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NURTURING STEM SKILL OF CREATIVE THINKING FOR SUSTAINABLE DEVELOPMENT IN SECONDARY SCHOOL SCIENCE STUDENTS' USING EXPERIENTIAL LEARNING APPROACH

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ABSTRACT

The study explored the effect of Experiential Learning Approach (ELA) on secondary school science students' creative thinking for sustainable development in Awka Education Zone. Two research questions, and three null hypotheses tested at 0.05 alpha levels guided the study. The study is a quasi-experimental research, adopting specifically the non-randomized control group design. 4755 senior secondary year 2 (SS2) students constituted the population. Multistage sampling procedure was employed to compose the sample size of 61 (27 males and 34 females) SS2 students. The sampled students who were in two intact classes were randomly assigned to experimental (12 males and 15 females) and control groups (15 males and 19 females) using a flip of a coin. Abbreviated Torrance Test for Adults (ATTA) validated by three experts with a reliability coefficient of 0.54 established using inter-rater reliability test, was used for data collection. Mean and Standard deviation were used in answering the research questions while Analysis of Covariance (ANCOVA) was used to test the null hypotheses. The findings of the study revealed that ELA enhanced science students' creative thinking skill more than CLM. Gender had no significant influence on students' creative thinking, although boys showed slightly more enhanced creative thinking than the girls. Also, there was no interaction effect of teaching methods and gender on science students' creative thinking. Based on results, the study concluded that ELA is a gender-inclusive strategy that improves science students' creative thinking. Based on the conclusion, recommendations were made among which include that ELA should be adopted by science teachers in schools to improve science students' creative thinking.

Keywords: Creative Thinking, Experiential Learning Approach, Science, STEM skills

Introduction

The incessant quest for scientific and technological advancements for sustainable development, has prompted the need to restructure the school science curriculum, especially in developing countries like Nigeria, to incorporate techniques that can help students not only acquire the necessary knowledge needed to grow but also foster in them skills needed for technological advancements, in a 21st century technology-driven world. Oktaviani et al (2019) posited that these skills needed by 21st-century students are skills that can; proffer solutions to environmental problems, meet challenges of changing times in everyday life as well as

produce competent student graduates who can thrive in a global competitive world. These skills of collaboration, critical thinking, creativity and communication, often referred to as the 4Cs' of STEM (Science, Technology, Engineering and Mathematics), according to Umiringtyas et al (2019) have been recognized and described by US-based Partnership for 21st Century Skills (P21), as tools needed for technological advancements as these skills when cultivated, fostered and mastered by students encourages self-dependability, self-exploration and self-motivation that promotes scientific and technological revolutions.

Creative thinking, one of the 4Cs' of STEM, has been recognized as an invaluable skill that is required for innovation. Kampylis and Berki (2014) defined creative thinking as the thinking that enables students to apply their imagination to generating ideas, questions, and hypotheses, experimenting with alternatives, and evaluating their ideas. It is the ability to see various points of view to solve a problem at hand, usually fostered by developing curiosity and imagination through learning activities (Shavab et al., 2023). Mursid (2018) asserted that it is one kind of thinking that solve problems from a singular perspective, avoiding orthodox solutions and thinking outside the box, allowing one to discover connections, meet new challenges and seek resolutions that are uncommon, original and new. Considering these definitions, Abe and Birabil (2022) concluded that creative thinking is the foundational basis for the prospect of numerous innovations in various countries around the world, that even the entire concept of reinventing the world today, through the presence of technology, is creatively complex.

In their respective studies, Andarwati (2019) and Muhali (2019) stated that creativity appears in the thought process when a person solves problems related to: a) Fluency in giving answers and or expressing opinions or ideas. b) Flexibility, namely the ability to express various choices in solving problems. c) Originality, namely the ability to issue various original ideas resulting from one's own thinking. d) Elaboration in the form of skills to broaden ideas and points of view that other people may not think of or can see. e) Tenacity and patience in encountering an unstable situation. Similarly, Abdullah et al (2015), in their study, noted that the characteristics of students who have the skill to think creatively in the learning process include ability to: think smoothly, generate many ideas, solve problems or questions, provide many ways or suggestions for doing various things, always think of more than one answer, and see problems from different points of view.

