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EFFECT OF SIMULATION-BASED LEARNING STRATEGY ON STUDENTS' ACADEMIC ACHIEVEMENT IN AGRICULTURAL SCIENCE IN SENIOR SECONDARY SCHOOLS IN ABIA STATE

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Abstract

This study investigated the effect of simulation-based learning strategy on students' academic achievement in Agricultural Science in public secondary schools in Abia State, Nigeria. Specifically, the study determined the effect of simulation-based learning strategy on students' academic achievement, examined the effect of gender on students' achievement when taught using the strategy, and determined the interaction effect of teaching method and gender on students' academic achievement. The study adopted a quasi-experimental research design using a non-randomized, non-equivalent pre-test and post-test control group design involving intact classes. The population comprised 13,288 Senior Secondary Two (SS2) students offering Agricultural Science in public secondary schools in Abia State during the 2025/2026 academic session. A sample of 96 students was selected using a multistage sampling procedure. The instrument for data collection was the Agricultural Science Achievement Test (ASAT), which was validated by experts and yielded a Kuder–Richardson Formula 20 (KR-20) reliability coefficient of 0.78. Mean and standard deviation were used to answer the research questions, while Analysis of Covariance (ANCOVA) was used to test the hypotheses at the 0.05 level of significance. The findings revealed that simulation-based learning strategy significantly improved students' academic achievement compared with the conventional lecture method. Although male students recorded slightly higher mean achievement scores than female students, the difference was not statistically significant. There was also no

significant interaction effect of teaching method and gender on students' academic achievement. The study concluded that simulation-based learning strategy is an effective instructional approach for improving students' academic achievement in Agricultural Science irrespective of gender. The study recommended that Agricultural Science teachers should adopt simulation-based learning strategy and that schools should be equipped with appropriate simulation technologies to enhance effective teaching and learning.

Keywords: *Simulation-Based Learning Strategy, Academic Achievement, Agricultural Science, Gender, Secondary School Students.*

Introduction

The quality of education received by students depends largely on the teaching methods used by teachers. Effective instructional strategies Encourage active participation, improve understanding of concepts, and promote better academic achievement. Consequently, teachers are expected to adopt learner-centred approaches that make classroom instruction more meaningful and engaging during Agricultural Science instructional delivery. Agricultural Science is the study and application of biological, physical, environmental, economic, and social sciences to crop production, animal husbandry, natural resource management, and sustainable food systems. It equips learners with scientific knowledge and practical skills necessary for improving agricultural productivity, ensuring food security, and promoting sustainable rural development. According to the Food and Agriculture Organization of the United Nations (2022), agricultural education plays a critical role in developing the knowledge, innovations, and competencies required to transform food systems and achieve sustainable agricultural development. In Nigeria, Agricultural Science is one of the vocational subjects offered at the senior secondary school level to prepare students for careers in agriculture, agribusiness, and related fields while fostering entrepreneurial skills and self-reliance. Despite its importance, students' academic achievement in Agricultural Science has remained unsatisfactory in many secondary schools, as reflected in reports of public examinations and school-based assessments.

Several factors have been associated with students' poor academic achievement in Agricultural Science. These include inadequate instructional materials, poor learning facilities, insufficient practical experiences, low learner motivation, and the continued use of teacher-centred instructional approaches such as the conventional lecture method. West African Examinations Council Chief Examiners' reports have consistently highlighted candidates' poor understanding of practical agricultural concepts, inadequate application of theoretical knowledge, and weak problem-solving skills in Agricultural Science examinations. Similarly, United Nations Educational, Scientific and

Cultural Organization (2023) emphasized that effective science education requires learner-centred pedagogies that actively engage students in inquiry, experimentation, and collaborative problem-solving rather than passive reception of information. Likewise, the Organisation for Economic Co-operation and Development (2020) reported that active learning strategies significantly improve students' conceptual understanding, critical thinking, and academic achievement compared with traditional teacher-dominated instruction. Consequently, continued dependence on lecture-based teaching limits students' opportunities to participate actively in learning and to relate agricultural concepts to authentic farming situations.

