

Effect of Animated-Media Instruction on Secondary School Students' Acquisition of Science Process Skills in Chemistry

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Abstract

The study investigated the effect of animated-media instruction (AMI) on secondary school students' acquisition of science process skills in Chemistry in Nnewi Education Zone, Nigeria. The study was guided by two research questions and three hypotheses tested at 0.05 significance level. The study employed the quasi-experimental research design. The population comprised 2,023 senior secondary school two (SS2) Chemistry students, from which a sample of 73 students was drawn using purposive and random sampling techniques. Data were collected using the Science Process Skills Acquisition Test (SPSAT) which was validated by three experts and with reliability coefficient of 0.94 determined using Kuder-Richardson Formula 20. The experimental group was taught using animated-media instruction, while the control group received teacher demonstration method. Results from pretest and posttest analyses (using mean, standard deviation, and ANCOVA) showed that AMI significantly improved students' acquisition of science process skills compared to the teacher demonstration method. Gender had a significant influence on students' acquisition of science process skills. There was no significant interaction effect of instructional strategies and gender on students' acquisition of science process skills. It was concluded that AMI is more effective than teacher demonstration method in enhancing students' acquisition of science process skills as it actively engages them through dynamic visual representations, aligning with broader research that emphasizes interactive, student-centered learning for developing scientific inquiry skills. The study recommended among others that, teachers of Chemistry should be trained and encouraged to implement animated-media instruction as a core instructional strategy to enhance students' acquisition of science process skills in Chemistry learning.

Keywords: Chemistry, science process skills, animated-media instruction, gender, secondary school

Introduction

The rapid advancement of technology and the increasing reliance on digital tools in every facet of life have underscored the critical importance of integrating innovative instructional media in education, particularly for developing essential scientific competencies required for meaningful participation in the 21st-century knowledge economy. In Nigeria, the introduction of Chemistry into the secondary school curriculum was intended to address this need by preparing students with practical skills for scientific inquiry and technological advancement. Perhaps, despite these efforts, secondary school students in Nigeria, particularly in Nnewi Education Zone of Anambra State, continue to exhibit low levels of acquisition of science process skills in Chemistry. Science process skills (SPS) are essential cognitive abilities that

enable students to engage with scientific concepts through hands-on experimentation and inquiry (Ugwuanyi & Nwafor, 2019). According to Olayinka (2019), SPS is broadly categorized into basic skills and integrated skills. Basic skills include observation, classification, measurement, and inference, which involve using the senses to gather information, grouping objects based on shared characteristics, using appropriate tools to quantify phenomena, and drawing conclusions based on observations. Integrated skills, on the other hand, involve the application of higher-level cognitive processes such as predicting, hypothesizing, experimenting, and analyzing data (Nnaji, 2020). Predicting involves making informed guesses about future events based on existing data, while hypothesizing proposes explanations that can be tested through experiments. Experimenting involves testing hypotheses under controlled conditions, and analyzing data involves interpreting results to draw valid conclusions. The development of these skills in Nigerian schools, especially through hands-on learning approaches, has been shown to improve students' grasp of Chemistry concepts, yet many students continue to struggle with mastering these foundational competencies. The persistent unsatisfactory acquisition of science process skills among secondary school students in Chemistry has been attributed to various factors, including inadequate laboratory facilities, insufficient qualified teachers, and the predominance of traditional teaching methods such as teacher demonstration and lecture-based approaches, which fail to foster critical thinking, problem-solving, and the practical application of knowledge in Chemistry (Okoro & Onyeka, 2022). The teacher demonstration method, according to Yusrida (2014), is an instructional approach in which the teacher actively performs an experiment, process, or procedure in front of the students while explaining each step. While this method allows students to observe and understand scientific concepts, one limitation is that it may not fully engage students in hands-on learning, which is essential for skill acquisition and the development of scientific inquiry skills. In contrast, innovative teaching strategies like the integration of animated-media could improve students' engagement and performance in science subjects, as animation provides dynamic visuals that simulate processes, demonstrate interactions, and elucidate structures, thereby making learning more interactive and engaging. Animated-media instruction according to Falode and Mohammed (2023) involves the use of audio-visual aids in the form of motion images to support teaching and enhance learning outcomes. The goal of animated-media instruction is to use animation-media tools to make abstract concepts more tangible, engaging, and easier to understand, especially in complex subjects like Chemistry. In teaching Chemistry, animated-media instruction can demonstrate intricate processes such as molecular interactions, chemical reactions, or laboratory procedures that may be difficult to visualize through traditional methods (McElhaney, Chang, Chiu and Linn, 2022). For example, in Chemistry, animations can be employed to show how molecules collide and bond during a reaction or to visualize the three-dimensional structure of compounds. This approach not only simplifies complex topics but also helps students retain knowledge more effectively by linking abstract theories to relatable and visually engaging content. Empirical evidence highlights the efficacy of animated-media instruction in improving student engagement and comprehension, particularly in science subjects like Chemistry. For instance, Ibrahim (2016) examined the effects of multimedia instructional strategies on Chemistry students' science process skills acquisition and achievement in Kano State and found that multimedia instructional strategy improved both the acquisition of science process skills and academic achievement better than the conventional laboratory method. Similarly, Mbonu-Adigwe, Eya, Bukar and Attah (2021) investigated the effect of multimedia integrated instruction on students' acquisition of science process skills in Basic science in Anambra State and revealed that multimedia integrated instruction is more effective in fostering students' acquisition of science process skills than the conventional method irrespective of gender. Furthermore,

