EFFECT OF MULTIMEDIA INSTRUCTION ON SECONDARY SCHOOL STUDENTS' ACHIEVEMENT IN CHEMISTRY IN ENUGU EDUCATION ZONE

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Abstract

This research examined the impact of multimedia instruction on the academic performance of secondary school students in chemistry within the Enugu Education Zone. The study was guided by two research questions and three null hypotheses. A pretest-posttest non-equivalent control group quasi-experimental design was employed. The target population consisted of 1,577 Senior Secondary 2 (SS2) chemistry students in the Enugu Education Zone, from which a sample of 160 students was selected. Data were collected using the Chemistry Achievement Test (CAT), which was validated by three experts. The reliability of the CAT was determined using the Kuder-Richardson Formula 20, resulting in a reliability coefficient of 0.82. Over a six-week period, the experimental group was taught specific chemistry concepts using multimedia instruction (MI), while the control group received instruction on the same concepts through the lecture method (LM). Research questions were addressed using mean and standard deviation, and the null hypotheses were tested using analysis of covariance (ANCOVA). The results indicated that multimedia instruction significantly improved students' chemistry achievement compared to the lecture method. Based on these findings, it was recommended that chemistry teachers, students, and curriculum developers integrate multimedia instruction as a teaching strategy, as it has proven more effective in enhancing students' acquisition of science process skills and overall academic achievement in chemistry than the lecture method.

Keywords: Multimedia, Instruction, Achievement, Chemistry

Introduction

Science is a structured field that constructs and arranges knowledge through testable explanations and predictions about the universe. Chemistry, a branch of science, focuses on the study of matter, its properties, transformations, and the behaviour of atoms, molecules, and ions (Housecroft & Sharpe, 2020). It examines the fundamental components of matter and their interactions to form new substances. Chemistry plays a vital role in addressing basic human needs such as food, clothing, shelter, health, clean air, and water. It is also foundational to various disciplines, including medicine, pharmacy, agriculture, nursing, engineering, and geology. According to Idika (2021), the knowledge and significance of chemistry make the universe more beneficial to humanity.

Despite the importance of chemistry and ongoing efforts by researchers and educators, achievement in the subject remains disappointingly low (Adeyemi, Ajayi, & Oludipe, 2022). An analysis of West African Senior Secondary School Certificate Examination (WASSCE) results from recent past reveals inconsistences in achievement in chemistry, which has become a concern for governments, educators, school administrators, and parents. The Chief examiner's report in 2020 showed that students raw mean score for first series was 24.0 which was better than the 2019-first series achievement of a raw mean score of 19.0. For school candidates in the same year, out of a total of 750, 175 students who sat for the examination, a raw mean score of 54.0 was observed which was better than the 2019 raw mean score of 14.46. In 2022, the students totalling 801, 522 achieved a raw mean score of 45.0 which was better than the raw mean score in 2021 which was 49.0. Students totalling 842, 030 who sat for chemistry obtained a raw mean score of 34.0 indicating a poor academic achievement of chemistry students compared to 2022 and 2021. This has spurred numerous studies exploring the causes of low achievement and potential solutions. For instance, Taber (2020) highlights that chemistry is an abstract subject, requiring learners to create mental models of invisible entities and processes. He emphasizes the need for teaching methods that focus on conceptual understanding rather than rote memorization of formulas and equations. Taber recommends the use of analogies, models, and visual aids to help students grasp abstract concepts.

Kind (2022) also notes that the abstract nature of chemistry can hinder deep understanding. To address this, Kind suggests incorporating real-world examples, visualizations, and hands-on activities into teaching. Ajayi and Adeyemi (2020) identify the lecture method, a widely used teacher-centered approach, as a contributing factor to poor achievement. Similarly, Aiyelabegan and Oyedeji (2022) argue that traditional teaching methods may be ineffective and advocate for alternative strategies such as inquiry-based learning and technology-enhanced instruction to improve outcomes.

