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Effect of Science-Technology-Society Approach on Creativity in Environmental Conservation Concept among Secondary School Biology Students in Zaria, Kaduna State

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Abstract
Creativity in STEM Education is now widely recognized as an essential 21st century skill, which can be fostered through innovative pedagogy. This study therefore examines the effect of Science-Technology-Society (STS) Approach on creativity in Environmental Conservation Concept among secondary school biology students in Zaria, Kaduna State. The design is quasi-experimental, specifically the non-equivalent pretest, posttest, control group design. A sample of 105 SS2 students from two schools was used for the study. Schools were purposively sampled from 28 public Schools in Zaria Education Zone. Students' Creativity Assessment Test (SCAT) was adapted and used for data collection. Three null hypotheses were formulated to guide the study and were tested using ANCOVA at $P \leq 0.05$ level of significance. Results obtained revealed that students exposed to STS Instructional Approach, exhibited significantly higher level of creativity than those taught concept environmental conservation using Lecture Method. There is no significant difference in the creativity level of male and female students in the experimental group. Gender and treatment were found not to have any significant interaction effects on students' level of creativity. On the basis of these findings, the study advocated for the teaching of Biology for creativity through innovative strategies like STS Approach.
Keywords: Science-Technology-Society, Creativity & Environmental Conservation

Introduction
In a rapidly changing world, globalization has radically reshaped the reality people live in, giving rise to serious global challenges that can only be solved if all of humanity work together (United Nations Department of Economic and Social Affairs (UN DESA), 2017). This is the focal point of the Sustainable Development Goals (SDGs) as it compels the global citizens to work coherently for common good. According to United Nations Official Document (2019), the SDGs are a collection of 17 global goals set by the United Nations General Assembly in 2015 for the year 2030. These goals are meant to improve the life of all around the globe. To be concise, they are a universal call to action to end poverty, protect the planet, reduce illiteracy through quality education and ensure that all people enjoy peace and prosperity (United Nations Sustainable Development Knowledge Platform, 2015). Hence, achieving these goals will involve everyone's participation and involvement. The researcher believes that providing better access to quality education especially in Science, Technology, Engineering and Mathematics (STEM), would go a long way to foster creativity, innovativeness and productivity among the global citizenry for the ultimate achievement of the SDG's come 2030.

Creativity is a complex yet important educational outcome (Liu, *et al*., Zhou, 2022). It has become a socially, academically and individually essential skill in the 21st century such that industries and businesses require it to survive and grow (Belanger, *et al*., 2016). In Science, Technology, Engineering and Mathematics (STEM) Education, creative thinking competence is needed for building individuals who are capable of critical and divergent reasoning in order to generate relevant solutions to the ever more complex problems faced by humanity (Hamza & Mohammed, 2018; Kupers, *et al*., 2019). According to Kampylis and Berki (2014), creative thinking is the kind of thinking that enables students to use their creativity to come up

with ideas, questions, and hypotheses, try out different options, and assess their own ideas, end products, and processes, as well as those of their peers. According to Xie and Paik (2019), creativity can be defined as the process of generating first-of-its-kind and inventive ideas, concepts, or thoughts and putting them together in creative and beneficial ways.

According to the National Policy on Education (FRN, 2013) effective teaching is required to maximize the creative potentials and skills of individuals for self-fulfillment and general development of the society. This implies that certain classroom experiences stimulate and foster creativity among learners. In fact, Rezende-Filho, *et al* (2014) noted that developed countries have since been utilizing various types of student-centered teaching techniques to nurture creativity in their students. This is especially important as it had produced very good quality human resources that had innovatively solved their developmental problems and enhanced their economic growth (Hamza & Mohammed, 2018). Therefore, any underdeveloped or developing country which desires economic, political, social and technological freedom must give priority to teaching STEM for creativity attainment.

Biology is one of the core science subjects taught in the Nigerian senior secondary education level and it is a popular subject among science students (Shuaibu, 2017). As stipulated by the Nigerian Educational Research and Development Council (NERDC, 2013), it has the objectives of preparing students to acquire meaningful and relevant knowledge as well as the ability to apply scientific knowledge to everyday life. Therefore, teaching Biology using approaches that inspire creativity is invaluable as it enables students not only acquire content knowledge but apply them in unique and innovative ways to solving social problems. One such innovative approaches is the Science-Technology-Society (STS) Approach.