When effectively nurtured, Crilly (2015) posited that Creative thinking skills help students solve problems, find ideas for solving the problem to the different perspectives, provide a great opportunity for students to exploit their knowledge in learning as well as allow them to provide precise explanations on specific tasks or situations. Supporting the premise, Shavab et al (2023) stated that creative thinking allows students to generate solution ideas from one problem and from something that

already exists to produce something new and can help them in dealing with unexpectedly difficult circumstances. Considering the benefits, the study sought to ascertain the effectiveness of ELA in fostering this skill of creativity in science students.

Experiential learning approach (ELA) also termed "learning by doing" is an instructional approach that promotes activity-engaged learning. Nwuba et al. (2022) defined it as an activity-based instructional approach that provide opportunities for learners to be actively involved in the learning process fostering their problem solving and decision-making skills. It is a form of experience-based learning that encompasses a variety of processes that give students a hands-on, group-based, and reflective learning experience that aids in their full acquisition of new knowledge and skills (Morris, 2020). Hence, ELA may simply be referred to as an activity-based instructional pedagogy that exposes learners to situations (opportunities) that requires hands on minds on engagements and experiences that foster learning.

In using ELA, Kolb and Kolb (2017) emphasized that students must go through four processes/phases, namely concrete experience, reflective observation, abstract conceptualization, and active experimentation, to expand their knowledge, practice problem solving and foster practical learning. The concrete experience stage emphasis on the need of individual learners to be open-minded and able to adapt to systematic approach to solving problems. In the reflective observation process, students are expected to display virtual visualizations of their experiences as well as try to express opinions on why and how they can occur. As such, reflection is essential for transforming experience into learning as it allows one to question the validity and usefulness of experiences. The abstract conceptualization process emphasizes on students understanding of concepts in general, referring to the processes of concrete experience and reflective observation. This abstract conceptualization process requires students to use critical and creative thinking to understand problems. After that, it is completed with the active experimentation process, in which students are expected to use the theory obtained during the abstract conceptualization process to make predictions and solve their problems. When effectively implemented, Scogin et al (2017) explained that students through ELA through concrete experiences, often occurring outdoors or outside of the classroom, provide higher level thinking opportunities as well as opportunities for students to build a range of non-cognitive and cognitive skills such as cooperation, collaboration, independence, responsibility, creativity and critical thinking which in the long run enhances their ability to think, acquire knowledge, be creative, and develop scientific and technological skills, in science.

Science in a 21st century global world has been recognized as the cornerstone for modern day technological advancements. Dianita (2023) defined science as the systematic study of nature or universe, acquired through observation, experimentation, measurement and recording, whose knowledge is applied to

every aspect of life. It is the systematic study of nature, acquired through the use of scientific method (Nwuba et al., 2023). As a field of study, science has done a lot for mankind over the years. For instance, life has been made much easier for man as a result of the advancements in science. That is, through science, one has been able to understand the environment, enabling one manipulate the conditions of the environment to ones benefit.

Supporting the premise, Takko et al (2020) stated that the knowledge of science helps man know more about the universe and with the application of this knowledge, it will be easier for man to explore the environment and his existence. Considering this importance, Okoli (2023) posited that education in science is therefore necessary as it exposes learners to the contents and processes of acquiring scientific knowledge and skills for practical applications in relevant areas to life, which invariably enables the individual to live effectively in the modern age of science and technology. The inculcation of these scientific knowledge and skills can be best achieved through the effective teaching of various science subjects such as biology, chemistry, physics, mathematics, geography, agriculture and health sciences using appropriate pedagogical approaches at the secondary school level. Taking cognizance of this, the study advocated for the adoption of ELA in teaching science subjects in schools to nurture STEM skills acquisition among students, irrespective of gender.

Gender is an attribute assigned to individuals based on their biological characteristics Obikezie et al. (2023) defined it as a universally accepted attribute assigned to individuals based on their sexual differences. Hence gender may simply be defined as a cultural and biological construct that distinguishes males from females. The influence of gender on students' learning outcomes in science, till today, has persevered as a difficult problem to science teachers based on the number of studies carried out to that effect. Still, there is no consensus as to whether it affects science students' creative thinking or not. For instance, Ayua, et al. (2023a), in their study, reported that male students have higher creative thinking than the females while Ayua, et al (2023b); and Nwuba et al (2024), in their respective studies, reported the contrary. On test for significant difference, while others (Ikyernum et al., 2022; Midilli et al., 2022; Terhemba et al., 2023) reported that gender had no significant influence on students' creative thinking, Ulger and Morsunbul (2017) and Zhang et al (2020) reported the contrary, in favour of the females.

