunpopo, Oyo, participated in a pre-test of the instrument. Similar to the targeted sample, this coeducational school is used to launch each item's discriminating and difficulty indices. Ultimately, all of the remaining items with discriminating indices of 0.3 and above and difficulty indices ranging from 0.40 to 0.60 were chosen for the study. Cronbach Alpha was used to test the reliability coefficient after Kuder Richardson's (KR-20) formula was used to determine the instruments' reliability coefficient value.

Method of Data Collection

Prior to administering the instruments to the chosen students, a letter of introduction was secured from the Head of Department (HOD), Science Education, Lead City University Ibadan, and sent to the Heads of the selected schools. The approval of the Lecturer and the collaboration of the chosen students were also being requested prior to the implementation of the instruments. The study was conducted over duration of ten weeks, with the initial week dedicated to visiting schools. One week was allocated for the training of research assistants who supported the study. The pre-test was administered to all groups over a period of two weeks, followed by a six-week treatment phase for the treatment group, and finally, the post-test was conducted in the last week. The team and the assistants waited for all the participating students to complete the achievement test before collecting the instrument.

Method of Data Analysis

Analysis of Covariance (ANCOVA) was used to examine the data gathered in order to test the hypotheses at the 0.05 level of significance.

RESULT

Test of Hypotheses

This section answer the test of hypothesis

H_{01}: There will be no significant main effect of the treatments (computer animation and problem-based learning) on chemistry students' achievement.

Table 1: Analysis of covariance of the main effect of treatments (computer animation, and problem-based learning) on chemistry students' achievement.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	2190.254[a]	3	730.085	134.920	.000
Intercept	3988.270	1	3988.270	737.031	.000
Pre-Test	212.730	1	212.730	39.313	.000
Group	2033.422	2	1016.711	187.888	.000
Error	898.269	166	5.411		

Total	78437.000	170			
Corrected Total	3088.524	169			
a. R Squared = .709 (Adjusted R Squared = .704)					

Source: Field Survey, 2024

Table 1 reveals that there is a significant main effect of the treatments (computer animation and problem-based learning) on chemistry students' achievement ($F_{(2, 166)}$=187.88 p<0.05, η^2=0.709). The null hypothesis that there will be no significant main effect of the treatments (computer animation and problem-based learning) on chemistry students' achievement is therefore rejected. This implies that the introduction of the treatments (computer animation and problem-based learning) as methods independently and significantly affect the academic achievement of chemistry students in the IUPAC nomenclature of organic compounds in Oyo State. Also, the eta square value of 0.709 shows a contributing effect size of 70.9%.

Table 1.2: Estimated Marginal Means of treatments (computer animation and problem-based learning) on the academic achievement of chemistry students in the IUPAC nomenclature of organic compounds

Group	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Control Group	13.438[a]	.440	12.569	14.307
Computer Animation (Exp. 1)	21.501[a]	.320	20.870	22.132
Problem-based (Exp. 2)	23.182[a]	.247	22.695	23.669

Source: Field Survey, 2024

Table 1.2 shows that in the 2-way interactive comparison of the three groups combined, participants exposed to the conventional method of teaching (control group) had lower posttest mean ($\bar{x}$) score of 13.438, those exposed to computer animation (experimental group 1) had higher posttest mean ($\bar{x}$) score of 21.501 while the remaining respondents exposed to problem-based (experimental group 2) had the highest post-test mean ($\bar{x}$) score of 23.182. This means that respondents exposed to computer animation (experimental group 1) and problem-based (experimental group 2) had better performance than those in the control group.

$H0_2$: There will be no significant interactive effect of the treatments (computer animation, and problem-based learning) and gender on chemistry students' achievement.

