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EFFECT OF INTEGRATING ARTS INTO SCIENCE, TECHNOLOGY, ENGINEERING, MATHEMATICS INSTRUCTIONAL APPROACHES ON STUDENTS' INTEREST AND ACHIEVEMENT IN ECOLOGY IN AKWANGA, NASARAWA STATE, NIGERIA

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Abstract

This study investigated the effects of integrating the arts into Science, Technology, Engineering and Mathematics instructional approaches on students' interest and achievement in ecology in Akwanga, Nasarawa State, Nigeria. Two research questions guided the study, and two null hypotheses were tested at the 0.05 level of significance. A quasi-experimental design of the pretest–posttest, non-equivalent control group type was adopted. The population comprised 3,336 Senior Secondary One (SS I) students in the 34 government secondary schools in Akwanga, from which a sample of 169 students (88 males and 81 females) was selected using a multi-stage sampling technique. Three intact classes from randomly selected schools were assigned to two experimental groups (the STEAM and STEM approaches) and one control group (the lecture method). Two instruments, the Ecology Interest Rating Scale (EIRS) and the Ecology Achievement Test (EAT), were used for data collection. The instruments were validated by experts and yielded reliability coefficients of 0.89 and 0.81 respectively. Mean and standard deviation were used to answer the research questions, while Analysis of Covariance (ANCOVA) was used to test the hypotheses. The findings revealed that students taught with the STEAM approach showed significantly higher interest in ecology than those taught with the STEM approach or the lecture method, while the interest of students taught with the STEM approach did not differ significantly from that of students taught with the lecture method. Students taught with the STEAM approach also recorded the highest achievement, followed by those taught with the STEM approach, while those taught with the lecture method recorded the lowest. The study concludes that integrating the arts into STEM instruction enhances both students' interest and achievement in ecology. It recommends that Biology teachers adopt the STEAM approach in teaching ecology and that teachers be trained to design arts-integrated lessons.

Keywords: STEAM, STEM, arts integration, ecology, interest, achievement.

Introduction

Biology education plays an important role in national development, as it equips learners with the knowledge and skills needed to understand living things and to apply that understanding to health, agriculture and the environment. In Nigeria, Biology is the

science subject most widely offered at the senior secondary level, and for many students it is the only science studied in any depth before they leave school. Within the subject, ecology carries particular weight. It deals with how organisms relate to one another and to their physical surroundings, and the SS I syllabus covers ecological factors, habitats, adaptation, food relationships, population studies, nutrient cycling and the management of natural resources. In a largely agrarian state such as Nasarawa, these ideas are close to daily life, since soil fertility, bush burning, deforestation, water quality and falling farm yields are familiar problems that ecology helps to explain.

Ecology also connects classroom science with the environmental problems that Nigeria faces as a nation. Desertification in the north, gully erosion in the south-east, oil pollution in the Niger Delta, the loss of forest cover and the decline of wildlife are all, at root, ecological problems, and responding to them requires citizens who understand how ecosystems function and how human activity alters them. For senior secondary students, ecology is often the first point at which Biology is applied to such issues in a systematic way. A sound grasp of the topic prepares them for further study in agriculture, environmental science, forestry, fisheries and public health, and it equips those who leave school after the senior secondary level to make informed decisions about land use, sanitation and the conservation of natural resources in their own communities. How well ecology is taught in secondary schools therefore matters well beyond the examination hall.

Despite its importance, ecology is one of the topics that students find most difficult. Many of its central ideas, such as energy flow through trophic levels, population density and the carbon and nitrogen cycles, describe processes that cannot be observed directly in a classroom. Students therefore construct their own explanations, and these are often mistaken. Ogundare et al. (2020) found widespread misconceptions about basic ecological concepts among senior school students in Oyo State and showed that these misconceptions are shaped by how the topic is taught. Students' drawings of ecosystems reveal similar gaps: Siswandari et al. (2026) found that tenth-grade students could depict the links between living and non-living components but struggled to represent the mechanisms behind ecological phenomena, even after instruction. These difficulties are reflected in the performance of candidates from Akwanga in the Senior Secondary Certificate Examination (SSCE) in Biology, which is presented in Table 1.

