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Effect of 5E Learning Cycle Model on Academic Performance of Senior Secondary School Students in Biology in Maiduguri Metropolis, Borno State, Nigeria

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Abstract

Although improving biology achievement remains a major concern in secondary education, evidence on the effectiveness of the 5E Learning Cycle Model in the context of senior secondary schools in Maiduguri Metropolis remains limited. This study examined the effect of the 5E Learning Cycle Model on the academic performance of senior secondary school students in Biology and investigated whether the effect varied by gender. A quasi-experimental design was employed among 864 SSS1 Biology students, from which 86 students (38 males and 48 females) were selected. The sample size was determined using Cochran's table, the school was selected through purposive sampling, and the students were randomly assigned to experimental and control groups, with 43 students in each group. Data were collected using the researcher-developed Biology Achievement Test, which yielded a Cronbach's alpha reliability coefficient of 0.79, and were analyzed using Analysis of Covariance and effect size statistics. The findings revealed that the 5E Learning Cycle Model had a statistically significant positive effect on students' academic performance, with post-test scores favoring those taught

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with the model (F = 55.018, p = .000, ηp^2 = 0.402). The results further showed that the effect of the model varied significantly by gender in favor of female students (F = 6.482, p = .013, ηp^2 = 0.073), indicating a medium effect size. These findings demonstrate that the 5E Learning Cycle Model is an effective instructional approach for improving students' achievement in Biology and suggest its value for more inclusive and responsive classroom practice. The study therefore contributes empirical support for learner-centered science pedagogy and implies that the Borno State Ministry of Education should promote the adoption of the 5E Learning Cycle Model in the teaching of Biology in senior secondary schools.

Keywords: Academic Performance; Biology Education; Gender Difference; Quasi-Experimental Study; 5E Learning Cycle Model

INTRODUCTION

There is a sudden shift of educational system worldwide. Before the 21st century, education systems across the world have been mainly focusing on students' acquisition of content and knowledge. During the late 20th century and early 21st century, the society underwent great changes in terms of economy and technology. This led to an era of scientific revolution which has been significantly defined by science and technology (Cherono, Samikwo & Kabesa, 2021). This necessitated the need for learners to develop 21st century skills that will enable them participate in these global issues. Learners with these skills are expected to be able to think critically, communicate, collaborate with others and be creative providing skills as well as possess skills that align with employers' needs. Science teaching should therefore be modified so as to meet the demands and needs of the society.

In Nigeria, at the Senior Secondary School level, Biology is one of the science subjects taught in addition to Chemistry and Physics subjects and are considered as a tool for technological advancement of any nation (Agoro, Akinoso, Oyediran & Olafare, 2017). The curriculum of science in Nigeria recommends that learners should be actively involved in teaching and learning processes as they should also have the opportunity to present their explanation for phenomenon and solution to concepts in science and technology (Agoro et al., 2017). Biology is an essential science subject and a requirement for further learning in a number of science-related professional courses such as Pharmacy, Medicine, Microbiology

and Agriculture (Nneji et al., 2024). It is a science subject whose teaching and approach are more targeted to practical work and engage students in learning activities in a way that their performance can be improved (Tuyishime & Tukahabwa, 2022).

The 5E learning cycle model developed by Bybee (2015) proposes that learning occurs through a cycle of five phases of Engage, Explore, Explain, Elaborate and Evaluate. The model provides a structured framework for improving student learning and performance across various subjects, including Biology. Each phase promotes active learning and deeper comprehension, which can significantly enhance students' academic performance. The approach is a student-centered teaching approach whose main purpose is to encourage students to learn based upon their own experiences where students work collaboratively to observe, investigate and draw conclusions

At the Engagement phase of 5E Learning Cycle Model; students are engaged and motivated to learn through hands-on activities, questions or real-world scenarios (Bybee, 2015). The concept of student engagement is very crucial in education context especially in the teaching and learning process. The engagement phase is designed to spark students' interest and connect them to the topic. It involves using techniques such as demonstrations, real-world questions or visual aids to stimulate curiosity. In Biology, this could involve discussing local environmental phenomena or using relatable examples to introduce science concepts. The Engagement phase is designed to pique students' curiosity and set the stage for learning by presenting stimulating questions, problems or scenarios that relate to the students' prior knowledge. This phase encourages active participation from the outset, making the learning experience relevant and meaningful.

