Effect of Animated-Media Instruction and Influence of Teacher-Student Relationship on Secondary School Students' Acquisition of Science Process Skills in Chemistry

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https://doi.org/10.56201/ijccp.vol.12.no6.2026.pg1.10

Abstract
The study investigated the effect of animated-media instruction (AMI) on secondary school students' acquisition of science process skills in Chemistry, moderated by teacher-student relationship (TSR) in Nnewi Education Zone, Nigeria. Guided by two research questions and three hypotheses tested at 0.05 significance level, the quasi-experimental design was employed. 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) and Teacher-Students' Relationship Scale (TSRS), validated by three experts, with reliability coefficients of 0.94 for SPSAT using KR-20 and 0.90 for TSRS using Cronbach's Alpha. 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 teacher demonstration method regardless of TSR level. There was no significant difference in science process skills acquisition between students with high and low teacher-student relationship, and no significant interaction effect between instructional strategies and TSR. It was concluded that AMI is a robust instructional strategy whose effectiveness for enhancing science process skills operates independently of the quality of teacher-student relationship, making it particularly valuable in diverse classroom contexts. The study recommended among others that school administrators should prioritize institutional adoption of animated-media instruction as a core pedagogical strategy to ensure equitable skill acquisition for all learners irrespective of individual teacher-student rapport.

Keywords: *Chemistry, science process skills, animated-media instruction, teacher-student relationship, secondary school*

