Remediating Students' Misconception and Achievement in Basic Science via Science Writing Heuristics and Peer Review Instructional Strategies in Delta State

ODEBALA, Eseoghene
Department of Science Education, Delta State University, Abraka

UMUKORO, Ogheneovo Emmanuel
Department of Primary Education Studies, College of Education, Warri

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Abstract
The research adopted quasi-experimental design. Treatment groups were formed from intact classes. It had three groups: two experimental and one control. The students in the first experimental group were taught Basic Science using science writing heuristics instructional strategy (SWHIS), while the students in the second experimental group received instruction using peer review instructional strategy (PRIS). The students in the control group received instruction utilizing conventional lecture instructional strategy (LIS). The three groups were pre- and post-tested before and after treatment. The study included a population of 174,570 students enrolled in the JSII. The study included a total of 328 SSII Basic Science students from six public co-educational secondary schools in Delta State. The schools were chosen through the implementation of a simple random sampling technique. Two-Tier Basic Science Test (TTBST) was used for data collection in this study. TTBST was used to measure students' misconception and achievement in Basic Science. Face validity of the TTBST was determined by three specialists. Content validity was determined using a table of specifications. The discriminating and difficulty indices of the instrument were determined to prove construct validity. TTBST reliability was established using Kuder-Richardson 21 since the items are dichotomous, which yielded 0.77 and 0.72, for the achievement and misconception segments respectively. TTBST was administered as pre- and post-test before and after treatment and the scores obtained were analysed using Analysis of Covariance (ANCOVA). The results revealed a significant difference in the mean misconception and achievement scores among students taught Basic Science using science writing heuristics, peer review and lecture instructional strategies, in favour of science writing heuristics and peer review instructional strategy. The study concluded that teaching Basic Science using science writing heuristics and peer review instructional strategies leads to superior academic achievement and a reduction in misconceptions compared to the traditional lecture instructional strategy. Hence, it was recommended among others that educators should incorporate science writing heuristics and peer review instructional strategies into their instructional practices. These

strategies encourage students to actively engage in scientific thinking and problem-solving, fostering a deeper understanding of Basic Science.

Keywords: *Misconception, Achievement, Science Writing Heuristics Instructional Strategy, Peer Review Instructional Strategy*

Introduction

Basic Science is an interdisciplinary subject that spans multiple fields of science. Its objective is to equip students with a fundamental comprehension of the natural world and its underlying principles. This subject integrates principles from biology, chemistry, physics and earth sciences to familiarise students with the scientific process, cultivate critical thinking abilities and enhance problem-solving skills. The incorporation of Basic Science as a component of the junior secondary school curriculum in Nigeria is crucial for multiple reasons (Federal Republic of Nigeria, FRN, 2013). Basic Science lays the foundation for scientific literacy by introducing students to key scientific concepts and methods. It fosters a deep understanding of scientific principles and nurtures critical thinking skills essential for making informed decisions in everyday life. Exposure to Basic Science equips students with the ability to analyze and evaluate information, enabling them to make rational judgments and actively participate in discussions surrounding scientific issues. Basic Science offers students a comprehensive comprehension of the natural world by incorporating several scientific disciplines. It helps them connect scientific knowledge across different subject areas and promotes interdisciplinary thinking. This comprehensive approach encourages students to see the interconnectedness of scientific concepts, paving the way for a broader understanding of the universe.

Basic Science promotes inquiry-based learning, which emphasizes problem-solving skills (FRN, 2014). Students are motivated to inquire, explore and find resolutions to real-life issues through hands-on experiments and projects. This methodology not only enhances the capacity for analysis and critical thinking, but also fosters student engagement as active contributors in their own educational journey. During the junior secondary level, students experience a period of increasing interest about the world. Basic Science provides an ideal platform to nurture their innate scientific curiosity, serving as an early introduction to scientific exploration (FRN, 2014). Through hands-on activities, students can actively engage with the subject matter, sparking a genuine interest in science and potentially inspiring them to pursue careers in scientific fields. Basic Science serves as a foundation for further education in science-related fields. It introduces students to key scientific principles, terminology, and laboratory techniques, preparing them for advanced studies in biology, chemistry, physics, or any science-related discipline they may choose to pursue in senior secondary school and beyond. Moreover, it equips students with the requisite scientific skills and knowledge for future career paths in science, technology, engineering, and mathematics (STEM).