Table 1: Senior Secondary Certificate Examination (SSCE) Results in Biology in Akwanga, Nasarawa State (2019–2025)

Year	Candidates Registered	Credit Passes (A1–C6)	% Credit Passes	Failures (D7–F9)	% Failures
2019	3,901	1,911	48.99	1,990	51.01
2020	3,507	1,571	44.80	1,936	55.20
2021	3,110	1,201	38.62	1,909	61.38
2022	3,482	1,590	45.66	1,892	54.34
2023	3,418	1,421	41.57	1,997	58.43
2024	3,817	1,520	39.82	2,297	60.18
2025	3,900	1,480	37.95	2,420	62.05

Source. Universal Basic Education Resource Centre (UBERC), Lafia, Nasarawa State (2025).

Table 1 shows that the proportion of candidates from Akwanga who obtained credit passes (A1–C6) in SSCE Biology remained below 50 per cent in every year from 2019 to 2025. The credit pass rate was highest in 2019 (48.99 per cent) and fell to 38.62 per cent in 2021. It recovered to 45.66 per cent in 2022 but declined in each of the following three years, reaching 37.95 per cent in 2025, the lowest in the period. Over the same period, the failure rate rose from 51.01 per cent to 62.05 per cent, so that by 2025 more than three in every five candidates failed to obtain a credit pass. Ecology makes up a substantial part of the Biology syllabus, and many of its examination questions require candidates to interpret diagrams, analyse population and energy-flow data and apply concepts to environmental situations. Persistent weakness in the topic is therefore likely to contribute to these results. The lecture method, which still dominates many classrooms, offers little remedy, since it presents ecological processes as definitions to be memorised and gives students few opportunities to observe, represent or apply them.

Beyond examination results, the way ecology is taught also matters for what Nigerian society now expects of school science. Students are expected not only to recall facts but to observe, measure, interpret data, solve problems and communicate their findings. Ecology is well suited to developing these competences, because its content can be studied in the school compound, in nearby farms and streams, and through simple data that students collect themselves. However, whether students develop these competences depends on how the topic is taught. When ecology is reduced to definitions copied from the chalkboard, students have little opportunity to practice the skills the curriculum intends them to acquire.

In response to these challenges, educators have increasingly advocated learner-centred approaches such as integrated Science, Technology, Engineering and Mathematics (STEM) instruction. Integrated STEM teaching combines content from the four disciplines with problem-centred, inquiry-based, design-based and cooperative learning (Thibaut et al., 2018). In an ecology lesson, this might mean counting organisms in a sample plot, graphing the counts, studying a habitat through digital images or video, and designing a simple ecosystem model or conservation plan. Studies have reported that STEM-based instruction improves students' learning outcomes in science (Cao et al.,

2025) and raises secondary school students' achievement in Biology in Nigeria (Usman et al., 2023). Among first-year Biology Education students in Nigerian universities, a technology-enhanced learning environment has likewise been found to improve both interest and achievement (Eya et al., 2024). The evidence base for integrated STEM is now substantial. In their meta-analysis of 66 experimental and quasi-experimental studies, Cao et al. (2025) found that the effects of STEM education were larger on cognitive outcomes than on non-cognitive outcomes such as interest and attitude and larger at the high-school level than at the primary level, with the largest effects reported for problem-oriented forms of teaching. These findings suggest that integrated STEM is well suited to improving achievement among senior secondary students, but that its influence on interest may be more limited in terms of direct relevance to the present study.

The Science, Technology, Engineering, Arts and Mathematics (STEAM) approach extends integrated STEM by adding the arts. Visual art, design, drama, music or the language arts are used alongside the STEM disciplines to explore and communicate ideas, although the definitions and classroom forms of STEAM vary widely (Perignat & Katz-Buonincontro, 2019). In a STEAM lesson on food relationships, students keep the counting, recording and graphing of a STEM lesson, but they also draw and colour the food web as a poster, take the roles of grass, grasshopper, lizard and hawk and act out what happens when one link is removed. The scientific content and the reasoning are the same; what changes is the number of ways in which students represent the ideas and the extent to which they produce something of their own. STEAM has been reported to improve students' conceptual understanding (Ozkan & Umdu Topsakal, 2021) and their motivation towards science (Mater et al., 2023), and gains in self-efficacy have followed both creativity-focused STEAM modules (Conradty et al., 2020) and a combined STEAM and maker curriculum (Jia et al., 2021).

