Effect of Multimedia Instruction on Secondary School Students' Acquisition of Science Process Skills in Enugu Education Zone

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Abstract
This research examined the impact of multimedia-based teaching on secondary school student's acquisition of science process skills within the Enugu Education Zone. The study was guided by two research questions while six null hypotheses were formulated and tested at 0.05 level of significance. The study was anchored on two theories namely, Cognitive Theory of Multimedia Learning (CTML) and Jerome Brunner's Theory. Pretest-posttest non-equivalent control group quasi-experimental design was employed. 1,577 Senior Secondary 2 (SS2) chemistry students in Enugu Education Zone was the target population, from which a sample of 160 students was selected. Instrument for data collection was Science Process Skills Acquisition Test (SPSAT), which was validated by three experts. The reliability of the SPSAT was determined using the Kuder-Richardson Formula 20 (KR-20) which resulted in a reliability coefficient of 0.74. 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 conventional method (CM). 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' acquisition of science process skills compared to the conventional method. Based on these findings, it was recommended that chemistry teachers, students, and curriculum developers should integrate multimedia instruction as a teaching strategy, as it has proven more effective in enhancing students' acquisition of science process skills and overall academic performance in chemistry than the conventional approach.

Keywords: *Multimedia, Instruction, Science Process Skills, Chemistry*

Introduction

Science is the harmonious symphony of curiosity, observation, experimentation and evidence-driven reasoning that orchestrates our understanding of the universe. Atkins and De Paula (2020) gave the definition of chemistry as the study of the properties, composition, and reactions of matter, with a focus on the atomic and molecular level. Chemistry is the bedrock of science and it is one of the core science subjects taught at the senior secondary school level in Nigeria (FRN, 2013). Chemistry is essential for meeting man's basic needs of feeding, clothing, shelter, health, clean air and water. It is central to many science subjects and disciplines such as medicine, pharmacy, agriculture, nursing, engineering, geology.

Science Process skills are defined as tools necessary to produce and use scientific information, perform scientific research, and solve science problems. These skills can be gained by students through science education activities (Lederman and Lederman, 2022). One of the most important and pervasive goals of schooling is to teach students to engage in critical thinking. All school subjects should share in accomplishing this overall goal. According to

Kuhn (2021), Science contributes its unique skill, with its emphasis on hypothesizing, manipulating the physical world and reasoning from data. Science is a two-way activity that involves "product" (the knowledge and outcomes of Science) and "process" (the skills and scientific procedures of investigation). The process of science involves the methods of approach employed and activities engaged in by scientists to arrive at a product (Bybee, 2022). Scientific experimentation and observation have come to be defined by the exercise of a process called the scientific method. The underlying skills and premises which govern the scientific method are referred to as science process skills.

Science process skills consist of both basic (simpler) science process skills and integrated (complex) science process skills. The basic (simpler) science process skills include observing, communicating, classifying, measuring, inferring and predicting, while the integrated (complex) science process skills are identifying and defining variables, collecting and transforming data, constructing tables, on data and graphs, describing relationships between variable, interpreting data, manipulating materials, formulating hypothesis, designing investigations, drawing conclusions, generalizing information and making operational definitions (Nwagbo and Chukelu, 2011). These skills provide the intellectual groundwork for scientific inquiry, such as the ability to describe natural objects and events.

Science process skills are fundamental techniques used to develop scientific knowledge and critical thinking. These skills enable students and researchers to design, conduct, and evaluate experiments effectively (Cakir, and Yilmaz, 2022). Science process skills are used in the experiments of scientists and students, as well as in the everyday life of an average person, to a degree. They allow everyone to conduct objective investigations and reach conclusions based on the results. The first of the science process skills, observation, involves noting the attributes of objects and situations through the use of the senses. Classification goes one step further by grouping objects or situations based on shared attributes. Measurement involves expressing physical characteristics in quantitative ways. Communication brings the first three skills together to report to others what has been found by experimentation. Inference and prediction are the more sophisticated of these skills. Beyond simply seeing and reporting results, scientists must extract meaning from them. These skills can involve finding patterns in the results of a series of experiments and using experience to form new hypotheses (Nwagbo and Chukelu, 2011). It is also essential for a scientist to be able to distinguish his objective observations from his inferences and predictions. This is because scientific inquiry and study depend on objectivity and an avoidance of hasty assumptions in experimentation.

In schools, the science curriculum focuses on the science process skills as essential tools that support the students to construct knowledge (Ongowo, 2017). For the students to comprehend science concepts, laws, principles, theory etc, it becomes essential to develop the ability to link the constructed knowledge and developed skills. Science process skills are inseparable in practice from the conceptual understanding that is involved in learning and applying science (Karamustafaogu, 2011). Realizing the importance of science process skills in solving scientific problems, the Federal Republic of Nigeria in her National Policy on Education stated that education should aim at helping the child in the acquisition of appropriate skills, abilities and competencies, both mental and physical for the individual to live in and contribute to the development of the society (FRN, 2013).