The lecture method, though popular for delivering information to large groups, is often criticized for its lack of innovation. It positions the teacher as the sole source of knowledge, discouraging critical thinking, problem-solving, and curiosity among students (Ajayi & Adeyemi, 2020). While it allows for quick curriculum coverage and is suitable for large classes, it promotes rote learning and passive reception of information (Adebayo, 2022). This approach often leads students to memorize concepts without understanding their practical applications, as noted by Ogunkola (2020), who found that rote memorization results in poor retention and comprehension of chemistry principles.

Teachers' reliance on the lecture method may hinder students' understanding, particularly of abstract concepts. Effective science education requires the use of diverse instructional strategies (Ajayi & Adeyemi, 2020). There is a growing need to shift from traditional methods to innovative, technology-enhanced approaches that foster meaningful learning (Aiyelabegan & Oyedeji, 2022). The rapid advancement of technology offers opportunities for both teachers and students to engage in more interactive and effective learning experiences. Research by Liu, Chen, and Huang (2023) shows that multimedia instruction enhances critical thinking and practical application of concepts by providing scenario-based learning environments, which lectures often lack. This highlights the importance of integrating innovative strategies, such as concept mapping, role-playing, guided inquiry, brainstorming, and multimedia instruction, into chemistry education.

Multimedia instruction, as defined by Lee and Lee (2022), involves the integration of text, images, audio, video, and animations to create interactive and engaging learning environments. Mayer and Moreno (cited in Mayer, 2021) describe it as the presentation of words and visuals to facilitate learning, where words can be written or spoken, and visuals can be static (e.g., diagrams, photos) or dynamic (e.g., animations, videos). The effectiveness of multimedia instruction lies in its ability to engage multiple senses, making complex concepts easier to understand through dual coding (verbal and visual) and cognitive load management (Mayer, 2020). Sweller (2010) adds that multimedia instruction reduces cognitive overload by breaking down complex information into manageable segments, thereby improving student achievement across subjects, regardless of gender.

Gender, as defined by the World Health Organization (WHO, 2021), refers to the socially constructed roles, behaviors, and attributes deemed appropriate for different sexes. The impact of gender on science achievement and process skills has been debated, with studies yielding mixed results. For example, Adeyemi, Ajewole, and Oyedeji (2022) and Oludipe (2012) found no significant gender differences in academic achievement. However, Oladejo, Oyinloye, and Oyeleke (2020) reported that male students outperformed females in acquiring science process skills. Maduabum (2011) observed that girls generally underperform in science compared to boys in Nigeria, while Ivowi (2017) found that gender and location did not significantly affect physics achievement. Given these inconsistent findings, further research is needed to determine whether gender influences science process skills and achievement in chemistry when multimedia instruction is used.

Purpose of the Study

The aim of this research was to examine the impact of multimedia instruction teaching on the academic achievement of secondary school students in chemistry within the Enugu Education Zone. Specifically, the study sought to:

1. Compare the average achievement scores of students taught chemistry through multimedia instruction with those taught using the traditional lecture method.
2. Assess the average achievement scores of male and female students taught chemistry via multimedia instruction versus those taught using lecture method.
3. Investigate the interaction between teaching methods and gender in influencing students' academic achievement in chemistry.

Research Questions

1. What are the mean achievement scores of students taught chemistry using multimedia instruction and that of those taught using lecture method?
2. What are the mean achievement scores of male and female students taught chemistry using multimedia instruction and that of those taught using lecture method?

Hypotheses

1. There is no statistically significant difference in the average achievement scores of students who were taught chemistry using multimedia instruction compared to those taught with the lecture method.
2. There is no statistically significant difference in the average achievement scores of male and female students who were taught chemistry using multimedia instruction versus those taught with the lecture method.
3. There is no significant interaction effect between instructional methods (multimedia instruction and lecture method) and gender on students' academic achievement in chemistry.