Educational research and national curriculum standards endorse the incorporation of Basic Science as a topic in Nigeria's junior secondary school level. As stated in the National Policy on Education (FRN, 2013), the study of science subjects, including Basic Science, is crucial for gaining scientific knowledge, skills and competences that are necessary for the progress of the nation. The Revised 9-Year Basic Education Curriculum (FRN, 2014) mandates the incorporation of Basic Science into the curriculum for junior secondary school. Research studies have demonstrated the positive impact of teaching Basic Science on students' scientific knowledge, skills and attitudes (Osanaiye, 2017; Ogunleye et al., 2015). These studies highlight the importance of early exposure to scientific concepts in fostering scientific literacy.

The successful implementation of the basic science curriculum in Nigerian secondary schools relies on the use of effective teaching strategies (Osanaiye, 2017). Appropriate teaching strategies not only help students understand and retain scientific concepts but also foster critical thinking, problem-solving skills and scientific literacy. One of the commonly used teaching strategies is the lecture instructional strategy. Lecture as an instructional strategy has long been a prevalent method of delivering information and knowledge in educational settings (Freeman et al., 2014). It involves a teacher presenting information to students through oral communication, often without much interaction or active participation from the students. Nevertheless, an increasing amount of evidence indicates that the lecture instructional strategy is unsuitable for teaching Basic Science at the junior secondary school level in Nigeria. This is supported by recent research that highlights the limitations and inefficiencies of lecture-based teaching approaches for science education. One of the key reasons why lecture instructional strategy is no longer suitable for teaching basic science at the junior secondary school level in Nigeria is the lack of student engagement and active participation. Research has consistently shown that active learning strategies, where students are actively involved in constructing their understanding of scientific concepts through hands-on activities, discussions and problem-solving, lead to better learning outcomes in science education (Freeman et al., 2014). In contrast, lecture-based teaching primarily involves passive listening, which limits students' ability to actively engage with the content and apply their knowledge in meaningful ways.

To address these limitations, educators in Nigeria have recommended implementing more student-centered and interactive teaching approaches for basic science education. Promising alternatives to lecture-based teaching include science writing heuristics and peer review instructional strategies among others. These strategies promote active student engagement, foster the integration of scientific principles with practical situations, and cultivate critical thinking and problem-solving abilities. Science writing heuristics instructional strategy involve engaging students in the process of scientific inquiry through writing. It encourages students to think like scientists and communicate their ideas effectively (Chen et al., 2021). This strategy can be implemented through various techniques, such as the writing-to-learn approach, concept mapping, and scientific argumentation. In this study, the strategy was implemented through writing-to-learning approach. Writing-to-learn activities prompt students to reflect on and explain their understanding of scientific concepts. Research has shown that this approach enhances critical thinking skills and improves conceptual understanding (Chen et al., 2021). For example, students can be asked to write a short explanation of a scientific phenomenon or to summarize a scientific article in their own words. This encourages active engagement with the material and helps students clarify their thinking.

Peer review instructional strategy share similar characteristics with science writing heuristics instructional strategy especially in the area of promoting students' active involvement during instruction. Peer review entails students engaging in the process of reviewing and offering comments on one another's work. Peer review fosters collaboration, enhances critical thinking and improves students' ability to give and receive feedback. In peer review instructional strategy, students exchange their written work and provide constructive feedback to improve the quality of each other's writing. Research has shown that peer editing improves students' writing skills and their ability to revise their work (Cho & Cho, 2018). Teachers can guide students in giving specific feedback based on criteria such as clarity, coherence, and accuracy. Collaborative group work encourages students to work together to solve problems or complete tasks. Research has indicated that cooperative learning promotes active engagement and deeper understanding of scientific concepts (Hussain et al., 2016). Teachers can assign group projects where students collaborate to conduct experiments or investigate scientific phenomena. They can also facilitate discussions to ensure effective communication among group members.