. Multimedia instruction can be defined as the combination of instructional methods that encourage learners to engage in active learning by mentally representing materials in words and pictures making connections between the pictorial and verbal representations (Clark and Mayer cited in Krishnasamy, 2016). Multimedia Instruction is also a computer-based guidance that involves the use of diverse types of media, such as presentations, web-based guides and online tutorials to convey an instructional message.

The rationale for multimedia instruction is that people can learn more deeply from words, pictures, computer generated images, graphics, animation and video clips than from words alone. The power of multimedia instruction lies in the fact that it is multi-sensory, stimulating and appealing to the many senses of the learners. It adds new dimensions to learning because concepts are easier to present and comprehend when words are complemented with images and animations (Ogunbote and Adesoye, 2016). In this vein, Mayer (2020) suggests that multimedia instruction helps learners to process information more effectively through dual coding (verbal and visual) and cognitive load management. Sweller (2010) argues that multimedia instruction can reduce cognitive overload by breaking down complex information into smaller, more manageable chunks. Clark and Mayer (2016) propose that multimedia instruction can facilitate learning by providing a more engaging and interactive learning environment, which can lead to increased motivation and attention. It began with the publication of Cornenius' Orbis Pictus (The World in Pictures) in the 1600s; and has progressed to a wide array of computer-based multimedia learning experiences that are available anytime and anywhere.

According to Udosoro (2011), gender is a cultural construct that distinguishes the roles, behaviour, and mental and emotional characteristics between males and females developed by society. Gender in science is the classification of roles males and females play in science. There have been contrasting opinions on gender-related issues on acquisition of science process skills. Several studies carried out to investigate whether gender affects acquisition of science process skills in science and chemistry in particular reported contradictory findings 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. Mutekwe and Modiba (2011) stated that prejudicial and biased teacher attitudes and expectations and persistent cultural myths, misconceptions and stereotypes constrain female students' aspirations to continue with science education. The authors concluded that the contributing factors for gender inequity include early childhood environment, family expectations, societal image, gender stereotypes, school environment and gender issues while some researchers such as Kessels (2015), and Bubany (2011) found differences in cognitive skills with females out performing males in certain tasks. Hedges (2015) found that males on average are disadvantaged in reading and writing skills. They found that females slightly out performed males in tests of reading, comprehension, and associative memory, on the other hand, males slightly out performed females in the tests of science subjects.

Given these inconsistent findings, further research is needed to determine whether gender influences acquisition of science process skills when multimedia instruction is used.

Purpose of the Study

The aim of this research was to examine the impact of multimedia-based teaching on the acquisition of science process skills by secondary school students within the Enugu Education Zone. Specifically, the study sought to:

1. Compare the average science process acquisition scores of students taught chemistry through multimedia instruction with those taught using the conventional method.
2. Assess the science process acquisition scores of male and female students taught chemistry via multimedia instruction versus those taught using conventional approaches.
3. Investigate the interaction between teaching methods and gender in influencing students' acquisition of science process skills.

Research Questions

1. What are the mean science process skill scores of students taught chemistry using multimedia instruction and that of those taught using conventional method?
2. What are the mean science process skill scores of male and female students taught chemistry using multimedia instruction and that of those taught using conventional method?

Hypotheses

1. There is no statistically significant difference in the average science process skills scores of students who were taught chemistry using multimedia instruction compared to those taught with the conventional method.
2. There is no statistically significant difference in the average science process skill scores of male and female students who were taught chemistry using multimedia instruction versus those taught with the conventional method.
3. There is no significant interaction effect between instructional methods (multimedia instruction and conventional method) and gender on students' acquisition of science process skill 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 Science Process Skills Acquisition Test (SPSAT) was adapted from Science Process Skills Acquisition Test developed by Mbonu (2019). The original copy was based on Electrolysis lesson and was modified by the researcher to suit the purpose of the study and the lesson plan prepared for the study. It has two sections A and B. Section A is on students' personal data while section B contains 20 Science process skill acquisition tests with four options, A, B C, and D. The SPSAT was used for both the pre-test and the post-test to collect data on science process skill acquired by the students. A table of specifications (TOS) guided the selection of questions. In scoring of the instrument, each correct answer got 1 point while 0 was scored to a question not answered correctly or any question not answered at all. The maximum score for all the 20 questions was 20 and the minimum score was 0.

The SPSAT was validated by three experts: one from the Department of Science Education and two from the Department of Education Foundations all at Nnamdi Azikiwe University, Awka. The reliability of the SPSAT was determined using the Kuder-Richardson Formula 20 (KR-20), yielding a reliability coefficient of 0.74.