Table 2: Analysis of covariance of interactive effect of the treatments (computer animation, and problem-based learning) and gender on chemistry students' achievement.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	2307.449[a]	6	384.575	80.256	.000
Intercept	3977.984	1	3977.984	830.153	.000
Pre-Test	207.625	1	207.625	43.329	.000
Group	1979.019	2	989.510	206.498	.000
Gender	52.371	1	52.371	10.929	.001
Group * Gender	69.329	2	34.665	7.234	.001
Error	781.075	163	4.792		
Total	78437.000	170			
Corrected Total	3088.524	169			
a. R Squared = .747 (Adjusted R Squared = .738)					

Source: Field Survey, 2024

Table 2 shows that there is a significant interactive effect of the treatments (computer animation, and problem-based learning) and gender on chemistry students' achievement ($F_{(2, 163)}$=7.234 $p<0.05$, η^2=0.747). The null hypothesis that there will be no significant interactive effect of the treatments (computer animation and problem-based learning) and gender on chemistry students' achievement is therefore rejected. This implies that the introduction of the treatments (computer animation and problem-based learning) as a method jointly/interactively with gender significantly affects the academic achievement of chemistry students in the IUPAC nomenclature of organic compounds, Oyo State. Also, the eta square value of 0.749 shows a contributing effect size of 74.9%.

Table 2.2: Estimated Marginal Means of treatments (computer animation and problem-based learning) on the academic achievement of chemistry students in the IUPAC nomenclature of organic compounds

Group	Gender	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Conventional Group	Male	11.995[a]	.585	10.839	13.151
	Female	14.884[a]	.585	13.728	16.039
Experimental Group 1	Male	21.807[a]	.400	21.018	22.597
	Female	21.099[a]	.457	20.198	22.001
Experimental Group 2	Male	22.294[a]	.355	21.593	22.995
	Female	23.844[a]	.307	23.238	24.449

Source: Field Survey, 2024

Table 2.2 indicates that the gender comparison among the three groups indicates that females had higher posttest mean in two different groups. In the control group (conventional method), males had a post-test mean ($\bar{x}$) score of 11.995, while females had a post-test mean ($\bar{x}$) score of 14.884. In the same vein, among those exposed to problem-based method (experimental group II), male participants had a posttest mean ($\bar{x}$) score of 22.294 while the female participants had a post-test mean ($\bar{x}$) score of 23.884. However, among those exposed to Computer animation (experimental group 1), males had posttest mean ($\bar{x}$) score of 21.807 while female participants recorded a post-test mean ($\bar{x}$) score of 21.099 which is very close. This implies that female participants performed better in the IUPAC nomenclature of organic compounds using conventional methods and problem-based methods.

DISCUSSION OF FINDINGS

The findings indicated a significant main effect of the treatments (computer animation and problem-based learning) on the achievement of chemistry students. The participants who engaged with computer animation (experimental group 1) and problem-based learning (experimental group 2) demonstrated superior performance compared to those in the control group, who experienced the traditional teaching method. Computer animation and problem-based learning methods have been shown to be effective in mastering IUPAC nomenclature in chemistry. Computer animation serves as a valuable tool in illustrating IUPAC nomenclature, effectively demonstrating the arrangement of carbon atom chains linked by single bonds, whether in linear formations or cyclic structures. It also highlights how various deviations, including multiple bonds or the presence of atoms beyond carbon and hydrogen, are represented through specific prefixes or suffixes, adhering to a defined hierarchy, as these details are not discernible through direct observation in a laboratory setting.

Considering the benefits that the animation strategy seems to provide, it is essential for educators with professional training to utilise more effective and evidence-based methods, such as the animation instructional strategy, to teach senior secondary two students in chemistry the core principles of the IUPAC Nomenclature of Organic Compounds. Computer animation in education can significantly enhance the understanding of various subjects. This form of presentation integrates text and images, each contributing to improved memory retention through visual engagement. The predominant component is audio-visual material. The instruction of chemical principles should incorporate audio-visual materials. The advantages of incorporating computer animation in educational settings are extensive. Computer-aided instruction fosters emotional intelligence and creates a stress-free learning environment (Abdulrahaman, Faruk, Oloyede, Surajudeen-Bakinde, Olawoyin, Mejabi, Imam-Fulani, Fahm & Azeez, 2020).