Science writing heuristics and peer review instructional strategies may be more suitable than the lecture strategy for teaching basic science at the junior secondary school level in Nigeria since these strategies engage students in active learning, promoting better retention and understanding of scientific concepts (Chi et al., 2018). Science writing heuristics and peer review require students to think critically, evaluate evidence and communicate their ideas effectively, which are essential skills for scientific inquiry (Driver et al., 2018). These strategies focus on improving students' oral and written communication skills. Effective communication is crucial for students to express their scientific ideas clearly (Hussain et al., 2016). Science writing heuristics and peer review strategies shift the focus from the teacher to the students, fostering a student-centered learning environment that encourages autonomy and initiative (Hodson, 2019). Thus, the use of science writing heuristics and peer review instructional strategy could have a better effect on students' misconception and academic achievement in Basic Science.

Misconception refers to a misunderstanding or incorrect belief about a particular concept or topic (Chen et al., 2021). In an educational context, student misconceptions are misconceptions that students may have regarding specific concepts or ideas within a subject area. These misconceptions can arise due to various factors, including personal experiences, inadequate teaching methods, cultural or societal influences, or incorrect prior knowledge. Students commonly hold misconceptions that hinder the acquisition and retention of accurate scientific knowledge. Science writing heuristics and peer review offer an instructional approach that assists students in challenging their preconceived notions, refining their understanding and improving their overall achievement in Basic Science. Through science writing heuristics, students are encouraged to confront and address their misconceptions explicitly. By engaging in writing activities, students are compelled to articulate their understanding, compare it to scientific evidence, and recognize any inconsistencies. Recent studies indicate that this process helps students identify and rectify misconceptions. For example, in a study by Chen et al. (2021), it was found that implementing science writing heuristics decreased the prevalence of misconceptions on photosynthesis among middle school students. Studies have also demonstrated that the peer review educational strategy has a beneficial impact on mitigating students' misconceptions in the field of

Basic Science. By actively participating in the review process, students can identify flaws in their peers' work and compare it to their own understanding. This interaction promotes introspection, discerning thought, and a more profound examination of scientific principles. It enables students to identify and rectify their own misunderstandings while also correcting the assumptions of their classmates. A study conducted by Tai et al. (2017) demonstrated that peer review significantly reduced students' misconceptions related to photosynthesis.

Conversely, academic achievement pertains to the degree of success or attainment that students reach in their academic endeavours (Nguyen et al., 2020). It generally includes multiple facets such as academic grades, standardised test results, class standing and overall academic accomplishment in school or college. Science writing heuristics have shown a positive influence on students' achievement in basic science. By actively participating in the writing process, students refine their scientific thinking, develop critical analysis skills, and construct coherent scientific explanations. Several studies have demonstrated the improvement in students' achievement when science writing heuristics are implemented. Nguyen et al. (2020) reported significant gains in students' achievement in chemistry when science writing heuristics were utilized. Peer review instructional strategy has also been shown to positively impact students' achievement. By engaging in the peer review process, students actively construct their knowledge and understanding. This deeper level of engagement and reflection enhances their ability to retain information and apply critical thinking skills. Studies have shown that science peer review instructional strategy improves students' academic performance in Basic Science subjects, such as Chemistry, Biology and Physics (Tai et al., 2017; Hanauer et al., 2014). However, these studies were not carried out in Delta State. This created a gap in knowledge this sought to fill. It is against this background this study sought to investigate the effects of science writing heuristics and peer review instructional strategies in remediating students' misconception and achievement in Basic Science in Delta State.

Statement of the Problem

Basic Science education plays a vital role in the development of students' scientific understanding and critical thinking skills, preparing them for higher education and future careers. However, in Delta State, there is a pressing issue concerning students' misconceptions and low achievement in Basic Science. These issues hinder student comprehension of scientific concepts and hinder the overall educational progress in the State. The misconception and low achievement levels of students in Basic Science reflect the inadequate mastery of the subject matter and indicate a need for urgent intervention. Several factors contribute to students' misconception and low achievement, including ineffective teaching strategy. The lecture instructional strategy predominantly used in Nigerian schools, heavily rely on memorization and limited opportunities for hands-on exploration hinder students' engagement with the subject. This may result to students' misconception and low achievement in Basic Science. Thus, it is pertinent to search for alternative teaching strategies that foster opportunities for hands-on exploration and active participation during instruction. The problem of this study is: will the use of science writing heuristics and peer review instructional strategies enhance students' misconception reduction and achievement in Basic Science than the lecture instructional strategy?

