Effect of Science-Technology-Society Approach on Creativity and Performance in Ecology among Secondary School Biology Students in Suleja Education Zone, Niger State, Nigeria

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Abstract
This study investigated the effect of Science-Technology-Society (STS) approach on creativity and academic performance in Aquatic and Terrestrial Ecology among secondary school Biology students in Suleja Education Zone, Niger State, Nigeria. A pre-test-Post-test Control Group Quasi-Experimental Design was employed for this study. The population of the study is composed of 2,263 SS2 Biology students from 8 public Senior Secondary Schools in Suleja Education Zone. From this population, 3 co-educational schools were randomly selected, pre-tested and subjected to ANOVA and Scheffes's Test statistics. From these, two (2) schools were found to be statistically equivalent academically and were randomly assigned assigned Experimental and Control groups. The sample for the study consisted of 150 (77males and 73 females) SS2 Biology students from the two academically equivalent Senior Secondary Schools. The students in the experimental group were taught the concept of Aquatic and Terrestrial Ecology for a period of six weeks using the STS Approach while the control group was taught the same the same content using lecture method. The instruments used for data collection are Ecology Performance Test (EPT) and Students' Creativity Assessment Scale (SCAS). The instruments were validated by experts and their reliability coefficients were determined using Pearson Product Moment Correlation (PPMC) and Spear Rank Order Correlation statistics respectively. The reliability coefficient of EPT is 0.87 and was obtained through test-re-test method while that of SCAS is 0.79 and was obtained using split-half (odd-even) method. Three research questions and three null hypotheses guided the study. The research questions were answered using mean, median and standard deviation while t-test independent and Man-Whitney U-test were used to test the null hypotheses at P <0.05 level of significance. Findings revealed that students in the experimental group performed significantly better than those in the control group both in academic achievement and creative traits attainment. However, no significant difference in the academic performance of the experimental group subjects was obtained in relation to gender, indicating that the STS Approach is gender-friendly. Based on the findings, it is recommended among others that Biology teachers should frequently use STS Approach in teaching Biology concepts.

Keywords: Science-Technology-Society, Creativity, Performance, Ecology, Suleja Educational Zone

Introduction

Science is recognized as the foundation upon which the bulk of the present day technological breakthrough is built (Shuaibu, 2017). It is defined by Ihejiamaizu & Ochui (2016) as an organized body of knowledge that is derived from the systematic observation of natural events and condition in order to discover laws and principles that govern phenomena in the natural world. Shaibu (2008) expressed the opinion that Nigeria citizens should pursue Science, Technology and Mathematics Education (STME) to prevent Nigeria from being perpetual slaves to the developed world. However, science requires searching for evidence that explains validity in terms of logic and experimentation. All of these activities exemplify and require creativity. Unfortunately, a focus on creativity and the acts that constitute it are not frequently found in typical Nigerian science classrooms (Bartel, 2001).

Biology is one of the subjects taught in Nigerian Senior Secondary Schools and it is a popular science subject of choice among the students (Shuaibu, 2017). According to Bichi (2008), the popular nature of Biology among the science subjects at Senior Secondary Certificate Examination (SSCE) is attributed to it being softer and relatively easier to learn than Chemistry or physics. Biology is conceptualized by Shuiabu (2017) as a unique life science discipline which deals with animate and inanimate objects, including their structure, function, growth, origin, evolution and distribution. However, Ogonnaya (2011) asserts that when students' result in Biology at SSCE is compared with that of other science subjects like Chemistry and Physics, Biology is usually the poorest.

