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Effects of Simulation and Problem-Solving Instructional Strategies on Students' Attitude towards Biology: Evidence from Delta State, Nigeria

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ABSTRACT

Students' attitude towards Biology remains a critical concern in science education due to its influence on learning outcomes, engagement, and career choices. This study investigated the effects of simulation, problem-solving, and lecture instructional strategies on students' attitude towards Biology in Delta State. The study also examined the interaction effect of instructional strategies and sex on students' attitude. A quasi-experimental design, specifically the pretest–posttest planned variation design, was adopted. The population comprised 29,068 SSII Biology students in public secondary schools, from which a sample of 295 students was drawn using a multi-stage sampling procedure. Data were collected using the Biology Attitude Scale (BAS), a 20-item instrument with a reliability coefficient of 0.77. The findings revealed that there was a significant difference in the mean attitude scores among students taught using simulation, problem-solving, and lecture instructional strategies. Students exposed to the problem-solving strategy recorded the highest improvement in attitude, followed by those taught using simulation, while the lecture method produced the least improvement. Furthermore, the results showed no significant interaction effect between instructional strategies and sex on students' attitude towards Biology, indicating that both male and female students responded similarly to the instructional approaches. The study concludes that learner-centred instructional strategies are more effective in enhancing students' attitude towards Biology than the conventional lecture method, and their effectiveness is not influenced by sex. It is therefore recommended that Biology teachers adopt problem-solving and simulation strategies to promote positive attitude towards the subject.

Keywords: Attitude towards Biology, simulation instructional strategy, problem-solving instructional strategy, lecture method, quasi-experimental design, secondary school students.

INTRODUCTION

Education is widely acknowledged as a fundamental instrument for individual empowerment, societal transformation, and national development. It equips individuals with the knowledge, skills, and attitudes required to adapt to societal demands and contribute meaningfully to socio-economic progress. In contemporary discourse, emphasis has increasingly shifted from mere access to education to the quality of instructional delivery, as the nature of learning experiences significantly determines students' academic outcomes and attitude towards learning (Van Deursen, 2020). Within this context, science education and Biology in particular occupies a pivotal position due to its relevance to health, agriculture, environmental sustainability, and a wide range of science-related careers.

Biology is a core subject in the Nigerian secondary school curriculum, designed to provide learners with essential scientific knowledge, laboratory skills, and functional attitudes necessary for everyday life and

future professional pursuits (Eze et al., 2021). Despite its importance and the interest it generates among students, persistent evidence indicates that many learners continue to record poor performance in the subject. Reports from the West African Examinations Council reveal a consistent trend of low achievement in Biology, thereby raising concerns among educators and policymakers (National Bureau of Statistics, 2023). Beyond achievement, students' attitude towards Biology has also been identified as a crucial factor influencing their level of engagement, persistence, and overall academic success.

A major factor associated with students' poor achievement and unfavourable attitude towards Biology is the predominance of the conventional lecture method in classroom instruction. The lecture method is largely teacher-centred, involving the transmission of knowledge from the teacher to learners who assume passive roles as listeners and note-takers (Van Deursen, 2020). This approach often limits opportunities for active participation, critical thinking, and problem-solving, which are essential for meaningful learning. Consequently, reliance on the lecture method may lead to superficial understanding of biological concepts and diminished interest in the subject.

In response to these challenges, there has been increasing advocacy for the adoption of innovative, learner-centred instructional strategies that promote active engagement. Among such strategies are simulation and problem-solving instructional approaches, both of which are rooted in constructivist learning principles. Simulation instructional strategy involves the use of role-playing, case studies, and computer-based models to replicate real-life biological processes, thereby enabling students to interact actively with content and develop deeper understanding (Jones et al., 2018; Smith & Carden, 2017). This approach enhances learners' critical thinking and allows them to explore complex concepts within a safe and controlled environment.

Similarly, problem-solving instructional strategy focuses on engaging students with real-world problems that require analysis, collaboration, and the application of prior knowledge. This strategy promotes active learning, intrinsic motivation, and the development of higher-order thinking skills (El-Shaer & Gaber, 2014; Emerhiona et al., 2018). By encouraging learners to construct knowledge through inquiry and collaboration, problem-solving instructional strategy aligns with contemporary pedagogical practices aimed at fostering independent and lifelong learners.