In the Explore phase of 5E Learning Cycle Model, learners explore the concept or phenomenon through investigations, experiments or data analysis (Bybee, 2015). The exploration phase allows students to actively investigate the subject matter through hands-on activities. Explore phase provides students with a common base of activities within which concepts, processes and skills are identified and conceptual change is facilitated. Also, in the explore phase, students actively engage in hands-on activities, experiments or collaborative learning experiences that allow them to investigate concepts and gather evidence. This phase encourages discovery and inquiry-based learning, as students form hypotheses, test ideas, and learn through direct experience which is particularly valuable in the sciences, where practical understanding is crucial. The students get to record data,

isolate variables, design experiments, create graphs, interpret results, and organize findings while the teacher checks for the students' understanding. In this phase the students are given various opportunities to think freely but within the limits of the activities. The student's role in this phase is vital and the teacher will play a passive role though the teacher will address and guide the students towards building a new concept during this phase. In this phase, "the teacher guides students toward coherent and consistent generalizations, helps students with distinct scientific vocabulary, and provides questions that help students use this vocabulary to explain the results of their exploration. This phase ensures that students not only understand the "how" but also the "why" behind the biological processes they have explored (Bybee, 2015).

In the Explain phase of 5E Learning Cycle Model, learners develop an understanding of the concept or phenomenon through explanations, discussions, and reflections (Bybee, 2015). In the explanation phase, teachers clarify key concepts based on students' experiences in the exploration phase. The focus is on connecting practical activities to theoretical knowledge. For example, after a biology experiment, the teacher may explain the scientific principles behind osmosis or diffusion. Clear explanations help solidify students' understanding and link the material to real-world applications.

The elaborate phase according to Bybee (2015) invites students to apply what they have learned in more diverse context. At this phase students build on their conceptual understanding by participating in activities that connect what they have learned in the previous phase to new events with increased levels of difficulty. Teachers can also use this phase to extend students' understanding and further connect the topic to real world.

At the Evaluate phase of 5E Learning Cycle Model, learners evaluate their understanding through assessments, feedback, and self-reflection (Bybee, 2015). The evaluation phase involves assessing students' understanding and providing feedback. This can take the form of quizzes, tests, or reflective assignments. Continuous evaluation allows teachers to gauge student progress and identify areas for improvement. The Evaluation phase involves both teacher-led and self-assessment of students' understanding and skills. The final Evaluate phase emphasizes assessment and reflection. This phase integrates opportunities for self-assessment throughout the Engage, Explore, and Explain phases, including self-quizzes and structured feedback. Evaluation methods may include formal assessments such as quizzes or tests, as well as more informal methods like group

discussions, presentations, or reflective activities. This phase allows for the measurement of learning progress and helps identify areas where further instruction or practice is needed.

One key reason for the success of the 5E model lies in its alignment with theories of experiential learning and social constructivism. Kolb (2015) asserts that learning is most effective when students actively participate in the construction of knowledge through concrete experiences and reflection. The 5E model promotes this through exploratory tasks, group collaboration, and concept reinforcement. Vygotsky's theory also highlights the importance of social interaction in learning, which is effectively embedded in the Explore and Explain stages of the model (Vygotsky, 1978).

Numerous studies have demonstrated that teaching approaches based on learning cycle models significantly enhance students' academic performance, particularly in science subjects. Cherono et. al. (2021) determined effect of 7E Learning Cycle Model on students' academic achievement in Biology in secondary schools in Kenya and found 7E LCM had a positive effect on students' academic achievement in Biology. The result of students in the experimental group had a higher mean score of 49.44 than those in the control group who had a mean score of 26.08.

