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Probing Experiential Learning Approach Effect on Critical Thinking Ability of Secondary School Student's in Biology

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ABSTRACT

The study explored the effect of Experiential Learning Approach (ELA) on secondary school students' critical thinking ability in biology in Awka Education Zone. Two research questions, and three null hypotheses tested at 0.05 alpha levels guided the study. The study is quasi-experimental research, adopting specifically the non-randomized control group design. 4755 senior secondary year 2 (SS2) students constituted the population. Multi-stage sampling procedure was employed to compose the sample size of 53 (15 males and 38 females) SS2 students. The sampled students who were in two intact classes were randomly assigned to experimental and control groups using a flip of a coin. Adapted Watson-Glaser Critical thinking appraisal (WGCTA) validated by experts with a reliability coefficient of 0.71 established using Kuder-Richardson 21, 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 students' critical thinking ability in biology more than CLM. Gender had no significant influence on students' critical thinking ability in biology. Also, there was no interaction effect of teaching methods and gender on students' critical thinking in biology. As a result, the study concluded that ELA is a gender-inclusive strategy that improves students' critical thinking. Based on the conclusion, recommendations were made among which include that ELA should be adopted by biology teachers in schools to improve students' critical thinking in biology.

Keywords: Experiential Learning Approach (ELA), Critical Thinking Ability. Biology, Gender

INTRODUCTION

In today's competitive society, the rapid pace of scientific advancements necessitates a revamped educational curriculum that emphasizes strategies to develop essential skills such as collaboration, critical thinking, creativity, and communication—collectively known as the 4Cs of STEM. These skills are crucial for technological progress and have been widely recognized as vital for fostering self-reliance and motivation among students (Kurniahtunnisa et al., 2023; Nwuba et al., 2022a; Dianita, 2023).

Critical thinking, a core component of the 4Cs, involves a rigorous process of evaluating information through observation, experience, and reasoning, which is fundamental for problem-solving and understanding everyday challenges (Lee, 2015; Nwuba et al., 2022a). Recognizing its significance, there is a strong advocacy for

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integrating experiential learning approaches in science education to enhance students' critical thinking capabilities. Experiential learning, or "learning by doing," engages students actively, helping them develop both cognitive and non-cognitive skills through real-world experiences (Morris, 2020; Scogin et al., 2017).

Biology, as a pivotal scientific subject taught in Nigerian schools, plays a critical role in preparing students for careers in various scientific fields such as medicine, pharmacy, and biotechnology (Nwuba et al., 2023a; Owolabi et al., 2019). The subject's relevance underscores the need for teaching approaches like experiential learning, which not only deepen students' understanding but also equip them with the necessary skills to advance in the fields of health and agriculture.

Furthermore, the study considers gender as a significant factor in learning preferences, with historical tendencies showing a division in subject interests between males and females (Chiketa & Okigbo, 2021; Nwoye et al., 2020; Nwuba & Osuafor, 2021; Obikezie et al., 2023). This aspect is crucial as it influences the approach to teaching and the potential impact of experiential learning on students' critical thinking abilities in biology, regardless of gender.

Research Objectives:

The study was guided by the following research questions:

1. What is the difference in the mean critical thinking ability scores of students taught biology with experiential learning approach (ELA) and those taught with conventional lecture method (CLM)?
2. What is the difference in the mean critical thinking ability scores of male and female students taught biology with ELA?

LITERATURE REVIEWS

The theory adopted for the study was David Kolb's theory of experiential learning.

David Kolb's theory of Experiential Learning

Experiential learning theory was propounded in 1984 by an American psychologist, David Kolb. The theory states that learning is a process whereby knowledge is created through the transformation of experience. That is, knowledge results from grasping and transforming of experiences. Kolb developed this theory using his experiential learning model which described two different ways of grasping experience (concrete experience and abstract conceptualization) and two ways of transforming experience (reflective observation and active experimentation). According to Kolb's model, concrete experience provides information that serves as a basis for reflection (reflective observation). From these reflections, one assimilates the information and forms abstract concepts (abstract conceptualization) and from these concepts, develops new theories about the world which they can actively test (active experimentation). Kolb further explained that through the testing of one's ideas, one once again gathers information through experience, thus, cycling back to the beginning of the process.