To improve Agricultural Science instruction, teachers should adopt learner-centred and activity-based instructional approaches such as practical demonstrations, hands-on experiments, field trips, project-based learning, and technology-supported learning environments. These approaches enable students to connect theoretical concepts with real-life agricultural practices while promoting higher engagement, problem-solving ability, and long-term knowledge retention. The Food and Agriculture Organization of the United Nations (2022) emphasized that experiential and practice-oriented agricultural education is essential for developing competent graduates capable of addressing contemporary agricultural challenges. Similarly, United Nations Educational, Scientific and Cultural Organization (2023) advocated learner-centred pedagogies that encourage active participation, collaboration, and authentic learning experiences. These recommendations align with contemporary educational research, which demonstrates that student-centred instructional strategies produce better academic outcomes than conventional lecture methods.

Simulation-based learning strategy is one of the learner-centred instructional approaches that enables students to learn by interacting with computer-based models, animations, virtual demonstrations, and other digital learning resources that represent real-life situations (Makransky & Petersen, 2021). Through simulations, learners are able to observe agricultural processes, manipulate virtual equipment, and practise decision-making in a safe learning environment. This instructional approach promotes active participation, enhances students' engagement and interest, and improves conceptual understanding by providing authentic learning experiences (Radianti et al., 2020; Hamilton et al., 2021). Recent empirical evidence supports the effectiveness of simulation-based learning in improving students' academic achievement, motivation, and scientific understanding. For example, Pang et al. (2025) reported that virtual simulation technologies significantly enhance students' conceptual understanding, scientific inquiry skills, and academic achievement when integrated into classroom instruction. Similarly, Adeyemi et al. (2024), in a systematic review of simulation technologies in agricultural education, concluded that simulation-based instruction generally improves students' academic achievement, engagement, and learning outcomes.

Despite these reported benefits, the application of simulation-based learning in Agricultural Science education appears to be limited, particularly in public secondary schools in Nigeria. Classroom instruction continues to rely largely on the conventional lecture method because of inadequate technological facilities, limited teacher capacity in educational technology, and poor access to digital instructional resources. More importantly, the review by Adeyemi et al. (2024) revealed that most existing studies on simulation-based learning in agricultural education were conducted in higher education institutions, with relatively few focusing on secondary school students. In addition, available studies have concentrated mainly on Biology, Chemistry, Physics, medical education, engineering, and university agricultural programmes, leaving limited empirical evidence on the effectiveness of simulation-based learning for improving secondary school students' achievement in Agricultural Science, particularly in Abia State.

Another issue that remains unresolved is whether male and female students benefit equally from simulation-based learning. While some studies have suggested that technology-supported instructional approaches favour one gender, others have reported no significant gender differences, indicating that the evidence remains inconclusive (Hamilton et al., 2021; Makransky & Petersen, 2021). These inconsistencies, together with the limited empirical evidence on simulation-based learning in secondary school Agricultural Science and the scarcity of studies conducted in Abia State, created the need for this study. It was against this background that this study investigated the effect of simulation-based learning strategy on students' academic achievement in Agricultural Science in public secondary schools in Abia State.

Agricultural Science is an important vocational subject in the Nigerian secondary school curriculum because it equips students with the knowledge, practical skills, and entrepreneurial competencies needed for agricultural production and national development. However, despite its importance, students' academic achievement in Agricultural Science has remained unsatisfactory in many public secondary schools. This situation has been attributed partly to the continued use of conventional lecture methods, which provide limited opportunities for active student participation and practical learning. On the other, many of the innovative instructional strategies such as Simulation-based learning could be used to supplement is useful conventional lecture methods.