Yanarates (2022) examined the effect of animated teaching on science teachers candidates' Chemistry achievement and learning persistence and concluded that animated teaching is an effective teaching method for improving academic achievement. These findings collectively suggest that animated-media instruction holds significant potential for enhancing science process skills acquisition in Chemistry and reducing the gender gaps in science studies including Chemistry. The influence of gender on students' acquisition of science process skills has been a subject of research in Nigeria, with studies showing both significant and non-significant effects. Gender refers to the social, cultural, and behavioural roles, characteristics, and expectations that societies attribute to individuals based on their perceived biological sex. In the context of education, gender has been shown to influence students' attitudes, interests, and performance in science subjects, including Chemistry (Ogunleye, 2017). Gender-related differences in learning outcomes often stem from cultural expectations, societal roles, and educational practices that shape students' engagement with science subjects. In some studies, gender has shown a significant influence on the acquisition of science process skills, particularly in terms of the ways male and female students approach problem-solving, observation, and experimentation. For instance, Ekon and Eni (2015) investigated gender and acquisition of science process skills among junior secondary school students in Calabar Municipality and found that gender did not significantly influence the acquisition of science process skills at the upper basic level. However, Okeke (2016) examined the effects of instructional computer animation on secondary school students' achievement and interest in Chemistry in Awka Education Zone and found that female students performed better than their male counterparts. Chikendu (2018) similarly reported that female students performed better than male students taught using instructional computer animation, implying that instructional computer animation enhances students' achievement and interest in Chemistry. These contrasting findings highlight the complex interaction between gender and science education, suggesting that while gender can influence the acquisition of science process skills, its impact may be mediated by factors such as teaching methods and classroom environment. Given these mixed findings, there is a need to further investigate the moderating effect of gender on the effectiveness of animated-media instruction in Chemistry education within the specific context of Nnewi Education Zone.

The situation in Nnewi Education Zone of Anambra State, Nigeria, underscores the urgency of addressing these educational challenges, namely poor acquisition of science process skills in Chemistry. Despite efforts by the state government to improve learning outcomes through various initiatives, many secondary school students continue to struggle with achieving satisfactory levels of science process skills acquisition in Chemistry. The persistence of this issue raises questions about the effectiveness of current instructional practices and highlights the need for evidence-based interventions to improve teaching and learning in this subject area. Animated-media instruction has emerged as a compelling potential solution to this instructional shortfall, offering dynamic and visually engaging representations of complex scientific concepts that could enhance both engagement and comprehension. Despite this promise, there is a notable scarcity of research on the specific effectiveness of animated-media instruction in the Nigerian context, particularly within the Nnewi Education Zone. Therefore, this study sought to investigate the effect of animated-media instruction on secondary school students' acquisition of science process skills in Chemistry in Nnewi Education Zone, while also examining the moderating role of gender.

Purpose of the Study

The purpose of the study was to determine the effect of animated-media instruction on secondary school students' acquisition of science process skills in Chemistry in Nnewi Education Zone. Specifically, the study sought to determine the:

1. Mean science process skills acquisition scores of students taught Chemistry using animated-media instruction (AMI) and those taught using teacher demonstration method (TDM).
2. Mean science process skills acquisition scores of male and female students taught Chemistry using AMI and those taught using TDM.
3. Interaction effect of instructional strategies (AMI and TDM) and gender (male and female) on students' acquisition of science process skills in Chemistry.