Introduction

The quality of science education remains a fundamental determinant of national technological advancement and economic development, particularly in developing nations like Nigeria where Chemistry education serves as a cornerstone for innovations in pharmaceuticals, agriculture, and energy sectors. Chemistry, as a branch of science, involves the study of matter, its composition, properties, and transformations (Timberlake, 2024), and is a core subject in the Nigerian secondary school curriculum essential for students aspiring to careers in medicine, engineering, and other science-related fields. However, the acquisition of essential science process skills such as observation, classification, measurement, experimentation, and inference among secondary school students in Nigeria, particularly in Nnewi Education Zone of Anambra State, remains a significant concern in educational research, with studies showing that many students lack proficiency in these foundational competencies necessary for effective scientific inquiry. Science process skills (SPS) are the cognitive and procedural abilities that enable learners to conduct scientific investigations effectively, facilitating the development of critical thinking, problem-solving, and practical knowledge (Avwiri and Okoli, 2021). According to Nnaji (2020), integrated skills involve the application of higher-level cognitive processes such as predicting, hypothesizing, experimenting, and analyzing data, which are crucial for conducting scientific investigations and formulating solutions to real-world problems. The acquisition of these SPSs equips students with the tools needed to explore scientific phenomena, draw evidence-based conclusions, and solve problems systematically. Obiageli et al. (2019) showed that students often struggle with mastering the practical components of science subjects, including Chemistry, which are essential for understanding scientific concepts and applying them in real-life contexts. One of the primary reasons for the poor acquisition of science process skills according to Okoro and Ugwoke (2021) is the inadequate availability and use of laboratory resources, which limits students' exposure to essential skills. This challenge calls for innovative instructional approaches that can simulate laboratory experiences and provide students with opportunities to develop science process skills even in resource-constrained environments. Animated-media instruction has emerged as a transformative pedagogical approach that utilizes computer-generated animations, graphics, and audio to enhance students' understanding of abstract concepts, especially those that are otherwise challenging to visualize through traditional teaching methods (Jeetha and Prasad, 2021). In teaching Chemistry, animations 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). The theoretical underpinnings of animated-media instruction are deeply rooted in Mayer's Theory of Multimedia Learning, which posits that individuals learn better when information is presented through both visual and auditory channels. Mayer (2009) outlined several principles including the multimedia principle (learning is enhanced when information is presented through both text and relevant visuals) and the modality principle (visuals should be accompanied by spoken words rather than written text to reduce cognitive load). Empirical evidence from Nigeria supports the efficacy of this approach, as Beichumila (2022) carried out a study on students' acquisition of science process skills in Chemistry through computer simulations and animations in secondary schools in Tanzania and found that teachers who effectively incorporated computer simulations in their lessons significantly contributed to students' engagement and the development of higher-order science process skills. Similarly, Avwiri (2022) studied effects of sequential usage of four teaching methods on secondary school students' Chemistry achievement and acquisition of science process skills in Delta State and found that students taught using sequences incorporating innovative methods showed the highest gain in mean science process skills scores. Okafor (2022) examined enhancing science process skills acquisition in Chemistry among secondary school students through context-based learning and concluded that context-based learning had significant effect on students' integrated science process skills. These findings collectively establish that technology-mediated instruction holds substantial promise for improving science process skills acquisition. The teacher-student relationship is a critical variable that influences students' acquisition of science process skills, referring to the emotional, cognitive, and social connections formed between teachers and students within the educational context (Hughes and Imms, 2021). According to Pianta, Hamre and Allen (2020), positive teacher-student relationships are characterized by high levels of trust and open communication, which create a conducive learning environment that fosters student engagement and motivation. Conversely, poor teacher-student relationships can lead to disengagement, low self-esteem, and poor academic performance. The quality of the teacher-student relationship may significantly moderate how students respond to innovative instructional strategies such as animated-media instruction. For instance, Eze and Nwankwo (2023) highlighted that positive teacher-student relationships significantly improve students' receptivity to technologically enhanced teaching methods, with students who reported stronger teacher support demonstrating higher mastery of topics when animated media was used. Maleka, Nafiza and Israt (2021) examined teacher-student interactions and academic performance of students in South Dhaka City Corporation and found a positive significant correlation between teacher-student interaction and academic performance. Bereket, Yohannes and Aklilu (2019) examined the relationship between student-teachers interaction and academic achievement of trainee teachers in Dilla College of teacher education and revealed that there was significant relationship between teacher-students relationship and academic achievement. Uchegbue (2024) examined teacher-students interaction and classroom management as predictors of skill acquisition in secondary education in Cross River State and found that teacher-student interaction is a crucial predictor of students' skill acquisition levels. These studies suggest that high-quality relationships may amplify the benefits of innovative instructional approaches by providing additional emotional and academic support. Therefore, understanding the moderating effect of teacher-student relationship on the effectiveness of animated-media instruction is essential for optimizing pedagogical outcomes in Chemistry education, particularly within the Nnewi Education Zone where such contextualized research is currently lacking. The interplay between animated-media instruction and teacher-student relationship underscores the complexity of teaching and learning processes in Chemistry, highlighting the need for evidence-based approaches that address the diverse needs of students in different classroom climates. As educational stakeholders strive to improve science education outcomes in Nigeria, particularly in Nnewi Education Zone where students often struggle with science process skills due to the abstract nature of Chemistry concepts and reliance on conventional teaching methods, there is a pressing need to investigate how animated-media instruction can be effectively implemented across varying relational contexts. This study aims to contribute to this discourse by examining how animated-media instruction, moderated by teacher-student relationship, can enhance the acquisition of science process skills among secondary school students in Nnewi Education Zone of Anambra State, Nigeria, thereby providing insights that can inform policy and practice in science education.

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 students with high and low teacher-student relationship taught Chemistry using AMI and those taught using TDM.
3. Interaction effect of instructional strategies (AMI and TDM) and teacher-student relationship (high and low) on students' acquisition of science process skills in Chemistry.