There are sound theoretical reasons to expect the arts to strengthen learning in ecology. Constructivists account of learning hold that students build understanding by acting on objects and ideas, fitting new experiences into existing mental structures or revising those structures when new experiences do not fit (Schunk, 2020). Drawing a food web, constructing a model of a habitat or acting out a feeding relationship are forms of action of this kind, and they give students concrete footholds for processes that cannot be observed directly. Research on multimedia learning adds that people learn more deeply from words and pictures together than from words alone (Mayer, 2021), and arts-based tasks require students to produce such combinations themselves rather than merely view them. Students' own drawings also reveal what they understand. Siswandari et al. (2026) used students' drawings of river ecosystems to show which interactions they could and could not represent, and found that these representations improved with instruction. Arts-based activities can therefore serve both as a means of learning and as a window on students' thinking that teachers can use to identify and correct misconceptions.

Evidence on the effects of STEAM on achievement is growing. A meta-analysis of 20 studies published between 2012 and 2022 reported a moderate average effect of STEAM on students' achievement in science learning, although most of the studies were conducted in South Korea and many at the

elementary level (Asrizal et al., 2023). STEAM programmes have also been implemented successfully in disadvantaged settings; Duo-Terrón et al. (2022) reported marked improvements in pupils' linguistic and mathematical competences after a STEAM programme was introduced in a primary school serving a low-income community. Evidence from senior secondary schools in sub-Saharan Africa, and from Biology topics such as ecology, remain scarce, which limits the extent to which teachers and policymakers in Nigeria can draw on this literature.

Interest and achievement are both important outcomes of such instruction. Interest refers to a learner's focused engagement with particular content and the predisposition to return to it over time (Renninger & Hidi, 2022). According to the four-phase model of interest development, interest begins as situational interest triggered by features of the learning environment, such as novelty, challenge and personal relevance. If the environment continues to provide meaningful engagement, this situational interest is maintained and may develop, through repeated positive experiences, into an emerging and eventually a well-developed individual interest that the learner carries beyond the classroom (Renninger & Hidi, 2022). Instruction therefore plays a decisive part in whether interest grows or fades. It supports attention, effort and persistence, and it influences whether students will continue with a subject beyond the examination. Achievement, on the other hand, is the measurable level of understanding that students attain in a subject, usually assessed through tests. An approach that raises achievement without raising interest may leave students able to pass an examination but unwilling to continue with the subject, while an approach that raises interest without improving achievement may make lessons enjoyable without deepening understanding. It cannot be assumed, however, that more active teaching will automatically raise interest. Wajngurt and Sloan (2019) found that students' interest in further STEM study fell during an arts-integrated chemistry course and that the course did not increase later enrolment in STEM subjects, while Conradty and Bogner (2020) found that a year of STEAM teaching raised students' self-efficacy and creativity but left their career motivation unchanged. Whether a given approach raises interest in a particular topic is therefore an empirical question that has to be tested in context.

While STEM and STEAM instruction have shown promise in improving students' learning, it remains unclear whether the arts component adds anything to the benefits of integrated STEM. Most available studies compare one of these approaches with conventional teaching, so the specific contribution of the arts is rarely isolated. A study that compares STEAM with both STEM and the lecture method can answer this question, because the STEM group differs from the STEAM group only in the absence of the arts. Many studies have also measured achievement alone, leaving open whether the approaches that improve test scores also make students more willing to engage with the subject. Interest and achievement need to be examined together, because an approach that improves one but not the other offers only a partial solution to the problems of ecology teaching. Such evidence is lacking for ecology in Nasarawa State.

In Akwanga Local Government Area of Nasarawa State, the setting of the present study, the weak Biology results shown in

Table 1, together with students' low interest in ecology, have persisted despite sustained efforts to improve the quality of science teaching. This situation calls for instructional approaches capable of making ecological concepts both more engaging and more comprehensible to learners. Empirical evidence on the relative effects of the STEAM and STEM approaches in this context would provide a sound basis for decisions by Biology teachers, curriculum planners, textbook writers and the Nasarawa State Ministry of Education. It is against this background that the present study seeks to determine the effects of integrating arts into science, technology, engineering, mathematics instructional approaches on students' interest and achievement in ecology in Akwanga, Nasarawa State, Nigeria.