Empirical studies have demonstrated the effectiveness of these active instructional strategies in improving students' academic achievement and attitude towards learning. For instance, simulation-based learning has been shown to enhance students' understanding and engagement through hands-on experiences (Ouahi et al., 2021; Oghoghovbe et al., 2023). Likewise, problem-solving approaches have been associated with increased motivation, self-efficacy, and deeper conceptual understanding among learners (Smith & Good, 2019). These findings suggest that active learning strategies possess greater potential for improving students' attitude towards Biology compared to traditional lecture-based methods.

Another important variable in science education research is students' sex, which has been examined as a possible factor influencing achievement and attitude towards learning. While some studies indicate that male and female students may respond differently to instructional strategies, others report negligible differences. This inconsistency underscores the need for further empirical investigation into whether sex moderates the effectiveness of instructional approaches in shaping students' attitude towards Biology (Eagly & Wood, 2022).

Against this backdrop, the present study investigates the effects of simulation, problem-solving, and lecture instructional strategies on students' attitude towards Biology. It further examines whether the effectiveness of these instructional strategies is influenced by students' sex. By providing empirical evidence on the comparative effectiveness of these approaches, the study seeks to contribute to the improvement of instructional practices in Biology and enhance students' learning experiences and attitude towards the subject.

Statement of the Problem

The persistent poor performance of secondary school students in Biology in Nigeria has remained a major concern for educators, policymakers, and other stakeholders in the education sector. Despite the recognised importance of Biology as a foundational science subject and its relevance to health,

environment, and career development, many students continue to achieve below expected standards in both internal and external examinations. Reports from examining bodies such as the West African Examinations Council have consistently highlighted this trend of underachievement (National Bureau of Statistics, 2023). In addition to low achievement, many students exhibit unfavourable attitude towards Biology, which negatively affects their interest, engagement, and willingness to pursue science-related careers. This situation suggests that the problem may not only be linked to curriculum content but also to the instructional approaches employed in teaching the subject.

The conventional lecture method, which dominates classroom practice, has been widely criticised for promoting passive learning and limiting students' active participation in the learning process (Van Deursen, 2020). Although innovative instructional strategies such as simulation and problem-solving have been identified as capable of enhancing engagement, critical thinking, and positive attitude towards learning, their application in Biology classrooms remains limited, particularly within the context of Delta State. Furthermore, there is a dearth of empirical studies that comparatively examine the effectiveness of these strategies in improving students' attitude towards Biology, as well as the extent to which students' sex may influence such outcomes. Therefore, the problem of this study is: will the use of simulation and problem-solving instructional strategies significantly improve students' attitude towards Biology more than the lecture method?

Purpose of the Study

The main purpose of this study is to investigate the effects of simulation, problem-solving, and lecture instructional strategies on students' attitude towards Biology. Specifically, the study seeks to:

1. determine the difference in the mean attitude scores among students taught Biology using simulation, problem-solving, and lecture instructional strategies;
2. examine the effect of interaction between instructional strategies and sex on students' attitude towards Biology.

Hypotheses

The following null hypotheses were formulated and tested at 0.05 level of significance:

1. There is no significant difference in the mean attitude scores among students taught Biology using simulation, problem-solving, and lecture instructional strategies.
2. There is no significant effect of interaction between instructional strategies (simulation, problem-solving, and lecture) and sex on students' attitude towards Biology.

METHODS

This study employed a quasi-experimental design, specifically a pretest–posttest planned variation design, to examine the effects of instructional strategies on students' attitude towards Biology. Intact classes were used to avoid disruption of normal school activities, while pretest scores served as covariates to control for initial group differences. Three instructional conditions were implemented: Simulation Instructional Strategy (SIS), Problem-Solving Instructional Strategy (PSIS), and Lecture Method (LM).

The population comprised 29,068 SS II Biology students in 478 public secondary schools in Delta State, Nigeria. A sample of 295 students was selected from six co-educational public secondary schools using a multi-stage sampling procedure. Schools were first stratified by senatorial district, after which two schools were randomly selected from each district. Intact classes were then assigned to the three instructional groups. Data were collected using the Biology Attitude Scale (BAS), a 20-item instrument structured on a four-point Likert scale. The instrument was validated by experts in Biology Education and Measurement and Evaluation, and its internal consistency was established using Cronbach's alpha ($\alpha = 0.77$).