Research Questions

1. What are the mean science process skills acquisition scores of students in observing, classifying, measuring, predicting, communicating skills, taught Chemistry using AMI and those taught using TDM?
2. What are the mean science process skills acquisition scores of students with high and low teacher-student relationship 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 students with high and low teacher-student relationship taught Chemistry using AMI and those taught using TDM.
3. There is no interaction effect of instructional strategies (AMI and TDM) and teacher-student relationship (high and low) 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, while the experimental group had 37 students. The instruments for data collection were Science Process Skills Acquisition Test (SPSAT) adopted from Avwiri (2021) and Teacher-Students' Relationship Scale (TSRS) adapted from Pianta (2001). The SPSAT comprised sections on titration experiments and preliminary and confirmatory tests for salts designed to evaluate students' acquisition of science process skills. The TSRS was a 15-item scale designed to generate scores on the relationship between the teacher and the students on a 5-point scale measuring closeness and conflict dimensions. The instruments were validated by three experts in the Departments of Science Education and Educational Foundations (Measurement and Evaluation Unit) at Nnamdi Azikiwe University, Awka. The reliability of SPSAT was determined using Kuder-Richardson Formula 20 (KR-20), which yielded a reliability coefficient of 0.94. The reliability of TSRS was assessed using Cronbach's Alpha, which yielded a coefficient of 0.90. 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 teacher demonstration method. The SPSAT and TSRS were administered as pretest before the commencement of the treatment. After the teaching, SPSAT and TSRS were 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)

SPS	Method	N	Mean Pre-test	SD Pretest	Mean Posttest	SD Posttest	Gained Mean
Observing	AMI	37	13.54	1.73	18.43	1.79	4.89
	TDM	36	13.28	1.72	16.44	2.25	3.16
Classifying	AMI	37	10.16	3.78	16.24	1.64	6.08
	TDM	36	10.22	5.06	15.50	1.99	5.28
Measuring	AMI	37	10.95	1.08	15.14	3.00	4.19
	TDM	36	10.58	1.18	12.61	1.70	2.03
Predicting	AMI	37	10.05	2.16	16.43	1.98	6.38
	TDM	36	9.25	1.83	11.67	1.59	2.42
Communicating	AMI	37	11.46	1.56	16.59	2.17	5.13
	TDM	36	11.33	1.64	14.72	2.15	3.39

In table 1 the mean gain science process skills scores of the students exposed to AMI are observing 4.89, classifying 6.08, measuring 4.19, predicting 6.38, and communicating 5.13. Those exposed to TDM had mean gain science process skills scores of observing 3.16, classifying 5.28, measuring 2.03, predicting 2.42, and communicating 3.39. Students taught chemistry using AMI has higher mean science process skills acquisition score in observing, classifying, measuring, predicting and communicating that those taught using TDM.

Table 2: Mean Science Process Skills Acquisition Scores of Students with High and Low Teacher-Student Relationship 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	High	24	57.37	4.19	83.21	6.09	25.84
	Low	13	53.92	5.12	82.15	5.08	28.23
TDM	High	22	55.23	5.94	70.27	3.71	15.04
	Low	14	53.79	6.14	72.00	4.85	18.21

Table 2 shows that the students with high TSR taught Chemistry using AMI had pretest mean science process skills acquisition scores score of 57.37 and posttest mean science process skills acquisition scores score of 83.21 with a gain in mean science process skills acquisition scores of 25.84 while the students with low TSR had pretest mean science process skills acquisition scores score of 53.92 and posttest mean science process skills acquisition scores score of 82.15 with gain in mean science process skills acquisition scores score of 28.23. Table 2 also reveals that the students with high TSR taught Chemistry using TDM had pretest mean science process skills acquisition scores of 55.23 and posttest mean science process skills acquisition scores score of 70.27 with a gain in mean science process skills acquisition scores of 15.04 while the female students had pretest mean science process skills acquisition scores of 53.79 and posttest mean science process skills acquisition scores of 72.00 with gain in mean science process skills acquisition scores of 18.21. High TSR students taught Chemistry using AMI had higher mean gained science process skills acquisition scores than those taught using TDM and also, low TSR students taught Chemistry using AMI had higher mean gained science process skills acquisition scores than the female students taught using TDM.