Statement of the Problem

Ecology is a compulsory and heavily examined part of the SS I Biology curriculum, yet students in Akwanga continue to show low interest in the topic and weak achievement in it. The lecture method, which still dominates many classrooms, presents ecological processes as definitions to be memorised and offers students few opportunities to observe, represent or apply them. Integrated STEM and arts-integrated STEAM approaches have been promoted as remedies, and studies elsewhere suggest that both can improve learning. Most of these studies, however, compare one approach with conventional teaching. It therefore remains unclear whether the arts component adds anything to the benefits of integrated STEM, and whether the two approaches affect interest and achievement differently. Evidence from Nasarawa State, particularly in ecology, is lacking, so teachers and curriculum planners in the state have little local evidence on which to base their choice of method. The problem of this study, stated as a question, is: What are the effects of the STEAM and STEM instructional approaches, relative to the lecture method, on SS I students' interest and achievement in ecology in Akwanga, Nasarawa State, Nigeria?

Objectives of the Study

The main objective of the study was to determine the effects of integrating the arts into science, technology, engineering and mathematics instructional approaches on students' interest and achievement in ecology in Akwanga, Nasarawa State, Nigeria. Specifically, the study sought to:

i. determine the effect of the STEAM approach, the STEM approach and the lecture method on students' interest in ecology; and
ii. determine the effect of the STEAM approach, the STEM approach and the lecture method on students' achievement in ecology.

Research Questions

The following research questions guided the study:

1. What are the mean interest ratings of students taught ecology using STEAM approach, STEM approach and the lecture method?
2. What are the mean achievement scores of students taught ecology using STEAM approach, the STEM approach and the lecture method?

Statement of Hypotheses

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

H_{O1}: There is no significant difference in the mean interest ratings of students taught ecology using the STEAM approach, the STEM approach and the lecture method.

H_{O2}: There is no significant difference in the mean achievement scores of students taught ecology using the STEAM approach, the STEM approach and the lecture method.

Methodology

This study employed a quasi-experimental design of the pretest–posttest, non-equivalent control group type, comprising two experimental groups and one control group. Experimental group 1 was taught ecology using the STEAM approach, experimental group 2 using the STEM approach, and the control group using the lecture method. The design was considered suitable because intact classes were used, which made the random assignment of individual students impossible (Creswell & Creswell, 2018). The population comprised 3,336 Senior Secondary One (SS I) students (1,950 males and 1,386 females) in the 34 government secondary schools in Akwanga Local Government Area, Nasarawa State, in the 2025/2026 session (Akwanga Education Area Office, 2026). A sample of 169 students (88 males and 81 females) was selected from three randomly chosen co-educational schools using a multi-stage sampling technique. One intact SS I class was used in each school, and the schools were randomly assigned to the STEAM group (59 students), the STEM group (55 students) and the control group (55 students).

Two instruments were used for data collection: the Ecology Interest Rating Scale (EIRS) and the Ecology Achievement Test (EAT). The EIRS consisted of 20 items on a four-point Likert scale, with negatively worded items reverse-scored, yielding possible scores from 20 to 80. The EAT consisted of 40 four-option multiple-choice items covering nine SS I ecology content areas and structured across the levels of Bloom's revised taxonomy, with a maximum score of 40. Both instruments were validated by three experts in the Department of Science, Technology and Mathematics Education, Nasarawa State University, Keffi, and were pilot tested with 30 SS I students at a school outside the sample. The reliability coefficients were 0.89 for the EIRS, estimated with Cronbach's alpha (Taber, 2018), and 0.81 for the EAT, estimated with the Kuder-Richardson Formula 21.