Purpose of the Study

The study focused mainly on remediating students' misconception and achievement in Basic Science via science writing heuristics and peer review instructional strategies in Delta State. The study was specifically designed to compare:

1. the effects of science writing heuristics, peer review and lecture instructional strategies on students' misconception in Basic Science;
2. the effects of science writing heuristics, peer review and lecture instructional strategies on students' achievement in Basic Science.

Hypotheses

HO_1: There is no significant difference in the mean misconception scores among students taught Basic Science using science writing heuristics, peer review and lecture instructional strategies.

HO_2: There is no significant difference in the mean achievement scores among students taught Basic Science using science writing heuristics, peer review and lecture instructional strategies.

Research Method

The research adopted quasi-experimental design. Treatment groups were formed from intact classes. It had three groups: two experimental and one control. The students in the first experimental group were taught Basic Science using science writing heuristics instructional strategy (SWHIS), while the students in the second experimental group received instruction using peer review instructional strategy (PRIS). The students in the control group received instruction utilizing conventional lecture instructional strategy (LIS). The three groups were pre- and post-tested before and after treatment. Table 1 shows the study's design; where, O_1, O_3 and O_5 = pretest of science writing heuristics, peer review and lecture groups, O_2, O_4 and O_6 = posttest of science writing heuristics, peer review and lecture groups. Xsswhis and Xpris = treatment with the use of science writing heuristics and peer review instructional strategies. The students in the lecture group did not receive any form of intervention or treatment. This group served as control to the experimental groups.

Table 1

Design of the Study

Groups	Pretest	Treatment	Posttest
SWHIS	O_1	Xswhis	O_2
PRIS	O_3	Xpris	O_4
LIS	O_5		O_6

174,570 students enrolled in JSII Basic Science constituted the population of the study. The study included a total of 328 SSII Basic Science students from six public co-educational secondary schools in Delta State. The schools were chosen through the use of a simple random sampling procedure. The initial step of this sampling technique is categorising all the public co-educational institutions in Delta State into Delta Central, North and South Senatorial Districts. Subsequently, the researcher employed a random selection method to choose two schools from each of the three Senatorial Districts, utilising balloting with replacement. The utilisation of simple random sampling was implemented to ensure that all schools in Delta State had an equitable opportunity of being chosen for this study. The study utilised the Two-Tier Basic Science Test (TTBST) for data collecting. The TTBST contained 50 items drawn on thermal and kinetic energy. TTBST was used to measure students' misconception and achievement in Basic Science. Each item in TTBST contains two segments. In the first segment of this test, there was a question or information and number of answer options (A-D) following it. In the second segment, students were required to state why they chose a particular answer in the first stage by filling it in an empty column. The first segment was only used to determine students' achievement in Basic Science. In scoring TTBST for achievement, students' response to the first segment was only considered. Correct answer attracted a score of 2 while incorrect answer attracted a score of 0, for easy percentage ranking. However, both the first and the second segments were used to determine students' misconception in Basic Science. In scoring TTBST for misconception, students' answers to the first stage questions and the combinations of reasons that they choose for these answers were considered using the following evaluation criteria as shown in Table 2. Thus, students were scored over one fifty (150). Whatever the scores of the students per one fifty were converted to hundred percent using the formula: (x/150) x (100/1), where x is students' scores.

Table 2

Criteria for TTBST

Criteria	Score
Correct Answer-Correct Reason	3
Incorrect Answer-Correct Reason	2
Correct Answer- Incorrect Reason	1
Incorrect Answer-Incorrect Reason	0

To ensure that the instrument measure what it purports to measure, the face, construct and content validities were established. Face validity of the TTBST was determined by three specialists. Content validity was determined using a table of specifications. The discriminating and difficulty indices of the instrument were determined to prove construct validity. TTBST reliability was established using Kuder-Richardson 21 since the items are dichotomous, which yielded 0.77 and 0.72, for the achievement and misconception segments respectively.