Robert as cited in Olorukooba & Lawal (2010) defined creativity as the ability to imagine and invent new mental or physical object. According to Robert, creativity is not the ability to create something out of nothing but the ability to generate new ideas by combining, changing or reapplying existing ideas. Grainger, Barnes & Scoffham (2006) see creativity as a cognitive process in which several intelligences are working in harmony and can be applied where seeing, thinking and innovating are combined. It is clear from these definitions that creativity involves a specific kind of thinking- a divergent thinking. It involves all mental abilities, process and manipulative skills that could result in the generation of new ideas and objects. Creative thinking skills as outlined by Olorukooba & Lawal (2010) include exploring ideas, generating possibilities, looking for many answers rather than just one and being curious. These skills are viewed as crucial for educated persons to cope with a rapidly changing world in today's science and technology society. However, children can only learn to think better if schools concentrate on teaching 'how' to do so. There is therefore the need to enhance children's acquisition of these creative thinking skills by intensifying the way science is taught in the classroom as achieving this has the capacity to improve students' achievement in all field of life especially in science and technology (Olorukooba & Lawal, 2010).

Science -Technology- Society (STS) Approach is defined by Yager & Akcay (2007) as an integrated approach to science teaching which involves dealing with students in their own environment and with their own frames of references. It is the teaching and learning of science in the context of human experiences (Yager in Olorukooba & Lawal, 2010). Ayua (2017) sees STS as an approach to determining and experiencing ways that science and technology concepts and processes are handled in society. It is the teaching starts with the application of such concepts on real issues or relevant question and ideas which provide linkages and connections to the concepts for the students. This way, science is related to the society of the students and science instruction is made current and part of the real world of the students, making science classes more exciting and

meaningful for all the students (Olorukooba & Lawal, 2010). The strategy involves 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 (Ayua, 2017).

According to Olorukooba & Lawal (2010), the STS Approach involves the following steps:

- Identification of problems with local interest and impact on the society. For example pollution of the only source of water in the community.
- Use of local resources to locate information that can be used to solve the problem
- Students produce solution to the problem.
- Students discuss the solution among themselves while the teacher moderates the solution.
- The solution is shared with the society to bring about scientific enlightenment among the people.

Teachers on the other hand are required to encourage students to:

- Observe things around their environment;
- Develop the habit of asking questions about things;
- Examine critically what they have heard through radio and television or read from books and magazines.
- Examine actions and solution to issues and problems with a view to offering alternatives viable solutions; and
- Express themselves freely.

However, observations from the Biology classrooms reveal that most teachers do not adopt instructional techniques that could stimulate students' creative thinking skills and academic performance (Ajayi & Osoko, 2013; Ihejiamezu & Ochui, 2016). Like other human traits, creativity cannot grow on its own but requires stimulation to develop fully in children (Salisu, 2017). Biology, whose objectives include the development of scientific attitudes and desirable thinking skills that are pragmatic and environment conscious, could be used to help students develop their creative thinking skills if appropriate instructional strategy is used (Lawal, 2010). In fact, Mohammed (2008) opined that STS Approach has been found to enhance students' understanding of science concepts because it focuses upon the personal needs of the students, societal issues, occupation and careers in science discipline as well as uses human resources in identifying and resolving local issues. Also, studies have shown that using STS approach in science class enhanced the development of creative traits of the students (Yager, et al., 2005; Nwuanyawu, 2005 & Wakili, 2007).

Academic performance as observed by Shuaibu (2017) is the exhibition of knowledge attained or skills development by a student in a subject designed by test scores assigned by teachers. It is influenced by a number of factors such as instructional materials available, class size, qualification and experience of science teachers, teaching strategies employed among others (Salisu, 2016). A number of studies have been carried out on the effects of STS approach on Students' academic performance in various science education disciplines and across different educational levels. For instance, Olorunkooba and Lawal (2010) discovered from their studies that Junior Secondary School students exposed to the STS approach performed significantly better academically than those in the lecture class when taught Basic Science. Therefore, this study is focused on investigating the effect of Science-Technology-Society (STS) Approach on creativity and academic performance in Aquatic and Terrestrial Ecology among secondary school Biology students in Suleja Education Zone, Niger State Nigeria.