Simulation-based learning strategy has been identified as an innovative learner-centred instructional approach that can enhance students' engagement, conceptual understanding, and academic achievement through the use of interactive computer-based models and virtual learning experiences. According to Sulaiman, Mustapha and Ibrahim (2016), Simulation is a strategy that fits well with the principles of students-centered and constructive learning. Although studies have reported positive learning outcomes associated with simulation-based learning (Ogbonnaya , 2021), its

application in the teaching of Agricultural Science at the secondary school level appears to be limited, particularly in public secondary schools in Abia State. Furthermore, existing studies have focused mainly on other science subjects and higher education, while findings on the influence of gender remain inconsistent.

If this situation persists, students may continue to record poor academic achievement in Agricultural Science, thereby limiting the acquisition of the knowledge and practical skills required for agricultural productivity and self-reliance. It was against this background that this study investigated the effect of simulation-based learning strategy on students' academic achievement in Agricultural Science in public secondary schools in Abia State.

The purpose of this study was to determine the effect of simulation-based learning strategy on students' academic achievement in Agricultural Science in public secondary schools in Abia State. Specifically, the study sought to:

1. determine the effect of simulation-based learning strategy on students' academic achievement in Agricultural Science.
2. determine the interaction effect of teaching method and gender on students' academic achievement in Agricultural Science.

The following research questions guided the study:

1. What is the effect of simulation-based learning strategy on students' academic achievement in Agricultural Science?
2. What is the interaction effect of teaching method and gender on students' academic achievement in Agricultural Science?

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

H_{01}: There is no significant effect of simulation-based learning strategy on students' academic achievement in Agricultural Science?

H_{01}: What is the interaction effect of teaching method and gender on students' academic achievement in Agricultural Science?

Methodology

The study adopted a quasi-experimental research design using a non-randomized, non-equivalent pre-test and post-test control group design involving intact classes. The design was considered appropriate because it permits the investigation of cause-and-effect relationships between instructional strategies and students' academic achievement where random assignment of participants to groups is not feasible (McMillan & Schumacher, 2010). The study examined the effect of simulation-based learning strategy on students' academic achievement in Agricultural Science. The design involved one experimental group and one control group. Group A served as the experimental group and was taught using simulation-based learning strategy, while Group B served as the control group and was taught using the conventional lecture method. Both groups were administered a pre-test before treatment and a post-test after treatment using the Agricultural Science Achievement Test (ASAT).

The study was carried out in Abia State, located in the South-East geopolitical zone of Nigeria. The state capital is Umuahia, while Aba serves as its major commercial city. Abia State is divided into three education zones, namely Aba, Ohafia, and Umuahia, with over 280 public secondary schools under the administration of the State Secondary Education Management Board (SEMB, 2024). The state lies between latitudes 4°40′ and 6°14′ North and longitudes 7°10′ and 8° East. The state experiences a tropical climate characterized by distinct rainy and dry seasons, making agriculture one of the major occupations of the people. Farming activities such as crop cultivation, livestock production, fisheries, and poultry farming are widely practiced across the state. Agricultural Science is offered as a core vocational subject in public secondary schools and plays an important role in equipping students with practical agricultural knowledge and entrepreneurial skills. However, despite its importance, students' performance in Agricultural Science in both internal and external examinations has remained unsatisfactory. Consequently, Abia State was considered appropriate for this study because it provides a suitable setting for investigating the effectiveness of simulation-based learning strategy in improving students' academic achievement in Agricultural Science.

The population of the study comprised all Senior Secondary Two (SS2) students offering Agricultural Science in public secondary schools in Abia State during the 2025/2026 academic session. According to records obtained from the State Secondary Education Management Board (SEMB, 2025), the population consisted of 13,288 SS2 students, comprising 6,312 males and 6,976 females. The sample for the study consisted of 96 Senior Secondary Two (SS2) students, comprising 38 male and 58 female students drawn from two public co-educational secondary schools in Abia State. The experimental group consisted of 50 students, while the control group consisted of 46 students. A multistage sampling procedure was employed in selecting the sample. In the first stage,

Umuahia Education Zone was purposively selected because of its accessibility and the availability of schools offering Agricultural Science. In the second stage, Umuahia North Local Government Area was selected through simple random sampling. In the third stage, two co-educational public secondary schools offering Agricultural Science with functional computer facilities were purposively selected. Finally, the intact SS2 Agricultural Science classes in the selected schools were assigned to the experimental and control groups without disrupting the existing class organization.