Data were collected in three phases: pretest, a five-week treatment period with one 80-minute double period per week, and posttest. The regular Biology teachers of the sampled classes served as research assistants after a one-week training programme on the lesson plans for their assigned approach. In the STEAM group, students worked in groups of five to draw food webs, act out feeding relationships, build ecosystem models from local materials, design conservation posters and present population data in charts. The STEM group covered the same content in the same group structure through inquiry, ICT-supported explanation, the design of simple models and plans, and quantitative tasks, but without the arts activities. The control group was taught through verbal explanation, chalkboard illustration and note-taking. The instruments were administered by the researcher with the trained research assistants, and the items were reshuffled for the posttest. To limit extraneous influences, the students' own teachers delivered all lessons from standardised lesson plans after common training; each group was located in a separate school to prevent contact between

groups; a five-week interval separated the pretest from the posttest; and the test items were reshuffled between administrations. Data were analysed using means and standard deviations to answer the research questions, and ANCOVA, with the pretest as covariate, was used to test the hypotheses at the 0.05 level of significance, controlling for initial group differences. Bonferroni comparisons identified the pairs of groups that differed, and partial eta squared was reported as the effect size (Field, 2018).

Result

Research Question One: What are the mean interest ratings of students taught ecology using the STEAM approach, the STEM approach and the lecture method?

Table 2: Mean and Standard Deviation of Interest Ratings of Students Taught Ecology Using STEAM, STEM and the Lecture Method

Group		Pre-Interest	Post-Interest
STEAM (EG_1)	Mean	47.58	59.07
	N	59	59
	Std. Deviation	6.871	7.924
STEM (EG_2)	Mean	49.85	55.25
	N	55	55
	Std. Deviation	5.455	5.324
Lecture (CG)	Mean	50.25	56.07
	N	55	55
	Std. Deviation	4.204	4.476

Note. EIRS scores range from 20 to 80.

Table 2 shows that the STEAM group began with the lowest mean interest rating (47.58, SD = 6.87) and finished with the highest (59.07, SD = 7.92), a gain of 11.49 points. The STEM group moved from 49.85 (SD = 5.46) to 55.25 (SD = 5.32), and the lecture group from 50.25 (SD = 4.20) to 56.07 (SD = 4.48). The gains in these two groups (5.40 and 5.82) were about half that of the STEAM group, and the lecture group's posttest mean was slightly above that of the STEM group. The STEAM group also had the largest posttest standard deviation, which shows that students in that group responded to the approach with more varied levels of interest than students in the other two groups.

Hypothesis One: There is no significant difference in the mean interest ratings of students taught ecology using the STEAM approach, the STEM approach and the lecture method.

Table 3: Analysis of Covariance of Students' Interest Ratings by Instructional Approach

Source	Type III SS	df	Mean Square	F	Sig.	Partial η²
Corrected Model	1555.466	3	518.489	16.574	.000	.232
Intercept	2562.427	1	2562.427	81.909	.000	.332
Pre-interest	1092.039	1	1092.039	34.907	.000	.175
Group	**766.438**	**2**	**383.219**	**12.250**	**.000**	**.129**
Error	5161.835	165	31.284			
Total	552952.000	169				
Corrected Total	6717.302	168				

Note. $R^2 = .232$.

Table 3 shows that, after adjusting for pre-interest, the instructional approach had a significant effect on students' post-interest ratings, $F(2, 165) = 12.25$, $p < .001$, partial $\eta^2 = .13$. The null hypothesis was therefore rejected. By conventional benchmarks for partial η^2 (Field, 2018), the effect lies at the boundary between medium and large. Pre-interest was itself a significant covariate, $F(1, 165) = 34.91$, $p < .001$, partial $\eta^2 = .18$, which confirms that adjusting for the initial differences between the intact classes was necessary. The Bonferroni test was used to locate the differences, and the results are presented in Table 4.

Table 4: Bonferroni Multiple Comparisons of Students' Mean Interest Ratings Exposed to STEAM, STEM and the Lecture Method

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
STEAM	STEM	4.847*	1.063	.000	2.277	7.418
	Lecture	4.211*	1.068	.000	1.627	6.795
STEM	STEAM	-4.847*	1.063	.000	-7.418	-2.277
	Lecture	-.637	1.067	1.000	-3.217	1.944
Lecture	STEAM	-4.211*	1.068	.000	-6.795	-1.627
	STEM	.637	1.067	1.000	-1.944	3.217

Based on estimated marginal means. *. The mean difference is significant at the .05 level. b. Adjustment for multiple comparisons: Bonferroni.