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

Stage 1: Pre-treatment

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

Stage 2: Treatment
The 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 traditional 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 science process skills scores of students taught chemistry using multimedia instruction and that of those taught using conventional method?
Table 1: Mean Process Skills Scores of Students taught Chemistry using Multimedia Instruction (MI) and Convention Method (CM)

Group	*N*	Pretest Mean	Pretest *SD*	Posttest Mean	Posttest *SD*	Gained Mean
MI	86	4.37	1.76	15.29	1.91	10.92
CM	74	4.70	2.09	10.68	2.87	5.98

Table 1 shows that students taught Chemistry using multimedia instruction had pretest mean science process skills score of 4.37 and posttest mean science process skills score of 15.29 with gained mean science process skills score of 10.92, while those taught chemistry using conventional method had pretest mean science process skills score of 4.70 and posttest mean science process skills score of 10.68 with gained mean science process skills score of 5.98. Students taught Chemistry using MI had a more homogeneous score in their pretest with a standard deviation of 1.76 than those taught using CM who had standard deviation of 2.09. In the posttest also, students taught Chemistry using MI had a more homogeneous score with a standard deviation of 1.91 than those taught using CM who had standard deviation of 2.87.

Research Question 2: What are the mean science process skills scores of male and female students taught chemistry using multimedia instruction and that of those taught using conventional method?

Table 2: Mean Process Skills Scores of Male and Female Students taught Chemistry using Multimedia Instruction (MI) and Conventional Method (CM)

Method	Gender	*N*	Pretest Mean	Pretest *SD*	Posttest Mean	Posttest *SD*	Gained Mean
MI	Male	41	4.17	1.82	15.34	1.83	11.17
	Female	45	4.56	1.71	15.24	2.00	10.68
CM	Male	24	4.33	2.18	10.71	3.24	6.38
	Female	50	4.88	2.05	10.66	2.71	5.78

Table 2 shows that the male students taught Chemistry using MI had pretest mean science process skills score of 4.17 and posttest mean science process skills score of 15.34 with a gain in mean science process skills scores of 11.17 while the female students had pretest mean science process skills score of 4.56 and posttest mean science process skills score of 15.24 with gain in mean achievement scores of 10.68. Table 2 also reveals that the male students taught Chemistry using CM had pretest mean science process skills score of 4.33 and posttest mean science process skills score of 10.71 with a gain in mean science process skills scores of 6.38 while the female students had pretest mean science process skills score of 4.88 and posttest mean science process skills score of 10.66 with gain in mean achievement scores of 5.78. Male students taught Chemistry using MI had higher mean gain science process skills score than those taught using CM and also, female students taught Chemistry using MI had higher mean gain science process skills score than the female students taught using CM.

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

Table 3: ANCOVA Test of Significance of Difference in the Mean Science Process Skills Score of Students taught Chemistry using MI and CM

Source	SS	df	Mean Square	F	Sig.	Decision
Corrected Model	924.589[a]	4	231.147	43.036	.000	
Intercept	3085.811	1	3085.811	574.532	.000	
Pretest	77.204	1	77.204	14.374	.000	
Method	812.246	1	812.246	151.228	.000	Sig.
Gender	2.156	1	2.156	.401	.527	Not Sig.
Method * Gender	.001	1	.001	.000	.989	Not Sig.
Error	832.505	155	5.371			
Total	29451.000	160				
Corrected Total	1757.094	159				

Table 3 shows that there is a significant main effect of the treatment on students' science process skills in Chemistry, $F(1, 155) = 151.228$, $P =.000 < 0.05$. Hence, the null hypothesis is rejected meaning that there is a significant difference between the mean science process skills scores of students taught chemistry using multimedia instruction and that of those taught using conventional method in favour of multimedia instruction.

Hypothesis 2: A significant difference does not exist in the mean science process skills acquisition of male and female students taught chemistry using multimedia instruction and that of those taught using conventional method.

Table 3 also shows that there is no significant main influence of gender on students' science process skill acquisition in Chemistry, F(1, 155) = 0.401, P =.527 > 0.05. Hence, the null hypothesis was not rejected meaning that there is no significant difference between the mean science process skills acquisition of male and female students taught chemistry using multimedia instruction and that of those taught using conventional method.

Hypothesis 3: There is no interaction effect of instructional methods (multimedia instruction and conventional method) and gender on students' acquisition of science process skills.
Table 5 further shows that there is no significant interaction effect of the instructional methods and gender on students' acquisition of science process skills in Chemistry, F(1, 155) = 0.000, P =.989 > 0.05. Hence, the null hypothesis was not rejected meaning that there is no interaction effect of instructional methods (multimedia instruction and conventional method) and gender on students' acquisition of science process skills.