Method

The study employed a quasi-experimental design, specifically the non-equivalent control group approach. It was conducted in the Enugu Education Zone of Enugu State. The target population included 1,577 SS2 students (745 males and 832 females) studying chemistry across 23 government-owned co-educational secondary schools in the zone. A sample of 160 students (65 males and 95 females) was selected from two secondary schools using a multi-stage sampling technique. First, one of the three Local Government Areas (LGAs) in the Enugu Education Zone was randomly selected, resulting in the choice of Enugu North LGA. Next, two co-educational secondary schools within the selected LGA were purposively chosen. Finally, a simple random method (coin toss) was used to assign one school as the control group and the other as the experimental group.

The primary data collection tool was the Chemistry Achievement Test (CAT), adapted by the researcher from past examination questions relevant to the study. The CAT consisted of two sections: Section A collected biographical data such as age and gender, while Section B included 50 multiple-choice questions with four options (A, B, C, and D) for each item. The questions were sourced from past examinations conducted by the West African Examination Council (WAEC) and the National Examination Council (NECO), focusing on topics such as hydrocarbons, homologous series, and organic compound nomenclature. A table of specifications (TOS) guided the selection of questions. Scoring was based on 2 points for each correct answer and 0 for incorrect or unanswered questions, with a maximum score of 100% and a minimum of 0. The CAT was validated by three experts: one from the Department of Science Education, another from the Department of Education Foundation, and a third from the Department of Measurement and Evaluation, all at Nnamdi Azikiwe University, Awka. The reliability of the CAT was determined using the Kuder-Richardson Formula 20 (KR-20), yielding a reliability coefficient of 0.82.

The experimental procedure was divided into three stages: pre-treatment, treatment, and post-treatment.

Stage 1: Pre-treatment

This phase involved introductions, training of research assistants, and the administration of a pretest.

Stage 2: Treatment

Trained research assistants conducted the teaching sessions in both schools, adhering strictly to the lesson plans provided by the researcher. The experimental group was taught using a Video-Based Multimedia Instructional Package (VBMIP) developed by the researcher, which included 3D models, animations, projected texts, images, and graphics. The control group, however, was taught the same content using the lecture method, following a separate lesson plan designed for this group.

Stage 3: Post-treatment

After five weeks of instruction and a revision period, the same test was re-administered as a posttest to both groups in their respective schools during the sixth week. The completed scripts were collected and handed over to the researcher for scoring and analysis.

The researcher analyzed the data using students' raw scores from the pretest and posttest to calculate the mean (ת) and standard deviation (SD). The hypotheses were tested using Analysis of Covariance (ANCOVA) to account for pretest scores when evaluating posttest results. The significance level was set at 0.05, with the decision rule being to reject the null hypothesis if the p-value was less than or equal to 0.05; otherwise, the null hypothesis was retained.

Results

Research Question 1: What are the mean achievement scores of students taught chemistry using multimedia instruction and that of those taught using lecture method?

Table 1: Mean Achievement scores of Students taught Chemistry using Multimedia Instruction (MI) and Lecture Method (LM)

Group	*N*	Pretest Mean	Pretest *SD*	Posttest Mean	Posttest *SD*	Gained Mean
MI	86	12.85	3.07	34.74	6.89	21.89
LM	74	13.14	3.35	23.58	3.82	10.44

According to Table 1, students who were taught Chemistry using multimedia instruction (MI) achieved a pretest mean score of 12.85 and a posttest mean score of 34.74, resulting in a mean gain of 21.89. In contrast, students taught Chemistry using the lecture method (LM) had a pretest mean score of 13.14 and a posttest mean score of 23.58, with a mean gain of 10.44. The pretest scores of students taught with MI were more consistent, as indicated by a standard deviation of 3.07, compared to those taught with LM, who had a standard deviation of 3.35. However, in the posttest, students taught with MI showed greater variability in their scores, with a standard deviation of 6.89, while those taught with LM had a more uniform achievement, reflected by a standard deviation of 3.82.