Nwagbo & Ugwanyi (2015) opined that stereotype in gender by different cultures also might have some effects on students' performance especially in science. Researches on gender and academic performance such as those of Ibrahim (2012) and Olorukooba, Lawal & Jiya (2012) observed that boys achieved better than girls, but studies by Bunkure (2012) and Dahiru (2013) pointed out that girls achieved better than boys. Researches on gender in relation to the STS Approach have further unveiled the efficacy of the method. Nwosu (2004) and Onu (2007) revealed from their independent studies that there is no significant differences in the mean academic performance scores of male and female students taught using the STS approach. Mohammed (2008) also affirmed that male and female Junior Secondary School Students do not differ significantly in their academic performance when taught Basic Science using the STS approach. It is therefore another aim of this study to examine the effect of Science-Technology-Society (STS) Approach on creativity and academic performance in Aquatic and Terrestrial Ecology among male and female secondary school Biology students in Suleja Education Zone, Niger State, Nigeria.

Statement of the Problem

The yearning for quality and effective instruction delivery has been a long standing objective of science education. The emerging concern for the poor achievement of students in school science and its resultant consequences on the production and development of future scientists, engineers and technologists had led to the search for instructional strategies that promote effective and improved has become a focus of research for two or more decades. The concern of this study is to investigate if the application of STS Approach can be used to enhance the teaching and learning of Ecology as well as foster students' creativity in science among secondary school Biology students in Suleja Education Zone, Niger State, Nigeria.

Research Questions

The following research questions were formulated to guide this research:

i. What is the difference in the mean academic performance scores of SS2 Biology students taught Aquatic and Terrestrial Ecology using STS Approach and those taught the same concept using lecture method.

ii. What is the difference in the mean creativity scores of SS2 Biology students exposed to the STS Approach and those taught using lecture method?
iii. What is the difference in the mean academic performance scores of male and female SS2 Biology student taught Aquatic and Terrestrial Ecology using STS Approach?

Null Hypotheses

The following null hypotheses were formulated to guide the study and were tested at $P \leq 0.05$ level of significance:

Ho1: There is no significant difference in the mean academic performance scores of SS2 Biology students taught Aquatic and Terrestrial Ecology using STS Approach and those taught the same concept using lecture method.

HO2: There is no significant difference in the mean creativity scores of SS2 Biology students exposed to the STS Approach and those taught using lecture method.

HO3: There is no significant difference in the mean academic performance scores of male and female SS2 Biology students taught Aquatic and Terrestrial.

Methodology

This study adopted the Pretest-Posttest Control Group Quasi-Experimental research design. The study comprised two groups: experimental and control groups. Both groups were pre-tested (O1) on the academic performance and creativity traits before the administration of treatment. The two groups were taught the concept of 'Aquatic and Terrestrial Ecology' fo a period of six (6) weeks. The experimental group (EG) was taught using STS Approach (X1) while the control group (CG) was exposed to lecture method (X0). Posttest (O2) was administered after treatment to determine the impact of the two instructional methods on students' creativity academic performance in the concept taught. The population of the study consisted of all SS2 Biology students in 8 public Senior Secondary Schools in Suleja Education Zone of Niger State, Nigeria. The schools have a total of 2,263 SS2 Biology students consisting of 1,380 males and 883 females. The students are already exposed to Biology teaching for at least one year before the study was carried out. The average age of the students is 17 years. The sample of this comprised 150 SS2 Biology students from two randomly selected public co-educational Senior Secondary Schools in the area. The sampling was done as follows: Simple random sampling through balloting was used to select three schools from the six co-educational Senior Secondary Schools in the study area. A general Biology performance test was administered to SS2 Biology students in each of the four schools randomly selected to determine their equivalence in terms of academic performance. This was achieved by subjecting the students' scores to the one way Analysis of Variance (ANOVA) and Scheffe post hoc test. One way ANOVA was used to find out if there are differences between the schools while the Scheffe's Post Hoc test was used to determine which schools are different and the sizes of the differences. The status of the schools were then determined using simple random sampling technique involving simple coin tossing. At the end of this exercise, two schools eventually were chosen and assigned as the experimental group and the control group. Two intact classes, one from experimental school and one from control school were drawn using balloting without replacement to ensure a fair selection of the arm of SS2 students to be used for the study in each school. The sample subjects for each school was intact classes of eighty (80) students for the experimental and seventy (70) students for the control group. The two schools were labelled as 'School A' and 'School B' to represent experimental and control groups respectively. Two instruments were used for collection in this study: Ecology performance Test (EPT) and Students' Creativity Assessment Scale (SCAS).