Discussion

The findings of the study indicated a significant difference in the mean science process skills (SPS) scores of students taught chemistry using multimedia instruction and those taught through conventional methods, favoring multimedia instruction. This result highlights the transformative potential of multimedia tools in enhancing students' understanding and application of science process skills. These skills, including observing, predicting, inferring, experimenting, analysing, and interpreting data, are critical for success in science education. Multimedia instruction offers dynamic and interactive learning experiences that make abstract chemistry concepts more tangible and relatable. By incorporating animations, simulations, and visualizations, multimedia tools can illustrate complex phenomena like molecular interactions and chemical reactions in ways that static lectures cannot achieve. Such visual and auditory enhancements cater to diverse learning styles, particularly for visual and kinesthetic learners, facilitating deeper comprehension and retention. This aligns with constructivist learning theories, which advocate for active engagement and multisensory learning as a means to construct meaningful knowledge.

On the other hand, conventional methods often emphasize rote memorization and passive listening, limiting opportunities for students to develop critical thinking and investigative skills. The conventional approach may not adequately support the inquiry-based learning processes required to master SPS, as it generally lacks the interactivity and exploratory components integral to science education. The observed effectiveness of multimedia instruction could also stem from its ability to simulate real-world scientific processes, offering virtual laboratories where students can manipulate variables and observe outcomes without the constraints of physical resources. This experiential learning fosters curiosity and problem-solving, which are essential to developing SPS. Moreover, multimedia environments often incorporate gamified elements, quizzes, and feedback loops, which sustain student engagement and provide immediate reinforcement, enhancing the learning process.

The findings of the study aligns with the findings of Serin (2011) that there was a statistically significant increase in the achievements and problem-solving skills of students in the experimental group that received computer-based science and technology instruction. The findings of the study also support the findings of Satyaprakasha and Behere (2014) there was a significant difference between the experimental and control group in process skill in biology concerning observation, generalization, interpretation, inference and prediction and total process skill in biology as compared to the conventional method. The finding of the study lends credence to the study of Ejelibe and Nnamonu (2023) that there was a significant difference in the mean science process skills acquisition scores of subjects exposed to games than those exposed to conventional method.

The superior performance 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 performance. 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 conventional method, while still widely used, often lacks the engagement and interactivity that multimedia provides. Conventional approach tends 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.

The finding that gender does not significantly influence the acquisition of science process skills in chemistry suggests that both male and female students have equal potential to develop and apply skills such as observation, classification, and experimentation, regardless of their gender. This aligns with the universality of basic science process skills development across genders, which is largely influenced by the methods and environment in which the instruction occurs, rather than by inherent gender differences. Furthermore, this finding can be seen as an indication that science process skills, particularly in a subject like chemistry, are more influenced by teaching strategies, teacher competence, and student motivation than by gender. The findings of the study is in line with the findings of Mbonu-Adigwe, Eya, Umate, and Attah (2021) that MII is more effective in fostering basic science students' acquisition of Science Process Skills than the conventional method irrespective of gender.

Conclusion

The significant difference in science process skills (SPS) scores between students taught chemistry using multimedia instruction and those taught through the conventional method highlights the effectiveness of multimedia in fostering critical skills. It can be concluded that multimedia instruction provides an interactive and engaging environment that supports active learning, enabling students to visualize complex concepts, conduct virtual experiments, and practice real-world scientific applications. The approach aligns with constructivist theories, which emphasize experiential and inquiry-based learning, making it more effective for developing SPS such as observation, analysis, and experimentation. The study also concludes that incorporating multimedia tools into the curriculum enhances not only academic performance but also equips students with practical skills applicable to scientific and technological careers. This finding calls for investments in multimedia resources, teacher training, and curriculum reform to ensure that education remains relevant, inclusive, and future-oriented. Thus, multimedia instruction has a transformative potential for science education and these findings suggest the need for its wider adoption to enhance students' acquisition of science process skills and learning experiences.

Recommendations

1. Teacher professional development should include training on how to effectively utilize multimedia in teaching. Educators should be equipped with the skills to create or select appropriate multimedia content and use it to support various learning styles, fostering a more interactive and student-centered classroom environment.

2. Schools should encourage a blend of multimedia instruction and conventional methods. Blended learning can leverage the strengths of both, providing students with opportunities for independent learning through multimedia while maintaining the structure and support of face-to-face instruction.
3. Focus should be placed on providing equitable opportunities for skill development in science process skills, regardless of gender. The lack of significant gender differences in science process skills suggests that instructional strategies need to ensure equal participation and practice opportunities for all students. Ensuring gender neutrality in educational processes could help bridge any existing achievement gaps in skills acquisition.

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