These inconsistent findings on gender call for further investigation to ascertain if the influence of gender on science students' creative thinking in science is significant or not. Hence, the study also investigated gender differences in creative thinking among secondary school science students taught using ELA. In light of this backdrop, the researchers were motivated to explore the effect of experiential learning approach on secondary school science students' creative thinking for sustainable development in Awka Education Zone of Anambra State.

Research Questions

The study was guided by the following research questions:

1. What is the difference in the mean creative thinking scores of students taught science concepts with ELA and those taught with Conventional Lecture Method (CLM)?
2. What is the difference in the mean creative thinking scores of students taught science concepts with ELA, with respect to gender?

Hypotheses

The following null hypotheses were formulated and tested at 0.05 alpha levels:

1. There is no significant difference between the mean creative thinking scores of students taught science concepts using ELA and those taught with CLM.
2. No significant difference exists between the mean creative thinking scores of male and female students taught science concepts using ELA
3. Gender and teaching methods have no interactive influence on students' creative thinking.

Research Method

The study is a quasi-experimental research, adopting specifically the non-randomized control group design, since random assignments of members to groups was not possible. A sample of 61 (26 males and 35 females) SS2 science students, drawn using multistage sampling procedure, from the 4755 SS2 science students in Awka Education Zone, constituted the sample size. The Abbreviated Torrance Test for Adults (ATTA), a shortened version of the original Torrance Creative Thinking Test (TCTT), developed by Goff and Torrance in 2002 was adapted to assess students' creative thinking. ATTA validated by three experts, was subjected to pilot testing using inter-rater reliability test, since the test comprised of essay questions. A reliability coefficient of 0.54 was obtained for the ATTA.

With approval from the principals of the two sampled schools, the experiment commenced with the briefing of the six science teachers (research assistants) from the two sampled schools, on two contacts, before the treatment started in earnest. The teachers (Physics, Chemistry and Biology) in the control group were instructed to teach as usual using the lesson plans on CLM, developed by the researchers, while the teachers in the experimental group were briefed on ELA, its features, and how to efficiently implement the instructional approach, during the teaching and learning process, using the lesson plans also developed by the researchers. Following the briefing, the adapted ATTA, which functioned as the pretest, was given to the two drawn intact classes that were divided into the control (15 boys and 19 girls) and experimental (12 boys and 15 girls) groups. Following the pre-testing, the two groups began a 4-week long treatment (teaching) activity. After the instructional sessions, both groups completed a post-test, which was used to calculate the post-test score. The data obtained from the two tests were analyzed using mean and standard deviation in answering the research questions and ANCOVA (Two-way ANOVA) in testing

the null hypotheses at 0.05 level of significance.

Presentation of Results

Research Question One: What is the difference in the mean creative thinking scores of students taught science concepts using ELA and those taught with CLM?

Table 1: Mean Creative Thinking and Standard Deviation scores of students taught Science using ELA and CLM

		Pretest		Posttest		
Groups	N	Mean	SD	Mean	SD	Gain in Mean
Experimental (ELA)	27	54.19	2.60	72.33	2.08	18.14
Control (CLM)	34	35.35	1.18	41.65	1.96	6.30
Mean Difference		18.84		30.68		11.84

Table 1 shows that the experimental group taught with ELA had the mean creative thinking score of 54.19 in their pretest and 72.33 in their posttest, with a gain in mean of 18.14 while their counterparts taught with CLM had 35.35 and 41.65 in their pretest and posttest respectively, with a gain in mean of 6.30. The mean difference of the gains in mean (11.84) for ELA and CLM, revealed that the experimental group had higher creative thinking scores than those in the control group, indicating that ELA enhanced students' creative thinking in learning more than CLM.

Research Question Two: What is the difference in the mean creative thinking scores of male and female students taught science concepts using ELA?

Table 2: Mean Creative Thinking and Standard Deviation scores of Male and Female students taught Science Concepts using ELA and CLM

		Pretest		Posttest		
Groups	N	Mean	SD	Mean	SD	Gain in Mean
Male	12	49.83	4.61	69.58	2.67	19.75
Female	15	57.67	2.71	74.53	3.03	16.86
Mean Difference		7.84		4.95		2.71

Table 2 reveals that male students taught with ELA had mean creative thinking scores of 49.83 and 69.58 in their pretest and posttest respectively while their female counterparts had 57.67 in their pretest and 74.53 in their posttest. The mean difference in the gains in mean is 2.71. From the gain in means, it can be deduced that male students showed a slightly higher level of creative thinking than their female counterparts, when both are taught using ELA, even though the females had a higher mean post test score.