Table 4 shows that the adjusted mean interest rating of the STEAM group exceeded that of the STEM group by 4.85 points ($p < .001$) and that of the lecture group by 4.21 points ($p < .001$). The STEM and lecture groups did not differ significantly (mean difference = −0.64, $p = 1.000$). The adjusted differences are larger than the raw differences in posttest means because the STEAM group started from the lowest level of interest. STEAM therefore produced significantly greater interest in ecology than both STEM and the lecture method, while STEM was no more effective than the lecture method in raising interest.

Research Question Two: What are the mean achievement scores of students taught ecology using the STEAM approach, the STEM approach and the lecture method?

Table 5: Mean and Standard Deviation of Achievement Scores of Students Taught Ecology Using STEAM, STEM and the Lecture Method

Group		Pretest	Posttest
STEAM (EG_1)	Mean	18.27	36.42
	N	59	59
	Std. Deviation	1.412	2.541
STEM (EG_2)	Mean	17.15	30.62
	N	55	55
	Std. Deviation	1.008	2.953
Lecture (CG)	Mean	17.53	25.40
	N	55	55
	Std. Deviation	1.345	0.974

Note. EAT scores range from 0 to 40.

Table 5 shows that the three groups began at similar levels of achievement, with pretest means between 17.15 and 18.27, or roughly 43 to 46 per cent of the maximum score. At the posttest the groups had separated clearly. The STEAM group reached a mean of 36.42 (SD = 2.54), a gain of 18.15 points. The STEM group reached 30.62 (SD = 2.95), a gain of 13.47 points, and the lecture group reached 25.40 (SD = 0.97), a gain of 7.87 points. The gain of the STEAM group was more than twice that of the lecture group.

Hypothesis Two: There is no significant difference in the mean achievement scores of students taught ecology using the STEAM approach, the STEM approach and the lecture method.

Table 6: Analysis of Covariance of Students' Achievement Scores by Instructional Approach

Source	Type III SS	df	Mean Square	F	Sig.	Partial η^2
Corrected Model	3499.267	3	1166.422	222.432	.000	.802
Intercept	526.180	1	526.180	100.340	.000	.378
Pretest	31.335	1	31.335	5.975	.016	.035
Group	**3123.511**	**2**	**1561.755**	**297.820**	**.000**	**.783**
Error	865.253	165	5.244			
Total	166216.000	169				
Corrected Total	4364.521	168				

Note. $R^2 = .802$.

Table 6 shows a significant effect of the instructional approach on students' achievement after adjusting for the pretest, $F(2, 165) = 297.82$, $p < .001$, partial $\eta^2 = .78$. The null hypothesis was rejected. The pretest was a significant but weak covariate, $F(1, 165) = 5.98$, $p = .016$, partial $\eta^2 = .035$, which is consistent with the similar starting levels of

the three groups. Table 7 presents the Bonferroni comparisons

Table 7: Bonferroni Multiple Comparisons of Students' Mean Achievement Scores Taught Ecology Using STEAM, STEM and the Lecture Method

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
STEAM	STEM	5.421*	.457	.000	4.315	6.526
	Lecture	10.769*	.442	.000	9.701	11.838
STEM	STEAM	-5.421*	.457	.000	-6.526	-4.315
	Lecture	5.349*	.440	.000	4.285	6.413
Lecture	STEAM	-10.769*	.442	.000	-11.838	-9.701
	STEM	-5.349*	.440	.000	-6.413	-4.285

Based on estimated marginal means. *. The mean difference is significant at the .05 level. b. Adjustment for multiple comparisons: Bonferroni.

All three pairwise differences in Table 7 were significant. The STEAM group outscored the STEM group by 5.42 points and the lecture group by 10.77 points, and the STEM group outscored the lecture group by 5.35 points (all $p < .001$). The approaches therefore ranked in a clear order of effectiveness for achievement: STEAM first, STEM second and the lecture method last.

Discussions

The findings revealed a significant difference in the mean interest ratings of students taught ecology using the STEAM approach, the STEM approach and the lecture method. This indicates that the instructional approach significantly influenced students' interest in ecology. Specifically, students taught with STEAM developed higher interest than those taught with STEM or the lecture method, while the interest of students taught with STEM did not differ significantly from that of the lecture group. This finding aligns with Mater et al. (2023) and Conradty and Bogner (2020), who reported that STEAM activities raised students' motivation, self-efficacy and creativity in science, with Conradty et al. (2020) and Jia et al. (2021), who reported gains in self-efficacy after STEAM instruction and with Perignat and Katz-Buonincontro (2019), who identified engagement as the outcome most consistently associated with STEAM. On the contrary, it contrasts with Wajngurt and Sloan (2019), who found that an arts-integrated chemistry course did not increase students' interest in further STEM study.