Kolb's experiential learning theory differs from that of the cognitive and behavioural theorists as it takes a more holistic approach and explains how experiences including cognition, environmental factors, and emotions influence the learning process. The implication of this theory is that the teacher should try and encourage students to construct hypotheses, make decisions and discover principles for themselves as the teacher guides and translates the information to be learnt into a format appropriate to the learner's current state of understanding.

Implementation of Experiential Learning Approach (ELA)

The aim of every innovative instructional method is to bring knowledge to the doorstep of learners through actively engaging them in the learning process. ELA entails any sort of real world, hands-on experience

that allows students to experience the topic that they are learning about directly. It is an approach that emphasizes on learning by doing and reflecting on doing (Okuakaji & Sukolatambaya, 2020). In implementing 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, emphasizes that individual learners should be open-minded and be able to adapt to a 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 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.

To effectively implement the four stages of ELA, Beard and Wilson (2018) asserted that the teacher should take on the role of a facilitator and guide, rather than direct the learning process. Beard and Wilson stressed that as a facilitator, the teacher is expected to Identify an experience in which students will find interest and be personally committed, tie the course learning objectives to activities and direct experiences so that they know what they are supposed to do as well as provide relevant and meaningful resources to help the students succeed while the students are allowed to experiment and discover solutions on their own. When effectively implemented, Andresen et al (2020) posited that experiential learning contributes to students' engagement, deeper learning, better academic performance, and improved career and life skills. Supporting the premise, Gisoi et al (2023) noted that ELA helps students relate to their learning specifically by giving them opportunities to connect new ideas with preexisting ones while building on their prior knowledge, enhancing their critical thinking skills, developing their ability to investigate the unknown, accept uncertainty and build up their self-confidence.

Critical Thinking Ability and its Features

Critical thinking is recognized as a vital cognitive ability essential for collecting, interpreting, analyzing, and evaluating information to reach reliable conclusions, particularly in science and technology (Chiketa & Okigbo, 2021; Kurniahtunnisa et al., 2023). Defined by Slameto (2014), critical thinking involves four key skills: interpretation, analysis, evaluation, and inference. Interpretation involves comprehending and conveying the significance of various experiences and data. Analysis allows for the examination and breakdown of information to support argumentation and evidence-based conclusions.

Evaluation involves assessing claims and making informed decisions, while inference entails synthesizing information from various sources to form hypotheses and conclusions. Fajrianthy and Septarini (2016) emphasize that these skills enable learners to become self-explorative and develop problem-solving abilities. Nwuba et al. (2022a) further note that these skills are crucial for students to understand logical connections and solve problems effectively. This study investigates whether the Experiential Learning Approach (ELA) can enhance students' critical thinking abilities, leveraging these skills to improve educational outcomes.

RESEARCH METHOD

Research Design

In this quasi-experimental study, a non-randomized control group design was employed.

Hypotheses

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

1. No significant difference exists between the mean critical thinking ability scores of students taught biology with ELA and those taught with CLM.
2. There is no significant difference in the mean critical thinking ability scores of male and female students taught biology with ELA.
3. There is no interaction effect of teaching methods and gender on students' critical thinking ability in biology.

Population and Sampling

A sample size of 53 *(15 males and 38 females)* senior secondary year two (SS2) students drawn from the 4755 SS2 students, in Awka Education Zone of Anambra State, Nigeria, using multi-stage sampling procedure were the research participants. The research participants who were in two intact classes were randomly assigned to experimental and control groups using a flip of a coin.

Instrument for Data Collection

An adapted version of the Watson-Glaser Critical Thinking Appraisal (WGCTA) validated by three experts with a reliability coefficient of 0.71 established using Kuder-Richardson 21, was used for data collection.

Experimental Procedure

The experiment commenced with the briefing of the biology teachers (research assistants) from the two sampled schools, on two contacts, before the treatment process. The teacher in the control group was told to carry on as usual using the lesson plans on Conventional Lecture Method (CLM), developed by the researchers, while the teacher in the experimental group was 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 WGCTA, which functioned as the pretest, was given to the two drawn intact classes that were divided into the control (7 boys and 17 girls) and experimental (8 boys and 21 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.

Data Analysis

Data collected from the administered tests were analyzed using mean and standard deviation to answer the research questions while Analysis of Covariance (ANCOVA) was employed at 0.05 alpha levels for testing the null hypotheses. In taking decisions, null hypothesis was rejected if the Probability (P) value is less than or equal to the level of significance (0.05), if otherwise, the null hypothesis was not rejected.