Null hypothesis One: There is no significant difference between the mean creative thinking scores of students taught science concepts using ELA and CLM.

Table 3: ANCOVA Test of Significant difference in Mean Creative thinking Scores of Students taught science concepts using ELA and CLM

Dependent Variable: PRE_ATTA

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Decision
Corrected Model	6046.779[a]	4	1511.695	15.084	.000	
Intercept	2456.372	1	2456.372	24.510	.000	
POST_ATTA	211.554	1	211.554	2.111	.152	
GENDER	82.817	1	82.817	.826	.367	
METHOD	**840.313**	**1**	**840.313**	**8.385**	**.005**	**Sig.**
GENDER * METHOD	**292.225**	**1**	**292.225**	**2.916**	**.093**	**Not. Sig**
Error	5612.303	56	100.220			
Total	128089.000	61				
Corrected Total	11659.082	60				

a. R Squared = .519 (Adjusted R Squared = .484)

ANCOVA test from table 3 reveals that at an F-value of 8.385, the P-value is 0.005. Since the P-value is less than 0.05 level of significance at df 1 and 56, the null hypothesis is rejected. This reveals that a statistically significant difference exists between the mean creative thinking scores of students taught science concepts using ELA (experimental group) and that of those taught using CLM (control group), in favour of those in the experimental group. This indicates that employing ELA in the classroom enhanced science students creative thinking.

Null hypothesis Two: No significant difference exists between the mean creative thinking scores of students taught science concepts using ELA, with respect to gender

Table 4: ANCOVA Test of Significant difference in Mean Creative thinking Scores of Male and Female Students taught science concepts using ELA

Dependent Variable: PRE_ATTA

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Decision
Corrected Model	449.068[a]	2	224.534	1.253	.304	
Intercept	1108.754	1	1108.754	6.187	.020	
POST_ATTA	39.994	1	39.994	.223	.641	
GENDER	331.465	1	331.465	1.850	.186	Not. Sig
Error	4301.006	24	179.209			
Total	84023.000	27				
Corrected Total	4750.074	26				

a. R Squared = .095 (Adjusted R Squared = .019)

Table 4 ANCOVA test shows that at an F-value of 1.850, the P-value is 0.186. Since the P-value is greater than 0.05 level of significance at df 1 and 24, the null hypothesis is not rejected. Showing that, no statistically significant difference exists between the mean creative thinking scores of male and female students taught science concepts using ELA. This indicates that the ELA significantly enhances science

students' creative thinking, irrespective of gender.

Null hypothesis Three: There is no interaction influence of gender and teaching methods on students' creative thinking

ANCOVA test result from table 3 shows that F-value of 2.916, the P-value is 0.093. Since the P-value is greater than 0.05 level of significant at df 1 and 56, the null hypothesis is not rejected, revealing that there is no interaction effect of gender and methods of teaching on science students creative thinking. This implies that the creative thinking of students in relation to the teaching methods, is not influenced by their gender.

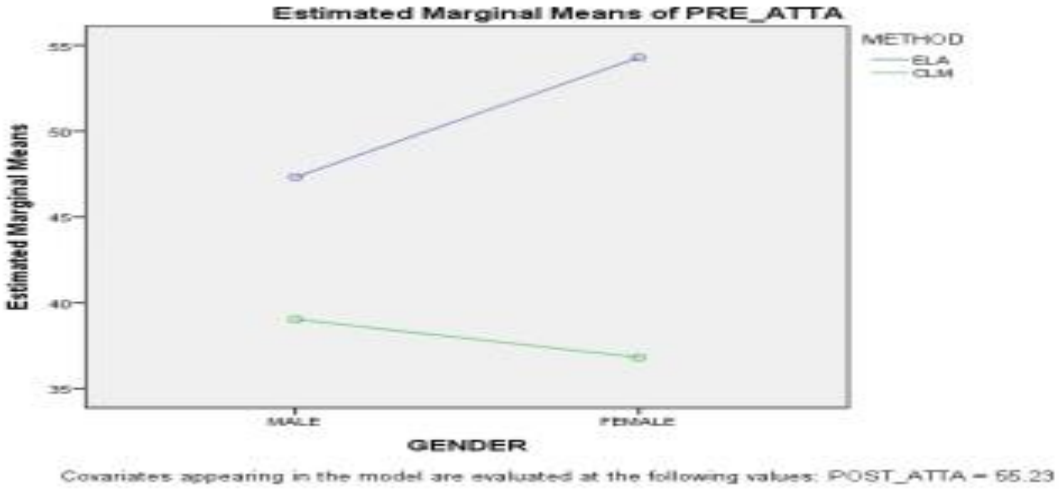


Figure 5: Profile Plot of Interaction influence of gender and teaching methods on science students' creative thinking