Science-Technology-Society (STS) Approach is described by Chowdhury (2016) as an integrated approach to science teaching which involves dealing with students in their own environments and with their own frames of reference. According to Ferguson (2022), it is the teaching and learning of science in the context of human experiences. They observed that through this approach, science is related to students' communities and science instruction is made current and part of the real world of students, making the lessons more exciting, meaningful and stimulating. Ayua (2017) further explained that the STS Instructional Approach involves a combination of several teaching methods like field-trip, discovery, practical experimentation, brainstorming and discussion among others, all in the context of human experience and societal applications. This approach has the potential to stimulate and foster students' creativity as it provides them the opportunity to examine and engage with real-world problems with a view to proffering viable and unique solutions to them (Joseph, 2018).

Studies in Educational Psychology and Neurophysiology such as Bloomberg, *et al*., (2023) and Okamoto, *et al.* (2021) maintain that sex differences occur in cognitive functioning among individuals. On the average, males are reported to outperform females in visual-spatial tasks and mathematical abilities (Ramírez-Uclés, & Ramírez-Uclés, 2020) while females outperform males in verbal abilities (Barel, & Tzischinsky, 2018). These differences in cognitive abilities between sexes have been attributed to a number of biological, social and psychological factors (Ramírez-Uclés, & Ramírez-Uclés, 2020). Since creative thinking is an integral part of cognitive functioning, it is therefore pertinent to examine if sex differences affects its development among students especially in Senior Secondary Schools.

Studies like He, and Wong (2021) and Nakano, *et al*., (2021) indicated that sex differences are good predictors of creativity skills among adolescents with females being more creative than males. Igbo, Onu, and Obiyo (2015) on the contrary, revealed that male secondary school students are more creative than their female counterparts. However, Usman, *et al*., (2018) showed that male and female secondary school students are not significantly different in their creativity traits when subjected to the same instructional treatment. This study therefore seeks to examine whether gender affects students' creativity in Biology when taught using STS Instructional Approach.

It is part of the national goals of science education in Nigeria to cultivate inquiring, knowing and rational minds for the conduct of a good life and democracy as well as to produce scientists for national development (Hamza & Mohammed, 2018). Kpaji and Ibrahim (2015) also mentioned the stimulation of creativity in learners as part of the objectives of science education in Nigeria. These broad national goals, as crucial as they sound, can only be achieved if STEM students are groomed to cultivate certain scientific skills which enable them to practically turn the goals to real life achievements. One such skills according to Hamza and Mohammed (2018) is creativity. Schreiber (2018) noted that every student has creative potentials and the teachers are the gatekeepers within the creative domain of the classroom. Therefore, they have the capacity to nurture creativity in their students through employing good instructional techniques.

However, this is not the case in Nigeria, as the predominant use of traditional teaching methods like Lecture has resulted in the production of less creative, less skilful and poor quality manpower (Kpaji & Ibrahim, 2015). These individuals are incapable of utilizing their knowledge to solve the developmental issues of the country (Hamza & Mohammed, 2018). Consequently, this has reduced Nigeria to a major consuming rather than producing nation and to a major importing rather than

exporting nation in the global market. Since creativity can be promoted by the use of innovative teaching strategies, this study seeks to investigate the effect of (STS) Instructional Approach on secondary school students' creativity in Biology.

Objectives of the Study

1. Determine the effect of STS Approach on Creativity level in environmental conservation concept among secondary school Biology students in Zaria, Kaduna State.
2. Examine the effect of STS Approach on Creativity level in environmental conservation concept among male and female secondary school Biology students in Zaria, Kaduna State.
3. Investigate any interaction effect between teaching approach and Gender on Creativity level among secondary school Biology students in Zaria, Kaduna State.

Hypotheses

1. There is no significant difference between mean creativity scores of Biology students taught t environmental conservation concept using STS approach and those exposed to lecture method in Zaria, Kaduna State.
2. There is no significant difference between mean creativity scores of Biology male and female students exposed to environmental conservation concept using STS Approach in Zaria, Kaduna State.
3. There is no significant interaction effect between teaching approach and gender on creativity level among secondary school Biology students in Zaria, Kaduna State.