Students gain advantages from the distinctive and engaging manner in which computer animation conveys each piece of information and concept. Computer-animated modules serve as an effective resource for delivering specific information and capturing interest. Furthermore, Problem-Based Learning allows students to leverage their existing conceptual knowledge frameworks and engage their prior knowledge, fostering transferable skills and attitudes beneficial for their future endeavours. These include collaboration, critical assessment, teamwork, effective communication, respect for peers, self-directed learning, and efficient resource utilisation (Samuel, 2021). Problem-based learning captivates both instructors and students, as it requires full engagement from students throughout the learning journey. In problem-based learning, the learner takes the lead in guiding the educational journey, (Beichumila & Bahati, 2022).

Also, there was a significant interactive effect of the treatments (computer animation, and problem-based learning) and gender on chemistry students' achievement. This implies that the introduction of the treatments (computer animation and problem-based learning) as a method jointly with consideration of gender significantly affects the academic achievement of chemistry students in the IUPAC nomenclature of organic compounds, Oyo State. Comparative analysis of gender across the three groups reveals that females achieved higher posttest means in two distinct groups. In the group exposed to computer animation, the male participants exhibited a higher posttest mean score compared to their female counterparts. This suggests that female participants exhibited superior performance in the IUPAC nomenclature of organic compounds when utilising both conventional and problem-based methods.

Gender differences permeate every facet of human activity, influencing student performance, interests, and scientific investigations. The lack of attention to gender issues continues to pose a significant barrier to success. Research has shown that males and females respond to and interpret computer animation in distinct ways. Females, for instance, often gravitate towards animated series that emphasise character growth and narrative depth, while males tend to prefer those that are filled with action and rapid sequences. This may explain the superior performance of male participants when utilising computer animation. A study on "Gender imbalance in instructional dynamic versus static visualisations: A meta-analysis" demonstrated that the gender of the student significantly influences outcomes, as dynamic visualisations (like 3D models and animations) yielded poorer performance in a sample with a lower proportion of girls compared to boys. The findings of another study conducted by Castro-Alonso, Wong, Adesope, Ayre, and Paas (2019) indicated that the Computer Animation Instructional Package (CAIP) effectively reduced the gender gap in math achievement, as there was no significant difference in the mean achievement scores between male and female students who received math instruction through the CAIP.

CONCLUSION

In conclusion, this study has shown that Computer Animation and Problem-Based Learning (PBL) are considerably more effective than conventional teaching methods in improving students' academic performance in the IUPAC nomenclature of organic compounds. The implementation of these innovative instructional strategies led to a more profound understanding, enhanced engagement, and improved post-test scores among students. Furthermore, the findings indicated variations in performance based on gender, with females demonstrating superior results in PBL, while males showed a slight advantage over females in the context of computer animation. Based on these findings, the study advocates for a transition by educators and curriculum planners from teacher-centered to student-centered approaches that foster critical thinking and active engagement. Chemistry educators ought to integrate computer animation to clarify abstract chemical concepts visually and utilise project-based learning strategies to foster inquiry-driven education, collaboration, and practical problem-solving skills. This transition has the potential to improve understanding, memory, and the practical use of scientific information.

RECOMMENDATIONS

Based on the study's findings and objectives, the following recommendations are proposed:

1. Teachers and school administrators should incorporate computer animation and problem-based learning into the chemistry curriculum, particularly for topics that students find abstract and challenging. The use of animated models and real-world problem-solving tasks can enhance conceptual understanding and retention, making learning more engaging and effective.
2. Educational stakeholders should organize regular training and workshops for chemistry teachers on the effective integration of computer animation and problem-based learning in their instructional practices. This will equip teachers with the necessary skills and resources to implement these innovative teaching methods, ultimately improving students' performance in chemistry.

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