Table 3: ANCOVA Test of Significance of Difference in the Mean Science process skills of Observing, Classifying, Measuring, Predicting and Communicating for Students taught Chemistry using AMI and TDM

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Posttest (Observing)	102.462[a]	6	17.077	4.308	.001
	Posttest (Classifying)	18.158[b]	6	3.026	.877	.517
	Posttest (Measuring)	140.576[c]	6	23.429	3.861	.002
	Posttest (Predicting)	435.514[d]	6	72.586	23.033	.000
	Posttest (Communicating)	96.460[e]	6	16.077	3.565	.004
Intercept	Posttest (Observing)	80.231	1	80.231	20.240	.000
	Posttest (Classifying)	68.692	1	68.692	19.908	.000
	Posttest (Measuring)	31.716	1	31.716	5.226	.025
	Posttest (Predicting)	14.982	1	14.982	4.754	.033
	Posttest (Communicating)	162.702	1	162.702	36.077	.000
Meth	Posttest (Observing)	58.166	1	58.166	14.674	.000
	Posttest (Classifying)	8.195	1	8.195	2.375	.128
	Posttest (Measuring)	102.599	1	102.599	16.906	.000
	Posttest (Predicting)	351.835	1	351.835	111.644	.000
	Posttest (Communicating)	80.746	1	80.746	17.904	.000
Error	Posttest (Observing)	261.620	66	3.964		
	Posttest (Classifying)	227.732	66	3.450		
	Posttest (Measuring)	400.547	66	6.069		
	Posttest (Predicting)	207.993	66	3.151		
	Posttest (Communicating)	297.650	66	4.510		
Total	Posttest (Observing)	22598.000	73			
	Posttest (Classifying)	18647.000	73			
	Posttest (Measuring)	14626.000	73			
	Posttest (Predicting)	15120.000	73			
	Posttest (Communicating)	18322.000	73			
Corrected Total	Posttest (Observing)	364.082	72			
	Posttest (Classifying)	245.890	72			
	Posttest (Measuring)	541.123	72			
	Posttest (Predicting)	643.507	72			
	Posttest (Communicating)	394.110	72			

From table 3, a significant main effect was observed for teaching methods with respect to posttest mean scores in the science process skills of observing $F(1, 64) = 14.674$, $P = .000 <$

0.05, measuring F(1, 64) = 16.906, P =.000 < 0.05, Predicting F(1, 64) = 111.644, P =.000 < 0.05, and communicating F(1, 64) = 17.904, P =.000 < 0.05. No significance main effect of the treatments was observed in the science process skill of measuring F(1, 64) = 2.375, P =.128 < 0.05. Therefore, there is significant difference in the mean scores of students in the science process skills of observing, measuring, predicting and communicating, those taught chemistry using AMI and those taught using TSM in favour of AMI. No significant difference in the mean science process skills of measuring was observed in the mean gains of students taught chemistry using AMI and those taught using TDM.

Table 4: ANCOVA Test of Significance of Interaction Effect of Teaching method and Teacher Students' Relationship on Students' Achievement in Chemistry

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
TSR	10.799	1	10.799	.434	.512
Meth * TSR	19.572	1	19.572	.787	.378
Error	1591.531	64	24.868		
Total	436881.000	73			
Corrected Total	4371.945	72			

Table 4 more so, show that there is no significant interaction effect of the instructional methods and TSR on students' science process skills acquisition scores in Chemistry, F(1, 64) = 0.787, P = 0.378 > 0.05. Therefore, the null hypothesis was not rejected meaning that there is no interaction effect of instructional strategies (AMI and TDM) and students-teacher relationship (High and Low) on students' acquisition of science process skills in Chemistry