FINDINGS AND DISCUSSION

Research Question one: What is the difference in the mean critical thinking ability scores of students taught biology with experiential learning approach (ELA) and those taught with conventional lecture method (CLM)?

Table 1: Result of mean and standard deviation differences between mean critical thinking ability scores of students taught using ELA and CLM

		Pretest		Posttest		
Groups	N	Mean	SD	Mean	SD	Gain in Mean
Experimental	29	9.31	0.41	11.24	0.48	1.93
Control	24	8.88	0.36	9.25	0.43	0.37
Mean Difference		0.43		1.99		1.56

Table 1 reveals that the experimental group's critical thinking ability mean scores were 9.31 and 11.24 in the pretest and posttest, respectively, with a mean gain of 1.93 while the control group's critical thinking ability mean score was 8.88 in the pretest and 10.29 in the posttest, with a mean gain of 0.37. The 1.56 difference in the gain in means showed that students taught with ELA outperformed those taught with CLM, indicating that ELA instruction was more effective in enhancing students' critical thinking ability.

Research Question two: What is the difference in the mean critical thinking ability scores of male and female students taught biology using ELA?

Table 2: Result of mean and standard deviation differences between mean critical thinking ability scores of students taught using ELA with reference to gender

		Pretest		Posttest		
Gender	N	Mean	SD	Mean	SD	Gain in Mean
Male	8	10.25	1.06	11.25	0.70	1.00
Female	21	8.95	0.41	11.23	0.60	2.28
Mean Difference		1.30		0.02		1.28

Table 2 shows that for the experimental group, the mean critical thinking ability scores for the male students were 10.25 and 11.25 in the pretest and posttest, respectively, with a mean gain of 1.00, while that for the female students was 8.95 in the pretest and 11.23 in the posttest, with a mean gain of 2.28. The 1.28 difference in gains in mean, revealed that female students had improved critical thinking skills more than their male counterparts, when both are taught using ELA.

Testing Hypotheses

Ho1: No significant difference exists between the mean critical thinking ability scores of students taught biology with ELA and those taught with CLM.

Table 3: ANCOVA Test of Significant Difference between the Mean Critical Thinking Ability Scores of Students Taught Biology Using ELA and those Taught Using CLM

Dependent Variable: WGCTAPretest					
Source	Type III Sum of Squares	Df	Mean Square	F	P-value
Corrected Model	55.122a	2	27.561	4.839	0.12
Intercept	207.890	1	207.890	36.502	.000
WGCTAPosttest	3.045	1	3.045	.535	.468
Method	48.835	1	48.835	8.575	.005

Source	Type III Sum of Squares	Df	Mean Square	F	P-value
Method*Gender	.522	1	.522	.089	.767
Error	234.765	50	5.695		
Total	6006.000	53			
Corrected Total	339.887	52			

a. R Squared = .162 (Adjusted R Squared = .129)

ANCOVA test from table 3 shows that at F-value 8.575, the P-value is .005. Since the P-value is less than 0.05 level of significance at df 1 and 50, the null hypothesis is rejected indicating that a significant difference exists between the mean critical thinking ability scores of students taught biology using ELA (experimental) and those taught using CLM (control group) in favour of those in the experimental group. This reveals that the use of ELA in teaching students enhanced their critical thinking ability.

Ho2: No significant difference exists between the mean critical thinking ability scores of male and female students taught biology using ELA.

Table 4: ANCOVA Test of Significant Difference between the Mean Critical Thinking Ability Scores of Male and Female Students Taught Biology Using ELA

Dependent Variable: Pretest

Source	Type III Sum of Squares	Df	Mean Square	F	P-value
Corrected Model	.577[a]	2	.289	.041	.960
Intercept	152.323	1	152.323	21.438	.000
Posttest	.576	1	.576	.081	.778
Gender	.029	1	.029	.004	.949
Error	184.733	26	7.105		
Total	3850.000	29			
Corrected Total	185.310	28			

a. R Squared = .003 (Adjusted R Squared = -.074)

Data analysis from table 4 shows that at F-value .004, the P-value is 0.949. Since the P-value is greater than 0.05 alpha levels at df 1 and 26, the null hypothesis is not rejected indicating that no significant difference exists between the mean critical thinking ability scores of male and female students taught biology using ELA. Hence, the use of ELA in enhancing students critical thinking ability is not gender biased.