Issaka (2025) examined the effect of learning cycle approaches on academic achievement of students in science in Ghana. Results of the study showed no statistically significant difference in the pre-test scores for the three model class groups. However, there was a statistically significant difference in the post-test scores for the three model groups. Also, there was a significant and very large effect of the 3E, 5E, and 7E models on the students taught with the 3E, 5E, and the 7E learning cycle approaches in favour of the 7E. The results further found no significant difference in scores for low- achievers and high achievers taught with the 3E, 5E, and 7E models.

In a study by Lawal (2023) in Lagos, Nigeria, the impact of the 7E Learning Cycle Model on secondary school students' academic performance in chemistry was examined. The research, involving 410 students, compared the academic achievement of students taught using the 7E model to those taught using traditional methods. The study found that students exposed to the 7E model showed significant improvements in their performance. Importantly, there were no significant gender-based differences observed, suggesting that the 7E model may have a gender-neutral effect, benefiting both male and female students equally.

Issaka (2020) determined gender difference in effect of inquiry-based teaching method on students' achievement and retention of concepts in Integrated Science in senior high school in Ghana. The study found out that inquiry-based method of teaching is very rewarding for both the male and female students. Contrary to this finding, Awoderu, Alebiosu and Oludipe (2018) who determined effect of learning cycle models on Nigerian senior secondary school students in Chemistry reported that the 113 male students recorded higher post-test achievement mean score of 22.30 (S.D. = 5.95) than the 75 female students who recorded post-test achievement mean score of 21.99 (S.D. = 5.22.

Adeyemi (2022) conducted a study in Nigeria, examining the effect of the 5E model on senior secondary students' achievement in chemistry. The study involved a quasi-experimental design with 188 students and the results revealed that male students generally outperformed female students in the post-test scores. This gender discrepancy suggests that male students may respond more favorably to the learning strategies embedded in the 5E model. The reasons for this gender-based difference could be linked to variations in learning styles, subject familiarity or societal factors.

Statement of the Problem

Numerous studies have demonstrated that teaching approaches based on learning cycle models significantly enhance students' academic performance particularly in science teaching. These research reports are mainly foreign based. The few studies conducted in Nigeria were carried out in the southern part of the country. The effectiveness of teaching approaches based on learning cycle models in Maiduguri metropolis which is situated in the northeast has not been thoroughly investigated. It is therefore necessary to determine the effectiveness of the 5E learning cycle model on senior secondary school students' academic performance in Biology in Maiduguri metropolis.

Objectives of the Study

The objectives of the study are to determine:

1. effect of 5E learning cycle model on academic performance of senior secondary school students in Biology in Maiduguri Metropolis, Borno State.
2. gender difference in the effect of 5E learning cycle model on academic performance of senior secondary school students in Biology in Maiduguri Maiduguri Metropolis, Borno State.

Research Hypotheses

The following hypotheses were tested in the study:

HO1: 5E learning cycle model does not have significant effect on academic performance of senior secondary school students in Biology in Maiduguri metropolis.

HO2: effect of 5E learning cycle model on academic performance of senior secondary school students in Biology in Maiduguri metropolis does not significantly vary with gender.

METHODOLOGY

The design of the study was quasi-experimental design. This design was utilized since students who participated in the study were found in intact classes. Students were assigned into two treatment groups: experimental and control groups. The quasi-experimental design was suitable because it allowed for the examination of cause-and-effect relationships while accommodating the constraints of conducting research in a natural educational setting where random assignment is not feasible (Cohen & Manion, 2007).

The population for the study was 864 senior secondary school (SSS) 1 Biology students in a science school within Maiduguri metropolis. Purposive sampling was used to select the school because the school had a well-structured Biology laboratory. The sample size for the study was determined using Cochran (1977) table for sample size determination where 86 students (38 males and 48 females) were randomly sampled. Eventually 43 students each were assigned to the experimental and control groups.

The instrument used for data collection was Biology Achievement Test (BAT) developed by the researchers. The instrument was subjected to content and face validation by experts in measurement and evaluation and Science Education units of the Department of Education, University of Maiduguri. The instrument was pilot tested in another senior secondary school. The reliability index of the instrument was ascertained using Cronbach's alpha coefficient and the result of the analysis indicated a value of 0.79 which is highly reliable.