Methodology

The design of this study is Quasi-Experimental, involving the Pretest, Posttest, Non-Randomized Groups Design. The study comprised two groups - an experimental and a control group. Both groups were pre-tested (O_1) on their creativity skills before the administration of treatment. The two groups were taught the concept of 'Conservation of Natural Resources' for a period of five (5) weeks. The experimental group (EG) was exposed to the STS Instructional Approach (X_1) while the control group (CG) was taught using Traditional Lecture Method (X_0). Posttest (O_2) was administered after treatment to determine the effect of the two instructional strategies on students' creativity in the concept taught.

The population of this study consists of all SS2 Biology students (2021/2022 academic session) in the 28 public Senior Secondary Schools in Zaria Education Zone of Kaduna State, Nigeria. The schools have a total of 8,603 SS2 Biology students consisting of 4,878 male and 3,725 female students (Zaria Zonal Education Directorate, 2022). Two schools were purposively sampled from the population based on average-small class size and mixed sex requirements of the researchers. The students in their intact classes were used as sample subjects for this study. The status of the schools as either experimental or control group was determined by simple coin tossing. The experimental group had 55 students (30 males and 25 females) while the control group had 50 students (33 males and 17 females) to give a sample size of 105 students (63 males and 42 females). This sample size is adequate based on the Central Limit Theory which recommends a minimum sample size of 30 students in an experimental study (Kwak, & Kim, 2017).

The instrument used for data collection in this study was Students' Creativity Assessment Test (SCAT) adapted from Animasahum (2007). This instrument consists of 33 items which requires the students to respond on a four-point rating scale of Strongly Disagree, Disagree, Agree and Strongly Agree. The ratings were also graded as 1, 2, 3, 4 and 5. SCAT was used to assess the creative traits attainment of the students in Conservation Concepts. SCAT was validated by two Professors in the Department of Science Education, Ahmadu Bello University, Zaria; one Associate Professor in the Department of Educational Psychology, ABU Zaria; as well as two experienced secondary school Biology teachers with a minimum qualification of B.Sc (Ed.) Biology. The validators were requested to study the instrument and verify if it actually measure what it was meant to test.

The instrument was pilot tested by a single administration on forty (40) SS2 students from a school not sampled for the study but which was part of the population. The reliability coefficient of SCAS was estimated using Cronbach Alpha statistic which produced a value of 0.79 indicating a strong internal consistency. The instrument was used for both pretest and posttest. A total of 30 minutes was given to each respondent to attempt the 33 items on the scale. Students who scored 100 and above were regarded as creative individuals while those who scored below 100 were considered less creative. Research questions were tested using Mean and Standard Deviation statistics while hypotheses testing was done using Analysis of Co-Variance at $P \leq 0.05$ level of significance.

The treatment administration to both groups was carried out as follows; in the initial phase of the study, students within the experiment group were tasked with responding to the pretest instrument (SCAS) during the first week of the treatment period. Subsequently, the researchers organized the students into eleven heterogeneous groups, each comprising five students,

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taking into account their gender and creativity levels. Following this, the researchers employed an instructional package founded on the STS Instructional Approach to teach Conservation Concepts. The instructional activities embedded within the package adhered to the steps delineated by Olorukooba and Lawal (2010) and were facilitated by the researchers, ensuring active student participation and teamwork. The treatment spanned five weeks, during which five topics encompassing Conservation Concepts were covered: Understanding Natural Resources and Conservation, Pollution Reduction, Conservation of Non-Renewable Resources, Conservation of Renewable Resources, and the Benefits of Conservation. Finally, in the sixth week, the students' posttest responses to the SCAS instrument were collected to gauge the impact of the treatment.

During the initial week of the treatment phase, the students in the control group engaged in a pretest by responding to the SCAS instrument. In contrast, the researchers chose not to group the students and instead employed a lesson plan designed around the Traditional Lecture Method to teach Conservation Concepts. This teaching approach was upheld for a duration of five weeks, covering identical topics as those in the experimental group. Subsequently, a posttest employing the SCAS instrument was administered in the sixth week to assess the outcomes of the treatment. Data obtained from the tests was analyzed using ANCOVA at 0.05 significance.