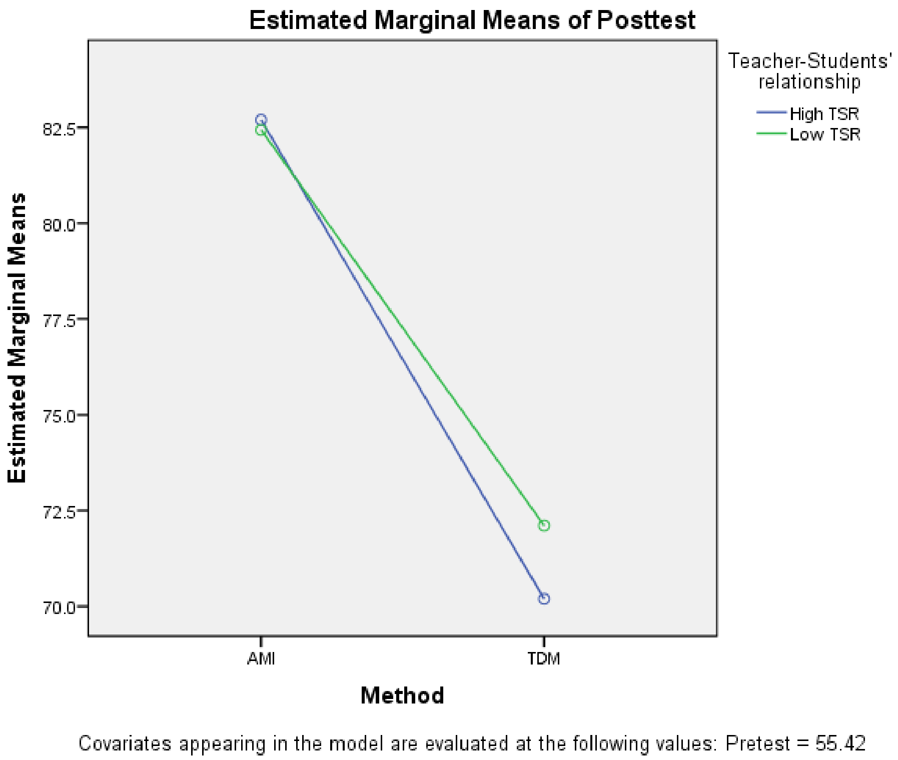

Figure 1: Plot of Interaction Effect of Teaching Method and TSR on Students' Science Process Skills Acquisition

The plot of interaction effect of instructional methods and TSR on students' science process skills acquisition scores in Chemistry as shown in Figure 4.2 is non-significant and disordinal. This shows that the instructional methods had different effects with respect to TSR as student with high TSR had higher science process skills score in AMI than students with low TSR whereas students with low TSR students had higher mean science process skills score in DTM than students with high TSR. The methods are therefore TSR-sensitive.

Discussion

The findings of the study reveal that students taught Chemistry using animated-media instruction (AMI) achieved a higher overall mean score in the acquisition of the science process skills of observing, classifying, measuring, predicting, and communicating compared to those taught using the teacher demonstration method (TDM), with further analysis showing a statistically significant advantage for AMI in the specific skills of observing, predicting, and communicating. The absence of a significant difference in the mean gains for the skill of measuring between the two groups is a notable exception, suggesting that this particular competency, which often involves practical manipulation and direct data collection, may be equally well-served by a clear, live demonstration as by an animation, or that the animated media used did not uniquely enhance this procedural skill beyond the clarity provided by a teacher. This pattern underscores that the primary strength of AMI lies in its capacity to make the invisible visible and the abstract concrete, thereby profoundly enhancing the cognitive and interpretive skills required for careful observation of molecular events, the formulation of predictions based on visualized models, and the articulation of complex processes skills that are inherently bolstered by the dynamic, repeatable, and detailed representations that animations provide. These findings are strongly corroborated by the collective evidence from related studies. The work of Yanarates (2022), which found animated teaching significantly improved Chemistry achievement and learning persistence among teacher candidates, aligns with the enhanced skill acquisition in observing and predicting, as a deeper conceptual understanding fostered by animation directly supports these higher-order processes. Similarly, Mbonu-Adigwe et al. (2021) reported a significant positive effect of multimedia integrated instruction on students' overall acquisition of science process skills in Basic Science, providing general support for the broader finding of AMI's superiority. The findings of this study further shows the consistent pedagogical strength of animated-media instruction (AMI) in Chemistry, demonstrating its capacity to operate independently of the qualitative dimension of the teacher-student relationship (TSR). Specifically, the results show that both students who enjoy a high TSR and those with a low TSR achieved significantly higher gained mean science process skills acquisition scores when taught with AMI compared to their counterparts taught via the teacher demonstration method (TDM), a pattern that underscores the inherent instructional power of well-designed animated content to facilitate learning regardless of the interpersonal dynamic in the classroom. Crucially, the analysis reveals no significant difference in the effectiveness of AMI between the high and low TSR groups, and furthermore identifies no interaction effect between instructional strategy and TSR level, leading to the pivotal conclusion that while a positive TSR is widely recognized as beneficial for the general learning climate, the superior efficacy of AMI for skill acquisition is a robust and standalone effect that functions equally across varying relational contexts; in essence, the animated media itself serves as such a potent and self-contained instructional vehicle that it compensates for or neutralizes the potential learning disadvantages typically associated with a weaker student-teacher rapport.