Research Question 2: What are the mean achievement scores of male and female students taught chemistry using multimedia instruction and that of those taught using lecture method?

Table 2: Mean Achievement Scores of Male and Female Students taught Chemistry using Multimedia Instruction (MI) and Lecture Method (LM)

Method	Gender	*N*	Pretest Mean	Pretest *SD*	Posttest Mean	Posttest *SD*	Gained Mean
MI	Male	41	12.22	3.17	32.39	5.99	20.17
	Female	45	13.42	2.90	36.89	7.02	23.47
LM	Male	24	14.42	3.91	24.46	4.47	10.04
	Female	50	12.52	2.88	23.16	3.44	10.64

As shown in Table 2, male students taught Chemistry using multimedia instruction (MI) achieved a pretest mean score of 12.22 and a posttest mean score of 32.39, resulting in a mean gain of 20.17. In comparison, female students taught with MI had a pretest mean score of 13.42 and a posttest mean score of

36.89, with a mean gain of 23.47. Table 4 further indicates that male students taught Chemistry using the lecture method (LM) had a pretest mean score of 14.42 and a posttest mean score of 24.46, yielding a mean gain of 10.04. Similarly, female students taught with LM had a pretest mean score of 12.52 and a posttest mean score of 23.16, with a mean gain of 10.64. Overall, both male and female students taught with MI demonstrated higher mean gain scores compared to their counterparts taught with LM. Specifically, male students in the MI group outperformed those in the LM group, and female students in the MI group also achieved greater gains than those in the LM group.

Hypothesis 1: There is no significant difference between the mean achievement scores of students taught chemistry using multimedia instruction and that of those taught using lecture method.

Table 3: ANCOVA Test of Significance of Difference in the Mean Achievement Score of Students taught Chemistry using MI and LM

Source	SS	Df	Mean Square	F	Sig.	Decision
Corrected Model	6023.415[a]	4	1505.854	57.838	.000	
Intercept	3663.607	1	3663.607	140.715	.000	
Pretest	605.350	1	605.350	23.251	.000	
Method	4618.554	1	4618.554	177.393	.000	Sig.
Gender	121.813	1	121.813	4.679	.032	Sig.
Method * Gender	129.137	1	129.137	4.960	.027	Sig.
Error	4035.529	155	26.036			
Total	150067.000	160				
Corrected Total	10058.944	159				

Table 3 indicates a significant main effect of the instructional treatment on students' Chemistry achievement, with $F(1, 155) = 177.393$ and $P = .000$, which is less than the 0.05 significance level. Consequently, the null hypothesis is rejected, indicating a statistically significant difference in the mean achievement scores of students taught Chemistry using multimedia instruction (MI) compared to those taught using the lecture method (LM), with MI yielding superior results.

Hypothesis 2: There is no significant difference in the mean achievement scores of male and female students taught chemistry using multimedia instruction and that of those taught using lecture method.

Table 3 further reveals a significant main effect of gender on students' Chemistry achievement, with F(1, 155) = 4.679 and P = .032, which is below the 0.05 significance level. As a result, the null hypothesis is rejected, indicating a statistically significant difference in the mean achievement scores of male and female students taught Chemistry using multimedia instruction (MI) compared to those taught using the lecture method (LM).

Hypothesis 3: There is no interaction effect of instructional methods (multimedia instruction and lecture method) and gender on students' achievement in chemistry.

Table 3 also demonstrates a significant interaction effect between instructional methods and gender on students' Chemistry achievement, with F(1, 155) = 4.960 and P = .027, which is below the 0.05 significance level. Consequently, the null hypothesis is rejected, indicating that there is a significant interaction effect between instructional methods (multimedia instruction and lecture method) and gender on students' achievement in Chemistry, as illustrated in Figure 1 below.