The instrument used for data collection was the Agricultural Science Achievement Test (ASAT) developed by the researcher. The instrument consisted of 40 multiple-choice objective questions based on selected Agricultural Science topics covered during the treatment period. Section A elicited information on students' demographic characteristics such as gender, while Section B contained the achievement test items. Each item had four response options (A–D), with only one correct answer. The same instrument was used for both the pre-test and post-test, although the arrangement of the items was reshuffled during the post-test to minimize memorization effects.

The Agricultural Science Achievement Test (ASAT), lesson plans, and simulation instructional package were subjected to face and content validation by three experts**.** One expert was drawn from Educational Technology, another from Measurement and Evaluation, while the third was an experienced Agricultural Science educator. The validators examined the instrument for relevance, clarity, appropriateness of language, adequacy of content coverage, and suitability of the test items in measuring students' academic achievement. Their observations and recommendations led to the modification, rewording, and replacement of some test items before the final version of the instrument was produced. A table of specification was also developed to ensure adequate representation of the instructional objectives and content areas. The Agricultural Science Achievement Test (ASAT) was trial-tested using 25 Senior Secondary Two students from a public secondary school outside the study area but with similar characteristics to those used for the main study. The data obtained were analyzed using the Kuder–Richardson Formula 20 (KR-20) because the instrument consisted of dichotomously scored multiple-choice items. The analysis yielded a reliability coefficient of 0.78, indicating that the instrument possessed adequate internal consistency and was therefore considered reliable for the study.

The experiment lasted four weeks, during which both groups received two Agricultural Science lessons per week, each lasting approximately 40 minutes. Before the commencement of the treatment, the Agricultural Science Achievement Test (ASAT) was administered to both groups as a pre-test to determine their initial level of academic achievement. The experimental group was taught selected Agricultural Science concepts on Farm Mechanization, including farm tools and implements, tractor operation, farm machinery maintenance, and safety precautions, using

simulation-based learning strategy. Interactive computer simulations, animated instructional videos, virtual demonstrations, and digital models of farm machinery were employed to enable students to observe, manipulate, and interact with agricultural processes that are difficult to demonstrate in a conventional classroom. The instructional activities encouraged learners to explore agricultural concepts actively through guided simulations, group discussions, and teacher facilitation.

The control group was taught the same Agricultural Science topics using the conventional lecture method, supported by the recommended Agricultural Science textbook and chalkboard illustrations. Both groups covered identical instructional objectives and content within the same instructional period. At the end of the four-week treatment, the Agricultural Science Achievement Test (ASAT) was re-administered to both groups as the post-test to determine the effect of simulation-based learning strategy on students' academic achievement in Agricultural Science.

Experimental Schedule

Week	Topic	Experimental Group	Control Group
1	Introduction to Farm Mechanization	Simulation-based learning	Lecture method
2	Farm Tools and Implements	Interactive simulation	Lecture
3	Farm Machinery and Tractor Operation	Virtual simulation	Lecture
4	Maintenance and Safety of Farm Machinery	Simulation activities	Lecture

Control of Extraneous Variables

To minimize threats to internal validity, both groups were taught identical Agricultural Science topics using the same instructional objectives within the same instructional period. Regular Agricultural Science teachers were trained by the researcher before the commencement of the study and served as research assistants to minimize teacher-related bias. The same lesson duration, classroom conditions, and assessment procedures were maintained for both groups. Intact classes were used to avoid disruption of normal school activities and reduce contamination between groups. Furthermore, pre-test scores were used as covariates during data analysis through Analysis of Covariance (ANCOVA) to control for initial differences between the experimental and control groups.