Results

Hypothesis

There is no significant difference between mean creativity scores of Biology students taught environmental conservation concept using STS approach and those exposed to lecture method in Zaria, Kaduna State.

Table 1: Results of ANCOVA on Mean Creativity Scores of Students in the Experimental and Control Groups.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	15930.226[a]	2	7965.113	32.085	.000	.386
Intercept	8375.671	1	8375.671	33.738	.000	.249
Pretreatment Creativity	4169.272	1	4169.272	16.794	.000	.141
Instructional Strategy	8252.451	1	8252.451	33.242	.000	.246
Error	25321.774	102	248.253			
Total	1761572.000	105				
Corrected Total	41252.000	104				

Significant at $P \leq 0.05$

Table 1 indicates that the F-value of 33.242 for instructional strategy is significant at 0.000. This is because, 0.000 is less than the 0.05 level of significance. This means that there is a significant difference in the mean creativity scores between students exposed to STS Instructional Approach and those taught using Traditional Lecture Method in favour of the former. In addition, the estimate of effect size is 0.246. This signifies that instructional strategy accounted for 24.6% of the variance in post-treatment creativity among students when their pre-treatment creativity is controlled. Hence, the null hypothesis is rejected implying that STS Approach significantly enhances Biology students' level of creativity in conservation concepts than traditional lecture method.

Hypothesis 2

There is no significant difference between mean creativity scores of Biology male and female students exposed to environmental conservation concept using STS Approach in Zaria, Kaduna State

Table 2: Results of ANCOVA on Mean Creativity Scores of Male and Female Students in the Experimental Group.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1913.378[a]	2	956.689	3.890	.027	.130
Intercept	5597.063	1	5597.063	22.761	.000	.304
EG_Pre_Trt_Creativity	1428.993	1	1428.993	5.811	.019	.101
EG_Gender	395.741	1	395.741	1.609	.210	.030
Error	12787.167	52	245.907			
Total	1063501.000	55				

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Corrected Total	14700.545	54

Significant at P ≤ 0.05

Table 2 reveals that the F-value of 1.609 for gender (i.e. of the experimental group) is not significant at 0.210. This is because, 0.210 is greater than the 0.05 level of significance. This means that there is no significant difference in the mean creativity scores between male and female students exposed to STS Instructional Approach. Moreover, the estimate of effect size is 0.030. This indicates that sex differences accounted for only 3% of the variance in post-treatment creativity among experimental group subjects when their pre-treatment creativity is controlled. Hence, the null hypothesis is retained implying that gender has no significant influence on Biology students' creative thinking competence in environmental conservation concepts.

Hypothesis 3

There is no significant interaction effect between teaching approach and gender on creativity level among secondary school Biology students in Zaria, Kaduna State

Table 3: Results of ANCOVA on Interaction Effect of Method and Gender on Mean Creativity Gain Scores of Students in the Experimental and Control Groups.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	16808.616[a]	4	4202.154	17.191	.000	.407
Intercept	7617.144	1	7617.144	31.162	.000	.238
Pretreatment Creativity	4380.380	1	4380.380	17.921	.000	.152
Instructional Strategy	8527.019	1	8527.019	34.885	.000	.259
Gender	878.237	1	878.237	3.593	.061	.035
Instructional Strategy * Gender	12.339	1	12.339	.050	.823	.001
Error	24443.384	100	244.434			
Total	1761572.000	105				
Corrected Total	41252.000	104				

Significant at P ≤ 0.05

Table 3 indicates that the F-value of 0.050 is not significant at 0.823 for the interaction between Instructional Strategy and Gender. This is because, 0.823 is greater than the 0.05 level of significance. This means that the interaction effect between instructional strategy and gender on students' creativity level is not statistically significant. Furthermore, the estimate of effect size is 0.001. This signifies that the interaction of instructional strategy and gender explains only 1% of the variance in post-treatment creativity among students when their pre-treatment creativity is controlled. Hence, the null hypothesis is retained implying that gender and teaching method combined do not interact to cause any significant effect on Biology students' creativity level in environmental conservation concepts.