There were three phases of data collection. These were the pre-test – first one week, treatment – four weeks, the post-test – one week. Data collection procedure commenced with the administration of pre-test to both the experimental and control groups to establish baseline performance in Biology before the intervention. The Biology

topics used during classroom teaching for both groups were (the cell, cell and its environment, properties and functions of cell and tissues and supporting systems). The experimental group were taught using the 5E learning cycle model (LCM) over a period of four weeks while the control group received instruction through traditional teaching method for same duration. After the intervention, both groups were administered the post-test.

The data collected were analysed using inferential statistical method. Inferential statistics of Analysis of Covariance (ANCOVA) and effects size were employed to determine the effect of the 5E learning cycle model on students' academic performance controlling for any differences in pre-test. Effect size was used to determine gender difference in effect of the 5E learning cycle on academic performance.

RESULTS

HO1: 5E learning cycle model does not have significant effect on academic performance of senior secondary school students in Biology in Maiduguri Metropolis, Borno State.

Table 1: Result of Analysis of Covariance (ANCOVA) on the Effect of 5E Learning Cycle Model on Academic Performance in Biology with Pre-test as Covariate

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	6466.985[a]	3	2155.662	21.552	.000	.441
Intercept	7103.592	1	7103.592	71.022	.000	.464
Pre-test	78.815	1	78.815	.788	.377	.010
Gender	648.290	1	648.290	6.482	.013	.073
Groups (Traditional vs. 5E)	5502.898	1	5502.898	55.018	.000	.402
Error	8201.573	82	100.019			
Total	95220.000	86				
Corrected Total	14668.558	85				

a. R2 = .441 (Adjusted R2 = .420). Tests of Between-Subjects Effects – Dependent Variable: Post-test.

Table 1. Depicts the result of Analysis of Covariance (ANCOVA) on academic performance of the experimental and control group after intervention.

As shown from table 1, it can be seen that the result shows that the groups variable (teaching method i.e. 5E vs. control) had a significant effect on students' academic performance with F-value of 55.018, p = 0.000, which is less than the 0.05 significance level. Hypothesis one is therefore rejected. This implies that the observed difference in performance between the experimental (5E model) and control (traditional teaching method) groups is p = 0.000 that is unlikely to be due to chance. The partial eta squared ($\eta p^2 = 0.402$) indicates a large effect size, showing that the 5E model accounted for about 40.2% of the variance in post-test scores.

HO2: Effect of 5E learning cycle model on academic performance of senior secondary school students in Biology does not significantly vary with gender.

Table 2: Descriptive Statistics for Each Group

Group	Gender		Mean score (X)		Standard Deviation (SD)	
			Pre-Test	Post-Test	Pre-Test	Post-Test
Experimental	M	18	21.49	59.07	5.20	8.53
	F	25	20.61	59.54	3.62	9.57
Total		43	42.10	118.57	8.82	18.10
Control	M	20	25.23	43.24	6.61	9.68
	F	23	23.64	42.10	7.67	8.66
Total		43	48.87	85.3	14.28	18.34

Table 3: Adjusted Means on Dependent Variable for Groups

Group	Gender			
	M	F	Mean score (X)	Standard Deviation (SD)
Experimental	18	25	58.09	8.42
Control	20	23	43.70	8.31
Total	38	48	101.79	16.73

Table 1 depicts the result of Analysis on Covariance (ANCOVA) on the effect of 5E learning cycle model on academic performance in Biology by gender. As shown from the table 1, it can be seen that the ANCOVA result also revealed a significant effect of gender on post-test scores with an F-value of 6.482, p = 0.013, which is less than the 0.05

level of significance. This means that the probability of the difference in scores between males and females occurring by chance is very low. The partial eta squared value (ηp^2 = 0.073) indicates a medium effect size, suggesting a moderate difference in performance between male and female students in response to the 5E learning cycle model in senior secondary school in Maiduguri Metropolis. Hypothesis two is therefore rejected.