The Ecology performance Test (EPT) is a 30 multiple choice item test development by the researcher by adapting past WAEC Biology objectives questions to determine the academic performance of students in Aquatic and Terrestrial Ecology. The instrument was developed from six topics of the concept of Aquatic and Terrestrial Ecology. .Student Creativity Assessment Scale (SCAS) was adopted from the Ibadan Creativity Assessment Scale (ICAS) which was developed by Akinboye (1977). It was used to assess the creativity traits attainment of the subject in Biology. SCAS was used to assess the creative traits attainment of the subjects in Biology. SCAS consists of four sections – A, B, C and D. Section A of the instrument sought for Bio-data of the respondents. The respondents were asked to use a 10-point scale to rate themselves on the items listed in sections B, C and D. The respondents were expected to rate items most descriptive of themselves high in an increasing order of magnitude (6,7,8,9); and to rate items least descriptive of themselves low in decreasing order of magnitudes (4,3,2,1 and 0). Zero being the rating for an item that is totally unlike the respondents. Items the respondents are not sure about are rated 5. A total of 30 minutes was given to each respondent to attempt the 89 items on the scale. Students who scored 60 and above were considered divergent thinkers and thus very creative individual while students who scored below 60 were not considered very creative. The measuring scale for the creative for the creative trait is shown in Figure 2:

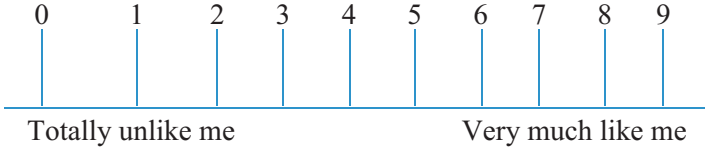


Figure 2: Creative Trait Measuring Scale

Both instrument (i.e. EPT and SCAS) were validated by a panel of three lecturers with a PhD qualification and minimum rank of senior lecturers in the Department of Science Education, Usman Danfodiyo University, Sokoto. One Senior lecturer in the Department

of Educational psychology, Usman Danfodiyo University, Sokoto as well as two experienced Biology teachers with a minimum qualification of B.Sc (Ed.) Biology also constituted the team of validators. The validators were requested to study the instruments and certify if each instrument actually tested what it was meant to test. They were also requested to examine whether the items were clear to avoid ambiguity; certify if they are appropriate for the level of students under study; check for possible errors in the instrument and suggest corrections.

The instruments were pilot tested on a group of forty (40) students in Government Day Secondary School, Maje, which was part of the population but not in the study sample. The reliability coefficient of EPT was found to be 0.87 obtained using Pearson Product Moment Correlation Coefficient (PPMC) statistic via test-retest method proposed by Tuckman (1975) and Sambo (2008). The reliability coefficient of SCAS was found to be 0.79 and was obtained using Spearman Rank Order Correlation Coefficient statistic through split-half method. Both instrument were used for pretest and posttest. The research questions were answered using mean, median and standard deviation statistics while t-test independent and Man-Whitney U-Test were used to test the null hypotheses at $P \leq 0.05$ level of significance.