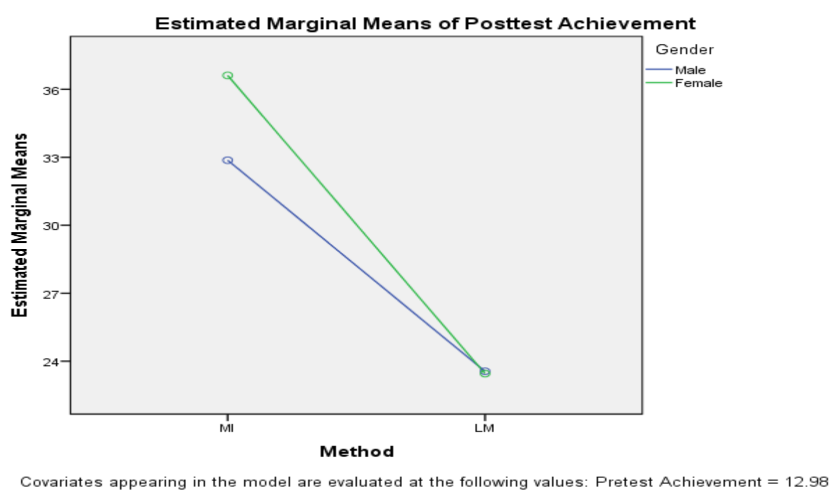

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Figure 1: Plot of interaction effect of instructional methods (MI and LM) and gender on students' achievement in Chemistry

The interaction effect of instructional methods and gender on students' Chemistry achievement, depicted in Figure 1, is both significant and disordinal. This indicates that the impact of instructional methods varies depending on gender, making them gender-sensitive. Due to the significant influence of gender, the potential interactions are further explored through a simple main effect analysis, as detailed in Table 4 and the accompanying table below:

Table 4: Pairwise Comparison and Univariate Test of Simple Main Effect of Methods within Each Level of Combination of the other Effects

Method	(I) Gender	(J) Gender	Mean Difference (I-J)	Std. Error	F	Sig.[b]
MI	Male	Female	-3.742*	1.113	11.307	.001
	Female	Male	3.742*	1.113		.001
LM	Male	Female	.105	1.291	.007	.935
	Female	Male	-.105	1.291		.935

Table 4 reveals a significant difference in the mean achievement scores of male and female students taught Chemistry using multimedia instruction (MI), favoring female students, with $F(1, 155) = 11.307$ and $P = .001$, which is below the 0.05 significance level. However, there is no significant difference in the mean achievement scores of male and female students taught Chemistry using the lecture method (LM), as $F(1, 155) = 0.007$ and $P = .935$, which exceeds the 0.05 significance level. This suggests that, in the context of instructional methods, particularly MI, female students perform better than their male counterparts, whereas both genders achieve similar results when the lecture method is employed.

Table 5: Pairwise Comparison and Univariate Test of Simple Main Effect of Gender within Each Level of Combination of the other Effects

Gender	(I) Method	(J) Method	Mean Difference (I-J)	Std. Error	F	Sig.[b]
Male	MI	LM	9.315*	1.342	48.147	.000
	LM	MI	-9.315*	1.342		.000
Female	MI	LM	13.161*	1.055	155.607	.000
	LM	MI	-13.161*	1.055		.000

Table 5 indicates a significant difference in the mean achievement scores of male students taught Chemistry using multimedia instruction (MI) compared to those taught using the lecture method (LM), favoring MI, with F(1, 155) = 48.147 and P = .000, which is below the 0.05 significance level. Similarly, there is a significant difference in the mean achievement scores of female students taught Chemistry using MI versus those taught using LM, also favoring MI, with F(1, 155) = 48.147 and P = .000, which is below the 0.05 significance level. This demonstrates that, regardless of gender (male or female), MI is a more effective instructional approach for teaching Chemistry than the lecture method.