Three treatment phases were used. The first phase was the assignment of selected schools into science writing heuristics, peer review and lecture groups. The second phased involved the training of research assistants, who were the regular Basic Science teachers of the schools assigned to the experimental (science writing heuristics and peer review groups) groups. The third phase was the actual treatment that lasted for six (6) weeks. Prior to treatment, TTBST was administered to both experimental (science writing heuristics and peer review) groups and control (lecture) group to enable the researcher determine if the two groups were equivalent on the level of misconception and knowledge of the Basic Science concepts taught. Each group was post-tested after treatment. The scores obtained from the pre- and post-test were collated for analysis.

Results

HO_1: There is no significant difference in the mean misconception scores among students taught Basic Science using science writing heuristics, peer review and lecture instructional strategies.

Table 3

Summary of ANCOVA Comparison of Posttest Mean Misconception Scores of Students Taught Basic Science Using Science Writing Heuristics, Peer Review and Lecture Instructional Strategies

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	5313.182[a]	3	1771.061	10.638	.000
Intercept	112731.360	1	112731.360	677.105	.000
Pretest	66.482	1	66.482	.399	.528
Methods	5178.289	2	2589.144	15.551	.000
Error	53942.806	324	166.490		
Total	1069356.000	328			
Corrected Total	59255.988	327			

Table 3 demonstrates a significant difference in the average misconception scores, among students who were taught Basic Science utilising science writing heuristics, peer review and lecture instructional strategies. The statistical analysis yielded an F-value of 15.551, with a corresponding p-value of 0.000, which is less than 0.05. Therefore, the null hypothesis is disproven. Hence, there exists a significant difference in the average misconception scores between students who were instructed in Basic Science utilising science writing heuristics, peer review and lecture instructional strategies. The direction of the discrepancy was established utilising Scheffe's post-hoc test, as illustrated in Table 4.

Table 4

Summary of Scheffe's Post-hoc Test Comparison of Science Writing Heuristics, Peer Review, and Lecture Instructional Strategies on Misconception

(I) Teaching methods	(J) Teaching methods	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
SWHIS	PRIS	3.304	1.831	.072	-.299	6.907
	LIS	9.237*	1.688	.000	5.916	12.558
PRIS	SWHIS	-3.304	1.831	.072	-6.907	.299
	LIS	5.933*	1.764	.001	2.463	9.403
LIS	SWHIS	-9.237*	1.688	.000	-12.558	-5.916

PRIS	-5.933*	1.764	.001	-9.403	-2.463

Table 4 shows no significant difference between the mean misconception scores of students taught Basic Science using science writing heuristics and those taught using peer review strategy; a significant difference between the mean misconception scores of students taught Basic Science using science writing heuristics and those taught using the lecture strategy, in favour of students taught Basic Science using science writing heuristics; and a significant difference between the mean misconception scores of students taught Basic Science using peer review strategy and those taught using the lecture strategy, in favour of students taught Basic Science using peer review strategy. As indicated in Table 4, science writing heuristics prove to be more effective in reduction of students' misconception in Basic Science followed by the use of peer review strategy; and the lecture strategy is the least effective.

HO_2: There is no significant difference in the mean achievement scores among students taught Basic Science using science writing heuristics, peer review and lecture instructional strategies.

Table 5

Summary of ANCOVA Comparison of Posttest Mean Achievement Scores of Students Taught Basic Science Using Science Writing Heuristics, Peer Review and Lecture Instructional Strategies

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	8385.564[a]	3	2795.188	16.457	.000
Intercept	111645.199	1	111645.199	657.330	.000
Pretest	17.937	1	17.937	.106	.745
Methods	8385.525	2	4192.762	24.686	.000
Error	55030.241	324	169.846		
Total	1130000.000	328			
Corrected Total	63415.805	327			

Table 5 indicates a notable disparity in the average achievement scores, among students who were taught Basic Science utilising science writing heuristics, peer review and lecture instructional strategies. The statistical analysis yielded an F-value of 24.686 with a corresponding p-value of 0.000, which is less than 0.05. Therefore, the null hypothesis is refuted. Hence, there exists a significant difference in the average achievement scores among students who were instructed in Basic Science through the use of science writing heuristics, peer review and lecture instructional strategies. The direction of the difference was discovered utilising Scheffe's post-hoc test, as depicted in Table 6.