Results

The results for this study are presented as follows:

HO1: There is no significant difference in the mean academic performance scores of SS2 Biology students taught Aquatic and Terrestrial Ecology using STS Approach and those taught the same concept using lecture method. The comparison of the posttest mean scores of the experimental and control groups in EPT is shown in Table 6:

Table 6: Result of t-test Analysis of Students' Academic Performance in Experimental and Control Groups.

Group	N	Mean	SD	Mean Difference	DF	t-value	p-value	Remark
Experimental	80	46.10	6.88	4.13	148	3.22	0.002	Significant
Control	70	41.97	8.80					

Significant at $P \leq 0.05$

The result in Table 6 shows that there is a mean difference of 4.13 between the academic performance of the experimental and control groups with mean scores of 46.10 and 41.97 and standard deviation scores of 6.88 and 8.80 respectively. Hence, the enhanced performance of the experimental group could be attributed to the treatment given using the STS Approach which answers research question level. This shows that there is statistically significant difference between the mean scores of the experimental and control groups in favour of the experimental group. The null hypothesis of no significant difference is thus rejected. This by implication means that the students in the STS class performed significantly better than those in the lecture class. Hence, STS Approach produced a higher effect on SS2 Biology students' academic performance in Aquatic and Terrestrial Ecology.

Ho2: There is no significant difference in the mean creativity scores of SS2 Biology students exposed to the STS Approach and those taught using lecture method. The result of Man-Whitney Rank Sum Test analysis of the mean scores of students in SCAS is presented in

Table 7: Result of Man-Whitney rank Sum Test Analysis of Students' Creativity in Experimental and Control Groups

Group	N	Median	25%	75%	Median Difference	U Statistic	T Value	P Value	Remark
Expr.	80	179.00	138.50	198.00	51.00	959.00	3444	0.001	Significant
Ctrl.	70	128.00	114.00	140.00					

Significant at $P \leq 0.05$

Table 7 reveals that there is a median difference of 51.00 in the creativity scores between the experimental and control groups with the median scores of 179.00 and 128.00 respectively. Therefore, the enhanced creativity of the experimental group could be attributed to the treatment given using the STS Approach which answers research question two. The result in Table 7 also reveals the Man-Whitney U statistic of 959.00, T-value of 3444.00 and P-value for the creative traits attainment of 0.001 at $P \leq 0.05$ level of significance. As the P-value of 0.001 is much less than 0.05, there exist a statistically significant difference in the mean creativity scores of SS2 Biology students exposed to STS Approach and those taught using lecture method in favour of the STS group. Thus, the null hypothesis of no significant difference is rejected.

Ho3: there is no significant difference in the mean academic performance scores of male and female SS2 Biology students taught Aquatic and Terrestrial Ecology using STS Approach. The result of t-test analysis is presented in Table 8:

Table 8: Result of t-test Analysis of Male and Female Students' Performance in the Experimental Group.

Group	N	Mean	SD	Mean Difference	Df	t-value	p-value	Remark
Male	45	45.64	7.09	1.04	78	0.67	0.506	Not Significant
Female	35	46.69	6.67					

Significant at P ≤ 0.5

The result in Table 8 reveals that there is mean difference of 1.04 between the academic performance of the male and female students in the experimental group with mean scores of 45.64 and 46.69 as well as standard deviation scores of 7.09 and 6.67 respectively. Therefore, male and female students differ only slightly in their academic performance when taught using the STS Approach which answers research question three. Table 8 further reveals a p-value of 0.506 which is much greater than the 0.05 significance level. The shows that there is no statistically significant difference in the mean academic performance scores of male and female SS2 Biology students taught Aquatic and Terrestrial Ecology using the STS Approach. Hence, the null hypothesis is retained.

Summary of Major Findings

The major findings are summarized thus:

1. There is a statistically significant difference in the mean academic performance scores of SS2 Biology student taught Aquatic and Terrestrial Ecology using STS Approach and those taught the same concept using lecture method.
2. There is a statistically significant difference in the mean creativity scores of SS2 Biology students exposed to the STS Approach and those taught using lecture method.
3. There is no statistically significant difference in the mean academic performance scores of male and female SS2 Biology students Aquatic and Terrestrial Ecology using STS Approach.