Discussion of Findings

The result in Table 1 shows that the mean creativity score of subjects in the experimental group is significantly greater than that of subjects in the control group. This indicates that the use of STS Approach in teaching environmental conservation concepts in Biology is viable in enhancing students' creative thinking competence at Senior Secondary School level. This could be due to the fact that in the STS class, students are made to identify local communal problems of interest and with the aid of local available resources, think out viable solutions to these problems. Such students are also encouraged to ask questions, perform activities to verify their hypotheses and scrutinize their results in group discussions. These do not happen in the lecture group. Therefore, the creative thinking competence of students in the experimental group has been greatly enhanced. This result corroborates earlier findings like Joseph (2018), and Usman, Joseph and Isah (2018). From the findings of Joseph (2018), STS Approach significantly enhanced students' creative traits attainment in Biology than the Conventional Lecture Method. Usman, Joseph and Isah (2018) revealed from their findings that the adoption of child-centered and innovative teaching strategies like Laboratory-Based Instruction results in a significantly higher mean creativity attainment scores among secondary school Biology students than the Conventional Lecture Method. Zhang (2021) indicated that Provocation and Emotional Mastery Programmes had significant impact on students' level of creativity. Amirshokoohi (2016) also affirmed that using activity

oriented teaching strategies like the STS Approach increased students' ability to come up with divergent views on issues which is a mark of their creativity.

The result in table 5 shows that the mean creativity scores of male and female students in the experimental group do not differ significantly. This implies the retaining of the null hypothesis which suggests that the STS Instructional Approach is gender friendly in fostering creativity of students in Biology. This is attributable to the nature of STS Approach which involves encouraging all students to question, hypothesize and seek evidence for the validity of their explanations irrespective of sex differences. This finding agrees with the findings of Joseph (2018) as well as Usman, Joseph and Isah (2018). In the findings of Ogunyemi as cited in Betancourt, Valadez, Rodríguez-Naveiras, Flores, and Borges (2022), no significant effect of gender on students' level of creativity was indicated when exposed to provocation and Emotional Mastery Techniques. Joseph (2018) revealed that male and female Biology students do not significantly differ in their creativity attainment when exposed to STS Approach. Similarly, Usman, Joseph and Isah (2018) indicated no significant gender difference in students' creative skills when exposed to Laboratory-Based Instruction. On the contrary, this finding disagrees with Permatasari, Budiyono and Pratiwi (2020) who indicated that male are more creative than female students. The finding could also be said to contradict the assertions of Betancourt, Valadez, Rodríguez-Naveiras, Flores and Borges (2022) who are unanimous on the existence of gender differences in cognitive functioning of which creativity is part.

Findings in Table 6 revealed that there is no significant interaction effect of strategy and gender on students' creativity level. This implies the retaining of the null hypothesis, indicating that the method of teaching does not interact with students' gender in causing any significant change in their level of creativity attainment in Biology. This result is in consonance with the findings of Usman, Joseph and Isah (2018) who in their independent studies indicated no interaction effect of treatment and gender on students' level of creativity attainment.

Conclusion

The result in this study shows that STS Instructional Approach is effective in enhancing the creative thinking competence of secondary school students in Biology when compared with the Traditional Lecture Method. It also indicates that male and female students do not differ significantly in their level of creative attainment when exposed to STS Approach which implies that the strategy is gender friendly. In addition, instructional strategy and gender do not interact significantly to affect students' creativity level. Therefore, stimulating the spirit of inquiry and critical thinking in students through STS Approach should be the priority of Biology teachers when teaching concepts which are sensitive to societal problems like Conservation. Students will form the habits of thinking divergently and acting creatively, which makes them favourably disposed to bringing innovations that leads to scientific and technological breakthroughs.

Recommendations

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

1. Biology teachers should consistently employ the STS approach in classroom instruction for the enhancement of Senior Secondary School students' creativity.
2. School administrators should encourage Biology teachers to de-emphasize the mere transmission of content and focus more on the development of creative thinking skills in students which is a requirement for coping with the ever advancing world.
3. The government should re-engineer the Nigerian educational system to de-emphasize rote and repetitive learning, knowledge for certification and reward for academic intellect. Rather, the system should accentuate the nurturing of students' creative thinking potentials to make it functional and relevant to the needs of the 21st century.

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