Research Questions

1. What are the mean science process skills acquisition scores of students taught Chemistry using animated-media instruction (AMI) and those taught using teacher demonstration method (TDM)?
2. What are the mean science process skills acquisition scores of male and female students taught Chemistry using AMI and those taught using TDM?

Hypotheses

1. There is no significant difference between the mean science process skills acquisition scores of students taught Chemistry using AMI and those taught using TDM.
2. There is no significant difference between the mean science process skills acquisition scores of male and female students taught Chemistry using AMI and those taught using TDM.
3. There is no interaction effect of instructional strategies (AMI and TDM) and gender (male and female) on students' acquisition of science process skills in Chemistry.

Method

The study adopted the quasi-experimental design; specifically, the pretest-posttest non-randomized control group design was used. The study was conducted in Nnewi Education Zone, Anambra State, Nigeria. The population of the study comprised 2,023 senior secondary year two (SS2) students offering Chemistry in the Zone. The sample size for the study was 73 SS2 students offering Chemistry in Nnewi Education Zone obtained through purposive and random sampling techniques. Two schools were purposively selected based on having well-equipped computer laboratories and co-educational status, then randomly assigned to experimental and control groups. The control group had 36 students (19 males and 17 females), while the experimental group had 37 students (21 males and 16 females).

The instrument for data collection was Science Process Skills Acquisition Test (SPSAT) adopted from Avwiri (2021). The SPSAT comprised sections on titration experiments and preliminary and confirmatory tests for salts, designed to evaluate students' acquisition of science process skills including observation, recording, experimentation, calculation, communication, measurement, inference, and hypothesis formulation. The instrument was validated by three experts in the Departments of Science Education and Educational Foundations (Measurement and Evaluation Unit) at Nnamdi Azikiwe University, Awka. The validators examined the instruments for clarity, ambiguity, and suitability for the level of the students under study. The reliability of SPSAT was determined using the Kuder-Richardson Formula 20 (KR-20), which yielded a reliability coefficient of 0.94.

The experiment was conducted in two phases. In the first phase, research assistants who were the regular SS2 Chemistry teachers in the experimental schools received training lasting one week. The second phase involved the implementation of the treatment. Students in the experimental group were taught using animated-media instruction, and the control group was taught using the teacher demonstration method. The SPSAT was administered as pretest before the commencement of the treatment. After the teaching, SPSAT was administered

again as posttest. Data relating to research questions was analyzed using mean and standard deviation, while data pertaining to hypotheses was analyzed using analysis of covariance (ANCOVA) at 0.05 level of significance.

Results

Table 1: Mean Science Process Skills Acquisition Scores of Students taught Chemistry using Animated-media Instruction (AMI) and Teacher Demonstration Method (TDM)

Group	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD	Gained Mean
AMI	37	56.16	4.77	82.84	5.70	26.68
TDM	36	54.67	5.97	70.94	4.21	16.27

Table 1 shows that students taught Chemistry using animated-media instruction had pretest mean science process skills acquisition score of 56.16 and posttest mean science process skills acquisition score of 82.84 with gained mean science process skills acquisition score of 26.68, while those taught with chemistry using teacher demonstration method had pretest mean science process skills acquisition score of 54.67 and posttest mean science process skills acquisition score of 70.94 with gained mean science process skills acquisition score of 16.27. Students taught Chemistry using AMI had a less homogeneous score in their pretest (4.47) than those taught using TDM (5.97). In the posttest however, students taught Chemistry using AMI had a less more homogeneous score (5.70) than those taught using TDM (4.21).

Table 2: Mean Science Process Skills Acquisition Scores of Students taught Chemistry using Animated-media instruction (AMI) and Teacher demonstration method (TDM)

Method	Gender	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD	Gained Mean
AMI	Male	21	56.19	4.09	84.43	5.19	28.26
	Female	16	56.12	5.68	80.75	5.83	24.63
TDM	Male	19	53.95	5.39	71.84	4.30	17.89
	Female	17	55.47	6.63	69.94	3.99	14.47

Table 2 shows that the male students taught Chemistry using AMI had pretest mean science process skills acquisition score of 56.19 and posttest mean science process skills acquisition score of 84.43 with a gain in mean science process skills acquisition scores of 28.26 while the female students had pretest mean science process skills acquisition score of 56.12 and posttest mean science process skills acquisition score of 80.75 with gain in mean t scores of 24.63. Table 4.3 also reveals that the male students taught Chemistry using TDM had pretest mean science process skills acquisition score of 53.95 and posttest mean science process skills acquisition score of 71.84 with a gain in mean science process skills acquisition scores of 17.89 while the female students had pretest mean science process skills acquisition score of 55.47 and posttest mean science process skills acquisition score of 69.94 with gain in mean scores of 14.47. Male students taught Chemistry using AMI had higher mean gained science process skills acquisition score than those taught using TDM and also, female students taught Chemistry using AMI had higher mean gained science process skills acquisition score than the female students taught using TDM.