Discussion of Results

The result in Table 4 shows that the mean score of subjects in the experimental group in EPT is gender that that of the subjects in the control group. This indicates that the use of STS Approach in teaching Aquatic and Terrestrial Ecology Concept in Biology is potentially viable in enhancing students' academic achievement at Senior Secondary School Level. This result is supported by the findings of other scholars and Science Education researchers like Butin (2000), Nwosu (2004), Onu (2007) and Mohammed (2008). In the STS class, students try to relate what they are learning to what is obtained in the society. That is, students try to see the relationship between the science in the classroom and what is happening around them outside the classroom. Also, the students are encouraged to ask questions and perform activities to verify their observations. These do not happen in the lecture group. Thus the academic achievement of the students in the experimental group has been enhanced.

The result in the table 5 shows the median score of experimental group in SCAS is higher than that of the control group. This suggests that the STS Approach does offer an advantage over the lecture method in encouraging growth in the creativity of the students. This is because of the nature of STS Approach which involves encouraging more students' questions, more student hypothesizing and stimulating more students to seek evidence for the validity of the explanations they offered. Not such forum was provided in the control group where all the idea, activities and evaluations focused on what was delivered by the teacher. This finding is in agreement with the findings of Butin (2000), Nwosu (2004), Yager, et al. (2005), Onu (2007) and wakili (2007). In their separate studies, they discovered that using activity oriented teaching strategies increased students' ability to come up with divergent views on issues which is a mark of their creativity.

Finding in Table 6 revealed that there is no significant difference in the academic performance scores of Male and Female students in the experimental group. This implies the retaining of the null hypothesis. Thus, the null hypothesis that states that there is no significant difference in the mean academic performance scores of Male and Female SS2 Biology students taught Aquatic and Terrestrial Ecology using STS Approach is hereby retained. This may be attributed to the fact that the STS approach equally engages actively both Male and Female students during teaching and learning. This result agrees with the findings of Nwosu (2004), Onu (2007) and Mohammed (2008). Nwosu (2004) and Onu (2007) indicated from their independent studies that there is no significant difference in the mean academic performance scores of Male and Female students taught using the STS Approach. While Mohammed (2008) affirmed that Male and Female Junior Secondary School student do not differ significantly in their academic performance when taught Basic Science using the STS Approach.

Conclusion

This study has shown that STS Approach can be used to enhance the academic performance and develop creativity among secondary school Biology Students. In addition, male and female students have been shown not to differ significantly in their academic performance when exposed to STS Approach implying that the strategy is gender friendly. Therefore, stimulating the spirit of inquiry and critical thinking through STS Approach should be the watch word of Biology teachers in classroom instruction. When this is done, students will form the habit of thinking and acting creatively thereby becoming favourably disposed to undertake innovations that could result in scientific and technological breakthroughs.

Recommendations

Based on these findings, the following recommendations are made:

1. Professional bodies such as Science Teachers Association of Nigeria (STAN) should organize

seminars, workshops and conferences on STS approach for Biology teachers across the nation on the effective use of the STS Approach.

2. Biology teachers should consistently employ the STS approach in classroom instruction for the enhancement of Senior Secondary School Students' academic performance and creativity in science.
3. The Federal and State Ministries of Education should provide adequate funds to sponsor Biology teachers on training in novel instructional strategies like the STS Approach which has the capacity to improve academic achievement and creativity of Senior Secondary School Students.
4. School administrations should give enough encouragement and ensure adequate supervision of Biology teachers as they employ the STS Approach in classroom instruction to promote meaningful learning as well as enhance students' creativity.
5. Curriculum planners and developers such as the NERDC should ensure the incorporation of STS Approach in curriculum implementation.

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