This finding is strongly supported by a body of research that, while affirming the value of positive interactions, also delineates the boundaries of their influence. For instance, the work of Maleka, Nafiza, and Israt (2021) on teacher-student interactions and academic achievement reaffirms the general positive correlation between TSR and learning outcomes, providing a backdrop against which the current findings become even more striking, as they show AMI achieving high results even when this relational variable is low. Similarly, Uchegbue (2024), who identified teacher-student interaction as a predictor of skill acquisition, nevertheless highlights that it operates within an ecosystem of instructional factors, thereby creating a conceptual space where a powerfully effective method like AMI could independently drive skill development. Most corroborative is the research by Bereket, Yohannes, and Aklilu (2019), which, while establishing a relationship between student-teacher interaction and trainee teachers' achievement, implicitly acknowledges that such interpersonal factors are but one component in a complex educational matrix. Collectively, these studies help contextualize the present findings by validating the importance of TSR as a general educational asset while simultaneously providing a framework to understand how a transformative instructional tool like AMI can supersede or operate independently of it, thereby offering a compelling argument for the prioritized integration of such technology to ensure high-quality, equitable skill acquisition in Chemistry for all students, irrespective of the relational dynamics within any given classroom.

Conclusion

The findings demonstrate that animated-media instruction (AMI) significantly enhances students' acquisition of science process skills in Chemistry compared to the traditional teacher demonstration method. More importantly, the effectiveness of AMI is robust and operates independently of the quality of teacher-student relationship, as there was no significant difference in skill acquisition between students with high and low TSR when taught using AMI, and no significant interaction between instructional strategy and TSR. This suggests that AMI can serve as an equalizing pedagogical tool that ensures high-quality skill development even in classrooms where building strong teacher-student rapport presents challenges. Animated-media instruction is therefore conclusively established as a more effective and resilient pedagogical method than teacher demonstration for fostering science process skills in Chemistry, with its efficacy holding true across diverse relational classroom contexts.

Recommendations

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

1. Chemistry teachers should adopt animated-media instruction as a core instructional strategy to enhance students' acquisition of science process skills, recognizing that its effectiveness does not depend on pre-existing strong teacher-student relationships.
2. School administrators and curriculum planners should prioritize institutional adoption of animated-media instruction as a core pedagogical strategy, ensuring equitable access to the technology and training required for its implementation to benefit all learners irrespective of individual teacher-student rapport.
3. Teacher training programs should incorporate instruction on the effective pedagogical use of animated media, emphasizing that AMI can serve as a powerful complementary tool that effectively bridges gaps in engagement and understanding, particularly for students with whom establishing strong personal connection is more difficult.
4. Educational policymakers should allocate resources for the development and integration of high-quality animated media into national Chemistry curricula, recognizing the potential of this instructional approach to democratize quality science education across diverse classroom environments.

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