Table 3: ANCOVA Test of Significance of Difference in the Mean Science process skills acquisition Score of Students taught Chemistry using AMI and TDM

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2780.414 ^a	8	347.552	13.976	.000
Intercept	3270.379	1	3270.379	131.511	.000
Pretest	8.402	1	8.402	.338	.563
Method	2149.571	1	2149.571	86.440	.000
Gender	147.493	1	147.493	5.931	.018
TSR	10.799	1	10.799	.434	.512
Meth * Gen	12.395	1	12.395	.498	.483
Meth * TSR	19.572	1	19.572	.787	.378
Gen * TSR	3.812	1	3.812	.153	.697
Meth * Gen * TSR	1.534	1	1.534	.062	.805
Error	1591.531	64	24.868		
Total	436881.000	73			
Corrected Total	4371.945	72			

Table 3 shows that there is a significant main effect of the treatment on students' science process skills acquisition in Chemistry, $F(1, 64) = 86.440$, $P = .000 < 0.05$. Therefore, the null hypothesis is rejected meaning that there is a significant difference in the mean science process skills acquisition scores of students taught Chemistry using AMI and those taught using TDM. in favour of AMI. Table 3 also shows that there is a significant main influence of gender on students' science process skills acquisition in Chemistry, $F(1, 64) = 5.931$, $P = 0.018 < 0.05$. Therefore, the null hypothesis is rejected meaning that there is a significant difference in the mean science process skills acquisition scores of male and female students taught Chemistry using AMI and those taught using TDM. Table 3 further shows that there is no significant interaction effect of the instructional methods and gender on students' science process skills acquisition in Chemistry, $F(1, 64) = 0.496$, $P = 0.483 > 0.05$. Therefore, the null hypothesis was not rejected meaning that there is no interaction effect of instructional strategies (AMI and TDM) and gender (Male and Female) on students' acquisition of science process skills in Chemistry.

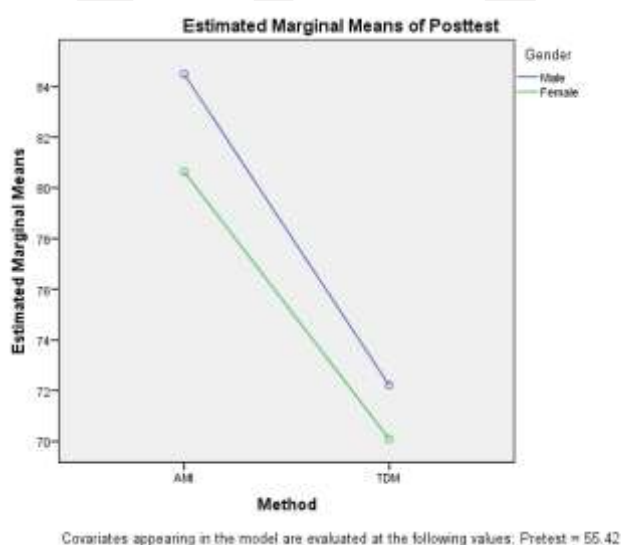


Figure 1: Plot of Interaction Effect of Teaching Method and Gender on Students' Science Process Skills Acquisition

The plot of interaction effect of instructional methods and gender on students' science process skills acquisition scores in Chemistry as shown in Figure 1 is non-significant and ordinal. This shows that the instructional methods had similar effect with respect to gender as males had higher science process skills score in AMI than females and there same was observed among students in DTM. The methods are therefore gender-biased.