Tables 2 and 3 reveals the mean scores and standard deviations for both experimental and control groups on difference in academic performance in Biology by gender in senior secondary school in Maiduguri Metropolis. Effect has been established. The mean shows the direction of the effect. In the experimental group, at the pre-test, the mean score of males was 21.49 to 59.07 at the post-test. At the pre-test the mean score of females was 20.61 to 59.54 at the post-test. Showing a slight improvement among the female gender than male gender with 0.47 mean score difference among the genders. This suggests that the 5E learning cycle model has significant effect on female gender's academic performance in Biology in senior secondary school

in Maiduguri metropolis.

DISCUSSION

The result of the study on effect of 5E learning cycle model on academic performance of senior secondary school students in Biology in Maiduguri metropolis after adjusting for pre-intervention scores indicates there was a statistically significant difference between the experimental and control groups performance on post-intervention scores (F= 55.018, p = 0.000, eta squared (ηp^2 = 0.402) . The 5E LCM was found to have a positive effect on students' academic performance in Biology probably due to its two vital components: engagement, exploration, explanation, elaboration and evaluation that is unique to this model. The models' emphasis on active learning, critical thinking and student-centered activities aligns with contemporary educational theories that prioritize deep learning over rote memorization. Kolb (2015) asserts that learning is most effective when students actively participate in the construction of knowledge through concrete experiences and reflection. The 5E model promotes this through exploratory tasks, group collaboration, and concept reinforcement. The finding of this study corroborates with that of Issaka (2025) who examined the effect of learning cycle approaches on academic achievement of students in science in Ghana.

Issaka (2025) reported a statistically significant difference in the post-test scores for three model groups in science teaching where a significant and very large effect of the 3E, 5E and 7E models on the students taught with the learning cycle approaches in favour of the 7E was found. Furthermore, Cherono et. al. (2021) reported 7E LCM had a positive effect on students' academic achievement in Biology in Kenya. The result of students in the experimental group had a higher mean score of 49.44 than those in the control group who had a mean score of 26.08.

The result of the study on effect of 5E learning cycle model on academic performance of students in Biology by gender reveals a moderate effect in favour of female students on post-test scores ($F= 6.482$, $p = 0.013$, eta squared ($\eta p^2 = 0.073$). The p- value is less than the 0.05 level of significance means the probability of the difference in scores between males and females occurring by chance is very low. The partial eta squared value ($\eta p^2 = 0.073$) indicates a medium effect size, suggesting a moderate difference in performance between male and female students in response to the 5E learning model in senior secondary school in Maiduguri Metropolis.

The reason for gender difference in the effect of the 5E LCM within the experimental group might be due to partial existence of environmental and situational differences based on the unequal composition of sample with respect to gender within the group with female students being higher than males. This finding is contrary to that of Adeyemi (2022) that determined the effect of the 5E model on senior secondary students' achievement in chemistry in Nigeria and found that male students outperformed female students in the post-test scores. Similarly, Awoderu, Alebiosu and Oludipe (2018) reported a higher mean score of 22.30 (SD. = 5.95) for male students than female students who recorded post-test achievement mean score of 21.99 (SD. = 5.22) in Chemistry among Nigerian senior secondary school students. These findings suggests male students outperforming females in Chemistry.

CONCLUSION

The result of this study have indicated that the 5E learning cycle model have significantly higher tendency of enhancing students' performance in Biology than the traditional teaching method. The model also have significant effect in enhancing female students' performance that their male counterpart.

Educational Implication

The major finding of this study is that 5E Learning Cycle Model was found to be more effective than traditional teaching method. The findings of this study will be applicable to students, teachers, the government and other education stake-holders. Students taught using 5E Learning Cycle Model construct knowledge actively through minds-on and hands-on activities. This gives students opportunity to collaborate with peers and teachers. Through interaction, they are able to learn effectively and develop critical thinking skills. This model requires students to have access to instructional resources such as science apparatus, materials and equipment. The government and other education stake-holders should ensure that infrastructure and instructional resources are available in schools.

Recommendations

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

1. Borno state Ministry of Education should endeavour to introduce the adoption of 5E learning cycle model in the teaching of Biology in senior secondary schools.
2. Biology teachers should be trained on effective utilization of 5E learning cycle model in teaching to build their teaching capacity.

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