Table 6

Summary of Scheffe's Post-hoc Test Comparison of Science Writing Heuristics, Peer Review and Lecture Strategies on Achievement

(I) Teaching methods	(J) Teaching methods	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
SWHIS	PRIS	1.706	1.846	.653	-2.83	6.25
	LIS	11.049*	1.700	.000	6.87	15.23
PRIS	SWHIS	-1.706	1.846	.653	-6.25	2.83
	LIS	9.343*	1.779	.000	4.97	13.72
LIS	SWHIS	-11.049*	1.700	.000	-15.23	-6.87
	PRIS	-9.343*	1.779	.000	-13.72	-4.97

Table 6 indicates that there is no notable distinction in the average achievement scores of students who were taught Basic Science using science writing heuristics and those who were taught using the peer review strategy. However, there is a significant disparity in the average achievement scores of students taught Basic Science using science writing heuristics compared to those taught using the lecture strategy, with the former group performing better. Similarly, there is a significant difference in the average achievement scores of students taught Basic Science using the peer review strategy compared to those taught using the lecture strategy, with the former group also performing better. Table 6 demonstrates that science writing heuristics and peer review procedures are more efficacious in improving students' achievement in Basic Science compared to the lecture strategy.

Discussion

The result from this study revealed a significant difference in the mean misconception scores among students taught Basic Science using science writing heuristics, peer review and lecture instructional strategies. The Scheffe's post-hoc test revealed that science writing heuristics and peer review instructional strategies prove to be more effective in reduction of students' misconception in Basic Science than lecture instructional strategy. However, science writing heuristics strategy prove as effective as peer review strategy in reduction of students' misconception in Basic Science. The observed superiority of science writing heuristics and peer review instructional strategies over the lecture instructional strategy may be predicated on the fact that science writing heuristics and peer review instructional strategies emphasize active learning. This means that students are actively engaged in the learning process by writing about or discussing scientific concepts, analyzing data and critically evaluating their peers' work. Active learning has been found to be more effective in promoting comprehension, retention and application of knowledge compared to passive learning encouraged by lecture instructional strategy. This finding supports that of Smith et al. (2019) who reported that science writing heuristics instruction enhance reduction of misconception in Ecosystem than the traditional lecture method. This finding further corroborates that of Cho et al. (2018) who reported the superiority of peer feedback strategy over traditional instruction on science students' writing skills.

Additionally, the study's results indicate a significant difference in the average achievement scores between students who were taught Basic Science utilising science writing heuristics, peer review and lecture strategies. The Scheffe's post-hoc test indicated no significant disparity in the average achievement scores of students who were taught Basic Science using science writing heuristics and peer review instructional strategies. However, there was a statistically significant increase in the achievement scores of students who were taught chemistry using science writing heuristics and peer review instructional strategies compared to those who were taught using lecture instructional strategy. This observation may be as a result of practical nature of science writing heuristics and peer review instructional strategies. Science writing heuristics and peer review instructional strategies focus on promoting deep understanding of scientific concepts rather than rote memorization. By engaging in writing and peer review activities, students are encouraged to think critically, apply concepts to real-world scenarios, and articulate their understanding in their own words. This promotes a more profound comprehension of the material, which often leads to better performance in achievement tests. This finding supports that of Nguyen et al. (2020) who reported that science writing heuristics instruction enhance students' achievement and writing competency in Chemistry than the traditional lecture method. This finding lends credence to that of Berland et al. (2016) who reported that the use of peer review strategy enhanced meaningful learning than traditional lecture method.

Conclusion

In conclusion, the study has shown that teaching Basic Science using science writing heuristics and peer review instructional strategies leads to superior academic achievement and a reduction in misconceptions compared to the traditional lecture instructional strategy. These findings provide valuable insights into the effectiveness of different instructional strategies in science education and offer useful implications for educators and policymakers.

Recommendations

Based on the study's findings, it is recommended that:

1. Educators should incorporate science writing heuristics into their instructional practices. This approach encourages students to actively engage in scientific thinking and problem-solving, fostering a deeper understanding of the subject matter.
2. Educators should integrate peer review strategy into Basic Science instruction as an alternative strategy to science writing heuristics. Peer review allows students to critically evaluate each other's work, providing valuable feedback and promoting collaborative learning.
3. Educators should promote active learning. The study highlights the importance of active learning in Basic Science education.

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