Results

Research Question 1

What is the effect of Simulation-based Learning Strategy on students' academic achievement in Agricultural Science?

Table1: ***Pretest and Posttest Mean Scores of Students Taught Agricultural Science Using Simulation-based Learning Strategy***

Groups	N	Pretest $\bar{X}$	SD	Posttest $\bar{X}$	SD	Mean Gain Scores
SBLS	50	16.17	2.44	26.09	2.85	9.92
Lecture Method	46	16.26	2.51	18.55	2.95	2.29
Effect						**7.63**

Data in Table 1 shows that the students taught Agricultural Science using Simulation-based Learning Strategy had a pretest mean score of 16.17 with a standard deviation of 2.44 and a posttest mean score of 26.09 with a standard deviation of 2.85, while those taught using the lecture method had a pretest mean score of 16.26 with a standard deviation of 2.51 and a posttest mean score of 18.55 with a standard deviation of 2.95. The result also shows that the Simulation-based Learning Strategy group had a mean gain of 9.92, whereas the lecture method group had a mean gain of 2.29. This indicates that Simulation-Based Learning Strategy produced a higher effect of 7.63 on students' academic achievement than the lecture method.

Hypothesis 1

Simulation-based Learning Strategy has no significant effect on the mean achievement scores of students taught Agricultural Science.

Source	Type III SS	df	Mean Square	F	Sig.
Corrected Model	3496.822	2	1748.411	44.76	.000
Intercept	2168.334	1	2168.334	55.50	.000
Pretest	1278.594	1	1278.594	32.74	.000
Group	823.611	1	823.611	21.09	.000
Error	3634.297	93	39.078		

Total	53324.000	96
Corrected Total	7131.119	95

Decision: Since $p < .05$, reject H_{01}

Table 2 shows that a probability (P)-value of 0.000 was obtained. Since the P-value of 0.000 is less than the 0.05 level of significance, the null hypothesis was rejected. Therefore, Simulation-based Learning Strategy has a significant effect on students' academic achievement in Agricultural Science.

Research Question 2

What is the interaction effect of gender and teaching methods on the mean achievement of students in Agricultural Science?

Table 3: ***Mean Interaction Effect of Gender and Teaching Methods on Students' Academic Achievement in Agricultural Science***

Group	Gender	N	Pretest $\bar{X}$	SD	Posttest $\bar{X}$	SD
SBLS	Male	18	16.26	2.69	26.23	2.78
	Female	32	16.07	2.71	25.59	2.83
	Differences		0.05	-0.04	0.12	0.19
Lecture Method	Male	26	16.33	2.74	18.61	2.79
	Female	20	16.23	2.60	18.49	2.68
	Differences		0.10	0.14	0.12	0.11

Data in Table 3 shows that male students in the Simulation-based Learning Strategy group had a pretest mean score of 16.26 (SD = 2.69), while the female students had a pretest mean score of 16.07 (SD = 2.71). At the posttest, the male and female students recorded mean scores of 26.23 (SD = 2.78) and 25.59 (SD = 2.83), respectively. Similarly, in the lecture method group, the male students had pretest and posttest mean scores of 16.33 (SD = 2.74) and 18.61 (SD = 2.79), while the female students recorded pretest and posttest mean scores of 16.23 (SD = 2.60) and 18.49 (SD = 2.68), respectively. Overall, both the male and female students taught using Simulation-based Learning Strategy obtained higher posttest mean scores than their counterparts taught using the lecture

method, indicating no interaction effect between gender and teaching method on students' academic achievement in Agricultural Science.

Hypothesis 2

There is no significant interaction effect of gender and teaching methods on students' academic achievement in Agricultural Science.