Ho3: There is no interaction effect of gender and teaching methods on students' critical thinking ability in biology

The result from table 3 shows that F-value is .089 and P-value is 0.767. Since the P-value is greater than 0.05 alpha levels at df 1 and 49, null hypothesis is not rejected, showing that there is no interaction effect of gender and methods of teaching on critical thinking ability of students in biology. This implies that the effect of the two instructional methods on the mean critical thinking ability of students in Biology does not depend on their gender.

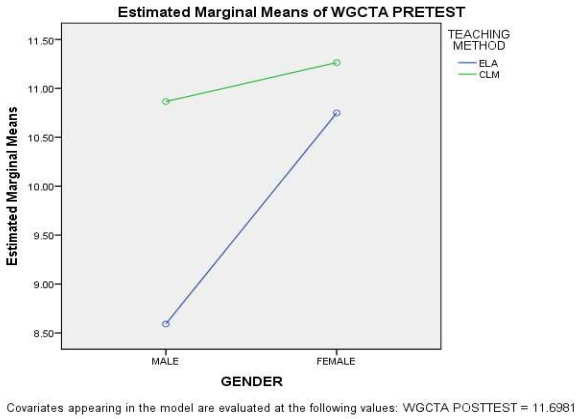

Figure VI: Profile Plot of Interaction Effect of Teaching Method and Gender on the Critical Thinking Ability of Students in Biology

The study demonstrated that students taught biology using the Experiential Learning Approach (ELA) significantly outperformed those taught with the Conventional Lecture Method (CLM) in critical thinking abilities, with the difference being statistically significant. This enhancement is attributed to ELA's hands-on, minds-on activities that foster individual and collaborative work, promoting active participation and problem-solving skills needed for complex real-world issues. These findings are consistent with similar studies in science education, such as those by Duran (2016), Samuel (2017), Dianita (2023), and Kurniahtunnisa et al. (2023), which have shown that innovative teaching approaches like ELA improve critical thinking more effectively than traditional methods.

Regarding gender, the study found that female students under ELA exhibited greater improvement in critical thinking than their male counterparts, aligning with prior research by Moafian and Ganizadeh (2011) and Mahanal et al. (2017). However, this gender difference was not statistically significant, suggesting that ELA's interactive learning environment provides equal opportunities for all students to engage and learn, as supported by Asuai (2013), Samuel (2017), and Bustami et al. (2018), who found no significant gender differences in critical thinking skills.

Additionally, the research indicated no significant interaction effect between teaching methods and gender on students' critical thinking abilities, corroborating findings by Asuai (2013) and Samuel (2017), and suggesting that the benefits of ELA are consistent across gender lines.

CONCLUSION

Considering the findings, the study established that experiential learning approach (ELA), regardless of gender, significantly improved students' critical thinking ability in biology. The study also revealed a non-significant influence of gender and teaching methods on students' critical thinking ability in biology. In light of this, it is therefore pertinent to say that ELA is a gender friendly instructional approach that promotes students' critical thinking ability in biology.

Following the results, the following recommendations were made:

1. Secondary school biology teachers should start incorporating ELA into their lessons to help students' foster their critical thinking ability.
2. To introduce biology teachers to cutting-edge pedagogical approaches like ELA, the government, education stakeholders, and professional organizations like Science Teachers' Association of Nigeria (STAN) should host seminars, symposia, workshops, and conferences for teachers.

3. Curriculum planners and developers should create curricula (and policies) that incorporates ELA in the teaching and learning of biology in secondary schools.
4. When preparing future biology teachers, universities and institutes that provide teacher education should prioritize and implement ELA.

LIMITATION AND FURTHER RESEARCH

The major limitations of the study are outlined as follows:

1. The study was delimited to two intact classes of small size, this as a result may limit the generalizability of the study.
2. The study was carried out using only one level of students (SS2 biology students)
3. The study was conducted using only four topics (Adaptation, Pollution, Decomposition and Conservation) in environmental biology.

In light of these limitations, the following suggestions for further studies were made:

1. A larger sample size should be sampled and studied to improve the generalizability of the study.
2. This study may be conducted using other levels of secondary school students to ascertain if the same effectiveness of ELA will be established.
3. The study could be conducted using other topics in biology to ascertain if ELA is effective in enhancing students' critical thinking ability.

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