The higher interest under STEAM may be attributed to the arts-based tasks, such as drawing food webs, dramatising predator–prey relationships and designing conservation posters, which introduce novelty, allow students to produce something of their own and connect ecology to familiar surroundings. These are the conditions under which situational interest is triggered and maintained (Renninger & Hidi, 2022). The absence of a difference between the STEM and lecture groups suggests that the arts component, rather than integration alone,

raised students' interest. This is consistent with the weaker effect of STEM on non-cognitive outcomes than on cognitive outcomes reported by Cao et al. (2025).

The findings also revealed a significant difference in the mean achievement scores of students taught ecology using the STEAM approach, the STEM approach and the lecture method. This indicates that the instructional approach had a significant effect on students' achievement in ecology. Specifically, students taught with STEAM achieved the highest scores, followed by those taught with STEM, while those taught with the lecture method achieved the lowest. This finding is consistent with Ozkan and Umdu Topsakal (2021), who found that STEAM improved students' conceptual understanding and reduced their misconceptions, and with Usman et al. (2023), who reported that STEM problem-based learning raised Biology achievement among Nigerian secondary school students. It also agrees with the meta-analyses of Asrizal et al. (2023) and Cao et al. (2025), which reported positive effects of STEAM and STEM on science achievement, and with Duo-Terrón et al. (2022), who reported improved competences under a STEAM programme in a disadvantaged school setting.

The superior achievement of the two integrated groups may be attributed to the problem-centred, inquiry-based and cooperative learning that characterise integrated STEM teaching (Thibaut et al., 2018). The further advantage of STEAM may be explained by the additional forms of representation that the arts provide. Learning from words and pictures together supports deeper understanding than learning from words alone (Mayer, 2021), and drawing, modelling and dramatising ecological relationships give students concrete footholds for abstract concepts such as energy flow and trophic levels (Schunk, 2020). Such activities also make students' misconceptions visible so that they can be corrected, as Ogundare et al. (2020) demonstrated for ecology in Nigerian classrooms, and Siswandari et al. (2026) found that students' ability to represent interactions within ecosystems in drawings improved significantly with instruction. However, because each approach was delivered in a single intact class, the size of the achievement advantage should be confirmed in larger studies.

Conclusion

The study concludes that integrating the arts into STEM instruction is more effective than both STEM and the lecture method in improving SS I students' interest and achievement in ecology in Akwanga, Nasarawa State. STEM without the arts improved achievement over the lecture method but did not increase interest, suggesting that the creative and expressive activities of STEAM were the primary source of the increase in interest. Because each approach was delivered in a single intact class, the size of the achievement advantage should be confirmed in larger studies. The direction of the evidence is nevertheless consistent: ecology lessons that let students represent, build and perform ecological ideas produce better learning and stronger engagement than lessons in which students only listen. More broadly, the study shows that the choice of instructional approach in ecology is not neutral. The same content, taught to comparable students over the same period, produced clearly different levels of interest and achievement depending on whether students listened, inquired, or

inquired and created. For a topic as abstract as ecology, and for students in a setting such as Akwanga, approaches that give students more ways to represent and act on ideas offer the best prospect of improving both understanding and engagement.

Recommendations

In view of the findings of this study, the following recommendations are made:

1. Biology teachers in Nasarawa State should adopt the STEAM approach for teaching ecology, using activities such as drawing food webs, dramatising ecological relationships, building ecosystem models and designing conservation posters.
2. Teachers who already use STEM-type activities should add deliberate arts-based tasks to them, since STEM alone did not raise students' interest above the level produced by the lecture method.
3. The Nasarawa State Ministry of Education and the Teaching Service Board should organise regular workshops to train Biology teachers in planning and managing arts-integrated lessons.
4. Curriculum planners and textbook writers should include worked STEAM activities and teacher guides for ecology topics in the senior secondary Biology curriculum and its supporting materials.
5. School administrators should provide basic materials for modelling, drawing and display, and should timetable double periods that allow enough time for group-based STEAM tasks.

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