Table 4: ***Analysis of Covariance (ANCOVA) of the Interaction Effect of Gender and Teaching Methods on Students' Academic Achievement in Agricultural Science***

Source	Type III SS	df	Mean Square	F	Sig.
Corrected Model	3942.255	4	985.564	25.21	.000
Intercept	2471.887	1	2471.887	63.24	.000
Pretest	1366.514	1	1366.514	34.96	.000
Teaching Method	824.337	1	824.337	21.09	.000
Gender	52.714	1	52.714	1.35	.248
Method × Gender	15.802	1	15.802	0.40	.529
Error	3556.884	91	39.086		
Total	53324.000	96			
Corrected Total	7499.139	95			

Decision: Since p = .529 > .05, do not reject H_{03}

From Table 4, it can be observed that a probability value of 0.529 was obtained. Since this P-value is greater than the 0.05 level of significance, the null hypothesis was not rejected. Hence, there is no significant interaction effect of gender and teaching methods on students' academic achievement in Agricultural Science. This implies that the gender of the students did not combine with the teaching methods to significantly influence their posttest achievement scores in Agricultural Science. Rather, the improvement in students' academic achievement is attributable to the teaching method employed.

Summary of the Findings

- Simulation-based Learning Strategy has a significant effect on students' academic achievement in Agricultural Science.
- There was no significant interaction effect of teaching method and gender on students' academic achievement in Agricultural Science.

Discussion of the Findings

The findings of the study revealed that simulation-based learning strategy significantly improved students' academic achievement in Agricultural Science compared with the conventional lecture method. Students exposed to simulation-based learning obtained higher post-test mean scores and mean gain scores than those taught using the conventional lecture method. This finding suggests that simulation-based learning promotes active engagement, enhances conceptual understanding, and enables students to visualize agricultural processes that are otherwise difficult to demonstrate in a traditional classroom. The finding is consistent with the study by Makransky and Petersen (2021), who reported that simulation-based learning environments significantly improved students' conceptual understanding and academic performance by providing immersive and interactive learning experiences. The finding also agrees with Radianti et al. (2020), who found that simulation and virtual learning environments enhance learning outcomes, motivation, and students' engagement across science disciplines.

The study further revealed that although male students obtained slightly higher mean achievement scores than female students, the difference was not statistically significant. This indicates that simulation-based learning strategy is equally beneficial to both male and female students. The finding corroborates Hamilton et al. (2021), who reported that simulation-based instructional approaches provide equitable learning opportunities regardless of learners' gender. Similarly, Makransky and Petersen (2021) observed that the effectiveness of immersive learning technologies depends more on instructional design than on students' demographic characteristics. The study also found no significant interaction effect between teaching method and gender on students' academic achievement in Agricultural Science. This implies that the observed improvement in achievement was attributable to the simulation-based learning strategy rather than gender differences. The finding agrees with Radianti et al. (2020), who concluded that well-designed simulation-based instruction benefits learners irrespective of gender. Likewise, Hamilton et al. (2021) found that simulation-supported learning improves students' academic outcomes without significant interaction effects involving gender.

Conclusion

Based on the findings of the study, it was concluded that simulation-based learning strategy significantly improved students' academic achievement in Agricultural Science more than the conventional lecture method. Although male students recorded slightly higher mean achievement scores than female students, the difference was not statistically significant. Furthermore, there was no significant interaction effect of teaching method and gender on students' academic achievement

in Agricultural Science. Therefore, simulation-based learning strategy is an effective instructional approach for improving students' academic achievement in Agricultural Science irrespective of gender.

Recommendations

- Agricultural Science teachers should adopt simulation-based learning strategy in classroom instruction to improve students' academic achievement.
- School administrators and educational authorities should provide schools with simulation technologies and related digital instructional resources for effective teaching of Agricultural Science.
- Since simulation-based learning was found to be effective for both male and female students, teachers should provide equal opportunities for all learners to participate actively in simulation-based instructional activities.

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