The intervention involved teaching the same Biology content to all groups using different instructional strategies over the treatment period. The SIS group was exposed to simulation-based activities, the PSIS group engaged in guided problem-solving tasks, while the LM group received conventional lecture-based instruction. A pretest was administered prior to the intervention, and a posttest was conducted afterwards using the same instrument. Data analysis was conducted using inferential statistics. Analysis of

Covariance (ANCOVA) was employed to test the hypotheses at the 0.05 level of significance. Where significant differences were observed, Scheffe post-hoc test was used to determine the direction of group differences.

RESULTS

Table 1: ANCOVA Comparison of the Posttest Mean Attitude Scores of Students Taught Biology Using Simulation Instructional Strategy (SIS), Problem-Solving Instructional Strategy (PSIS) and Lecture Method (LM)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	649.622 ^a	3	216.541	3.282	.021
Intercept	96714.877	1	96714.877	1465.714	.000
Pretest	16.667	1	16.667	.253	.616
Methods	619.388	2	309.694	4.693	.010
Error	19201.578	291	65.985		
Total	1110360.000	295			
Corrected Total	19851.200	294			

The ANCOVA results for the posttest mean attitude scores show a F-value of 4.693 with a p-value of 0.010. Since the p-value is less than 0.05, H_{01} is rejected. This indicates that there is a significant difference in the posttest mean attitude scores among the groups (SIS, PSIS, and LM). The instructional strategies have had a different effect on students' attitude towards Biology. The direction of the difference is shown in Table 2.

Table 2: Scheffe Post-Hoc Test Comparison of the Difference in the Mean Attitude Scores of Students Taught Biology Using Simulation Instructional Strategy (SIS), Problem-Solving Instructional Strategy (PSIS) and Lecture Method (LM)

(I) Methods	(J) Methods	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
SIS	PSIS	-1.940	1.154	.245	-4.78	.90
	LM	1.611	1.171	.389	-1.27	4.49
PSIS	SIS	1.940	1.154	.245	-.90	4.78
	LM	3.551*	1.148	.009	.73	6.38
LM	SIS	-1.611	1.171	.389	-4.49	1.27
	PSIS	-3.551*	1.148	.009	-6.38	-.73

To determine which specific group differ, a Scheffe Post-Hoc Test was conducted in Table 2 and the results are presented below: The Scheffe Post-Hoc Test results indicate that there is no significant difference in the mean attitude scores between the Simulation Instructional Strategy (SIS) and Problem-Solving Instructional Strategy (PSIS), with a mean difference of -1.940 ($p = 0.245$), suggesting both strategies are similarly effective in influencing students' attitudes. Similarly, there was no significant difference between the SIS and Lecture Method (LM) groups, with a mean difference of 1.611 ($p = 0.389$). However, the PSIS group scored significantly higher in attitude compared to the LM group, with a mean difference of 3.551 ($p = 0.009$). The overall ANOVA results led to the rejection of the null hypothesis, indicating a significant difference in the mean attitude scores among the groups. Specifically, the findings suggest that PSIS is significantly more effective than LM in improving students' attitudes toward Biology, while SIS does not differ significantly from either PSIS or LM.

Table 3: ANCOVA on Interaction Effect Between Instructional Methods (SIS, PSIS & LM) and Sex on Students' Mean Attitude Scores in Biology

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Remark
Corrected Model	928.829 ^a	6	154.805	2.356	.031	HO ₁₂ is not rejected
Intercept	93617.630	1	93617.630	1424.868	.000	
Pretest	36.800	1	36.800	.560	.455	
Methods	693.540	2	346.770	5.278	.006	
Sex	7.997	1	7.997	.122	.727	
Methods * Sex	270.939	2	135.469	2.062	.129	
Error	18922.371	288	65.703			
Total	1110360.000	295				
Corrected Total	19851.200	294				

Table 5 shows the ANCOVA results for the interaction effect between instructional methods (Simulation, Problem-solving, and Lecture) and sex on students' attitude towards Biology. The interaction term (Methods * Sex) has an F-statistic of 2.062 and a p-value of 0.129, which is greater than the 0.05 significance level. This indicates that the interaction between instructional methods and sex does not significantly affect students' attitude towards Biology. Therefore, HO₁₂ is not rejected, suggesting no significant interaction effect.