Discussion

The results indicating a significant difference in the mean achievement scores of students taught Chemistry using multimedia instruction (MI) compared to those taught through the lecture method (LM), with MI yielding better outcomes, highlight the effectiveness of modern teaching technologies in improving student learning. This finding is consistent with numerous studies that emphasize the advantages of multimedia in education. Multimedia instruction typically combines text, audio, video, and interactive elements, catering to diverse learning styles and engaging students more effectively than traditional lecture methods. By enhancing comprehension, retention, and active learning, multimedia tools make abstract scientific concepts more accessible and easier to grasp.

The superior achievement of students in the MI group may be attributed to the multiple channels for information processing offered by multimedia, as suggested by the Cognitive Theory of Multimedia Learning (CTML). This theory proposes that students process verbal and visual information simultaneously, allowing them to better understand and internalize complex ideas. Additionally, the interactive nature of multimedia encourages active learning, where students engage with the content, practice critical thinking, and receive immediate feedback, further boosting their academic achievement. These findings align with the work of S. Ibrahim (2019), who also found that students exposed to multimedia instruction achieved higher academic outcomes.

In contrast, the lecture method, while still widely used, often lacks the engagement and interactivity that multimedia provides. Lectures tend to be passive, with students receiving information without much opportunity for interaction or immediate feedback. This approach may not accommodate different learning preferences, as it assumes a one-size-fits-all model. Multimedia instruction, however, offers personalized learning experiences, particularly benefiting visual and kinesthetic learners.

Moreover, multimedia can make Chemistry more engaging by demonstrating complex processes through simulations and animations, which are difficult to replicate in a traditional classroom. This visual representation helps students better understand chemical reactions and processes, leading to deeper comprehension. These advantages have been supported by other studies, which report improved academic achievement, increased motivation, and greater student satisfaction with multimedia instruction compared to traditional methods. The findings of this study are consistent with those of Amosa, Yaki, Gana, and Ughovwa (2016), who observed that students taught with multimedia outperformed those taught using conventional methods. Similarly, the results align with the work of Ademola (2018), Oloyede (2019), and Oyodeji (2020), who found that students in the experimental group using multimedia instructional packages showed significant improvement in posttest scores compared to the control group.

The significant disordinal interaction between teaching methods (MI and LM) and gender on students' academic achievement in Chemistry provides valuable insights into how gender and instructional approaches influence learning outcomes. The interaction reveals that female students perform better than male students when MI is used, while both genders perform equally under the lecture method. This suggests that MI may align more closely with the learning preferences of female students, who may benefit more from the multimodal approach that multimedia offers.

Research has shown that multimedia instruction, which incorporates visual aids, videos, animations, and interactive elements, can enhance understanding and retention of complex concepts. These tools may particularly resonate with female students, who often excel in environments that emphasize visual and verbal learning. The multimodal nature of MI provides multiple avenues for engaging with content, enabling female students to process information more effectively. Additionally, multimedia instruction has been linked to increased engagement and motivation, especially in challenging subjects like Chemistry.

Conversely, the equal achievement of male and female students under the lecture method suggests that traditional, teacher-centered instruction may create a more uniform learning environment for both genders. This supports existing literature indicating that lecture methods can be effective in contexts where students rely on direct instruction to build foundational knowledge

(Abdullahi, Aishatu, and Mubarak, 2023). In such settings, where multimedia resources are limited, gender-based differences in learning styles are less likely to emerge.

Conclusion

The findings suggest that multimedia instruction significantly improves students' Chemistry achievement compared to the traditional lecture method. It can be concluded that incorporating multimedia into Chemistry education is an effective strategy for enhancing students' achievement and comprehension, emphasizing the importance of adopting modern, interactive teaching tools in the classroom.

Recommendations

1. Educators should incorporate multimedia resources, including videos, simulations, and interactive animations, into their teaching methods to boost student comprehension and engagement.
2. Professional development programs for teachers should provide training on the effective use of multimedia tools in the classroom.
3. Teaching approaches should be customized to leverage the unique strengths and learning preferences of different genders.

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