Discussion

The study's finding revealed that students taught science concepts using ELA showed a higher mean creative thinking score than their counterparts taught with CLM. This difference in mean was proved to be statistically significant by the test of null hypothesis 4 in table 3 of the study. This statistically significant improvement shown by the students in the experimental group could be attributed to the nature of the instructional approach (ELA) which exposed students to concrete opportunities, encouraging them to experience things for themselves and obtain firsthand information.

In using ELA, students were exposed to activities that helped them; develop and build their knowledge of science concepts and procedures; gave them opportunities to explore their own self; provided them with a similar set of experiences so that everyone participated in classroom discussions despite their socio-economic status, thereby encouraging thinking vast and outside the box, rather than memorizing the correct response, in efforts to proffer solutions to problems, boosting their creativity. ELA

principle diminishes dependence upon authority as its implementation in learning environments puts the students into the center, providing richer learning opportunities that foster creative and critical thinking skills.

The findings of the study lend credence to that of Chesimet et al (2016) that ELA had a significant effect on students' mathematical creativity as students taught with ELA performed better than their counterparts in the control group taught with conventional teaching method. The findings of the study also concur with that of Ayua et al (2023a), Ayua et al (2023b), and Suana et al (2023) who reported in their respective studies that activity-based innovative approaches similar to ELA significantly enhanced students' creative thinking when compared to conventional approaches.

On gender, the findings of the study revealed that ELA improved science students creative thinking irrespective of gender, although the improvement was more for the males than the females. Further testing for significant between means in table 4, however revealed that the difference between gender, when both are taught using ELA, is not statistically significant. This statistically insignificant difference in gender maybe attributed to the nature of ELA, which provided equal opportunities for both male and female to be actively engaged throughout the learning process boosting their confidence, self-esteem, creativity, critical thinking, communication and collaborative skills. The findings of the study agree with that of Ayua et al (2023a), Ayua et al (2023b), Ikyernum et al (2022); Midilli et al (2022) and Terhemba et al (2023) who reported in their respective studies that activity-based innovative approaches, similar to ELA, enhanced science students' creative thinking irrespective of gender. The findings however disagreed with that Ulger and Morsunbul (2017) and Zhang et al (2020) who reported a significant difference between gender, in favour of the females.

On interaction effect, the finding of the study from table 7 revealed that there was no significant interaction effect of gender and teaching methods on science students' creative thinking. This implies that the effect of teaching methods across gender on creative thinking of students was consistent. The finding of the study disagrees with the findings of Ayua et al (2023a) and Ayua et al (2023b), who reported in their studies on creative thinking that that there was interaction effect of gender and teaching methods on students' creative thinking.

Conclusion

The study established that ELA significantly improved science students' critical thinking ability and creative thinking irrespective of their gender, as the experimental group taught with ELA had higher mean critical thinking ability and creative thinking scores than their counterparts taught with the CLM. The study also revealed a non-significant influence of teaching methods and gender on science students' critical thinking ability and creative thinking. In light of this, it is therefore pertinent to say that ELA is a gender friendly approach of learning that

nurtures students' critical thinking ability and creative thinking

Recommendations

In the light of the findings of the study, the following recommendations were made:

1. Science teachers in secondary schools should adopt the use of ELA to nurture science students' critical thinking ability and creative thinking for sustainable development.
2. Seminars, symposia, workshops, and conferences should be organized for science teachers by education stakeholders, including the government and professional bodies like Science Teachers' Association of Nigeria (STAN) to familiarize teachers with innovative instructional approaches such as ELA.
3. Greater emphasis should be placed on student-student interaction during the teaching and learning process as this will enable students learn from each other those things they cannot learn from the teacher or textbooks, hence enhancing their critical thinking ability and creative thinking.
4. Curriculum planners and developers should redesign the science curriculum (and make policies) that will incorporate the use of ELA in the teaching and learning of science in secondary schools to foster in students the skills of critical and creative thinking.
5. Teacher training colleges and institutions should emphasize and adopt ELA in training pre-service biology teachers.
6. School administrators and educational stakeholders should provide instructional facilities and materials that will help teachers effectively implement, and students learn using ELA.

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