Discussion

The finding that there is a significant difference between the mean science process skills acquisition scores of secondary school students taught Chemistry using animated-media instruction (AMI) and those taught using teacher demonstration method (TDM), in favour of AMI, highlights the effectiveness of interactive, student-centered instruction over traditional didactic approaches. This suggests that AMI creates a more engaging and meaningful learning environment, where students actively construct knowledge, observe dynamic visual representations of chemical processes, and apply scientific concepts through realistic simulations. The superiority of AMI can be attributed to its ability to visualize abstract chemical phenomena at the molecular level, slow down or speed up complex reactions for clarity, and consistently present perfect experimental procedures, thereby allowing students to focus on process and analysis rather than potential inconsistencies of live demonstration. Such experiential learning not only deepens conceptual understanding but also fosters higher-order thinking skills, leading to improved acquisition of science process skills such as observation, classification, measurement, prediction, and communication. In contrast, the teacher demonstration method, which often involves passive observation of teacher-performed experiments, appears less effective in promoting mastery of practical and theoretical components of Chemistry. This finding is strongly supported by existing research across various educational contexts. Ibrahim (2016) examined the effects of multimedia instructional strategies on Chemistry students' science process skills acquisition and achievement in Kano State and found that multimedia instructional strategy improved both the acquisition of science process skills and academic achievement better than the conventional laboratory method. The study concluded that the interactive nature of multimedia fosters deeper cognitive engagement, enabling students to apply theoretical knowledge to practical scenarios. Similarly, Mbonu-Adigwe, Eya, Bukar and Attah (2021) investigated the effect of multimedia integrated instruction on students' acquisition of science process skills in Basic science in Anambra State and revealed that multimedia integrated instruction is more effective in fostering students' acquisition of science process skills than the conventional method. Their research reinforces the premise that combining visual and auditory elements through technology creates a multisensory learning environment conducive to skill mastery. Furthermore, Yanarates (2022) examined the effect of animated teaching on science teachers' candidates' Chemistry achievement and learning persistence and concluded that animated teaching is an effective teaching method for improving academic achievement. Collectively, these studies affirm that animated-media instruction represents a transformative pedagogical approach that consistently outperforms traditional demonstration methods in building the foundational skills necessary for scientific thought and experimentation.

The finding that there is a significant difference between the mean science process skills acquisition scores of male and female students taught Chemistry using AMI and TDM indicates that gender plays a role in how students benefit from instructional strategies. However, the finding that there is no significant interaction effect between instructional strategies and gender suggests that while gender independently influences science process skills acquisition, the effectiveness of AMI relative to TDM is consistent across both male and female students. This implies that AMI is equally effective for both genders, though male and female students may have different baseline levels of skill acquisition. The absence of

interaction effect is particularly powerful as it indicates that AMI serves as an equitable pedagogical intervention that elevates the entire cohort's capability for scientific inquiry without preferentially benefiting one gender over another. These findings are corroborated by previous research. Ekon and Eni (2015) investigated gender and acquisition of science process skills among junior secondary school students in Calabar Municipality and found that gender did not significantly influence the acquisition of science process skills, suggesting that observed differences are attributable to instructional exposures rather than innate capabilities. However, Okeke (2016) examined the effects of instructional computer animation on secondary school students' achievement and interest in Chemistry and found that female students performed better than their male counterparts. Similarly, Chikendu (2018) reported that female students performed better than male students taught using instructional computer animation. The current study's finding of significant gender main effect but no interaction effect suggests that when an intentionally designed and effective method like AMI is implemented, it serves as a tool that benefits all students while acknowledging existing gender differences in baseline skill levels.

Conclusion

The findings indicate that animated-media instruction (AMI) significantly enhances students' acquisition of science process skills in Chemistry compared to the traditional teacher demonstration method. This suggests that active, technology-enhanced instructional strategies are more effective for improving students' scientific inquiry skills in Chemistry. Furthermore, while gender independently influences science process skills acquisition, AMI demonstrates equitable effectiveness for both male and female students, with no significant interaction between instructional strategy and gender. Animated-media instruction is therefore conclusively established as a more effective pedagogical method than teacher demonstration for fostering science process skills in Chemistry, with its efficacy holding true across gender groups.

Recommendations

Based on the findings of the study, the following recommendations are made:

1. Teachers of Chemistry should be trained and encouraged to implement animated-media instruction (AMI) as a core instructional strategy to enhance students' acquisition of science process skills and engagement in Chemistry learning.
2. Teacher training programs should incorporate instruction on the effective pedagogical use of animated media to maximize student acquisition of science process skills, with emphasis on its gender-neutral efficacy to encourage equitable adoption in all Chemistry classrooms.
3. Chemistry teachers and educators should implement animated-media instruction in teaching Chemistry to promote gender-inclusive learning and ensure equal academic opportunities for both male and female students.
4. Students of Chemistry should utilize animation videos available on the internet to aid their learning and improve their science process skills in Chemistry.

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