DISCUSSION

The study revealed that there is a significant difference in the mean attitude scores among students taught with different instructional strategies. The results showed that the PSIS group had the highest improvement in attitude scores, followed by the SIS group, while the LM group showed the smallest improvement in students' attitude toward Biology. This suggests that the type of instructional strategy also plays a crucial role in shaping students' attitude towards the subject. The increased attitude scores for PSIS and SIS groups can be attributed to the active nature of these strategies. Problem-solving and simulations engage students in real-world applications of the subject matter, which can increase their interest, relevance, and enjoyment of Biology. These interactive methods allow students to see the practical implications of their learning, leading to a more positive attitude. On the other hand, the lecture method, being more passive, offers limited interaction and student engagement, which may not have the same effect on students' attitude toward the subject. This finding is consistent with the research by Okafor and Agboghoroma (2023), who found that problem-solving strategies positively influenced students' attitude by making learning more interactive and enjoyable. Additionally, Akhigbe and Ogufere (2019) found that simulations significantly improved students' attitude towards Biology by providing engaging, hands-on learning experiences. These studies support the current study's finding that active learning strategies, such as PSIS and SIS, lead to better attitude outcomes compared to lecture-based teaching methods. This aligns with the broader educational research that highlights the importance of student engagement for fostering positive attitude (Hattie & Donoghue, 2016). However, it contrasts with earlier studies which suggested that lecture methods could be just as effective in improving students' attitude when well-structured, especially when student engagement is factored in (Ogundare & Ibeneme, 2022). The current study suggests that, despite potential for engagement, lecture methods are less effective in improving student attitude compared to interactive strategies.

The study again revealed that there is no significant interaction effect between instructional methods and sex on students' attitude towards Biology. The ANCOVA results indicated no significant interaction between instructional methods and sex on students' attitude towards Biology, with a p-value of 0.129. This suggests that the change in students' attitude, whether positive or negative, was not significantly influenced by their sex, despite being taught with different instructional methods. One possible explanation is that the instructional methods (SIS, PSIS, and LM) were engaging enough for both male and female students to equally improve their attitude toward Biology. Since the strategies were designed

to engage students actively or passively, both sexes might have experienced similar benefits in attitude change regardless of the method used. Additionally, sex-neutral engagement in the classroom could have minimized any potential interaction effect, leading to equal attitude changes among male and female students. This finding supports previous studies, such as those by Okafor & Agboghoroma (2023), which showed that interactive instructional strategies, such as simulations and problem-solving, did not result in sex-specific differences in attitude change. Studies by Freeman et al. (2014) also indicated that active learning strategies tend to promote more favorable attitude toward the subject among all students, regardless of sex. However, this contrasts with some past research, such as that of Anari et al. (2023), which suggested that sex differences might influence attitude in more traditional, lecture-based environments, where males and females may have different levels of engagement or interest. In this case, however, the findings suggest that the instructional methods used were sufficiently inclusive to produce similar changes in attitude for both sexes.

CONCLUSION

The evidence indicates that instructional strategy is a decisive factor in shaping students' attitude towards Biology, with learner-centred approaches producing more favourable outcomes than the conventional lecture method. The observed pattern of improvement suggests that strategies which actively engage students in thinking, interaction, and application are more effective in fostering positive dispositions towards the subject. In contrast, passive instructional approaches appear less capable of stimulating sustained interest and enthusiasm for Biology. In addition, the absence of a significant interaction effect between instructional strategies and sex suggests that the effectiveness of these teaching approaches is consistent across male and female students. This implies that improvements in students' attitude towards Biology are primarily attributable to the nature of the instructional strategy rather than learner sex, reinforcing the suitability of these approaches for diverse classroom settings.

RECOMMENDATIONS

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

1. Biology teachers should adopt problem-solving and simulation instructional strategies in classroom practice, as these approaches have been shown to significantly improve students' attitude towards Biology compared to the conventional lecture method.
2. Teacher training institutions and professional development programmes should emphasise learner-centred pedagogies, particularly simulation and problem-solving techniques, to equip teachers with the necessary skills for effective implementation.
3. Curriculum planners and education policymakers should integrate active learning strategies into the Biology curriculum, ensuring that instructional guidelines encourage the use of interactive and inquiry-based teaching methods in secondary schools.
4. School administrators should provide adequate instructional resources and support, such as simulation tools, laboratory facilities, and instructional materials, to facilitate the effective implementation of innovative teaching strategies in Biology classrooms.

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