

EFFECTS OF 5Es TEACHING CYCLE ON RETENTION ABILITY IN RADIOACTIVITY CONCEPT AMONG SENIOR SECONDARY SCHOOL STUDENTS OF VARIED ABILITY IN ENUGU STATE, NIGERIA

Dr. Mbamalu Oby Justina¹ & Dr. Isiadinso Nnenna Chizoba²

Department of Science Education

¹Alex Ekwueme Federal University Ndufu Alike, Ebonyi State, Nigeria

obymbamalu@gmail.com

²Department of Science Education, Enugu State University of Science and Technology

nnennamuojekwu4@gmail.com

Abstract

This study investigated the effects of the 5Es Teaching Cycle on the retention ability of senior secondary school students of varied ability levels in the concept of Radioactivity in Physics in Enugu State, Nigeria. The study was motivated by the persistent poor retention and achievement of students in Physics, particularly in abstract concepts such as radioactivity. A quasi-experimental pretest-posttest non-equivalent control group design was adopted. The population comprised Senior Secondary Two (SS II) Physics students in public secondary schools in Enugu State. A sample of students selected through purposive sampling participated in the study. The instrument for data collection was the Radioactivity Retention Test (RRT), validated by experts in Physics Education and Measurement and Evaluation, with an established reliability coefficient. Data collected were analyzed using mean, standard deviation, and Analysis of Covariance (ANCOVA). Findings revealed that students exposed to the 5Es Teaching Cycle retained radioactivity concepts significantly better than those taught using the conventional lecture method. The study also found no significant gender difference in students' retention when taught using the 5Es Teaching Cycle. The study concluded that the 5Es Teaching Cycle is an effective learner-centered instructional model capable of enhancing students' retention of Physics concepts irrespective of ability level. It was recommended that Physics teachers be trained through workshops and professional development programmes on the effective implementation of the 5Es Teaching Cycle in secondary school classrooms.

Keywords: 5Es Teaching Cycle, Radioactivity, Retention Ability, Physics Education, Ability Levels.

Introduction

Physics is a fundamental science that explains natural phenomena and provides the foundation for technological advancement and innovation. It contributes significantly to national development through its applications in engineering, medicine, telecommunications, energy production, and environmental management. The teaching and learning of Physics therefore remain essential for preparing students for careers in science, technology, engineering, and mathematics (STEM) fields. Despite its

importance, students' achievement and retention in Physics concepts continue to be a major concern among educators and policymakers in Nigeria and other developing countries (Aina & Adedo, 2020).

Retention refers to the ability of learners to preserve acquired knowledge and recall it when required after a period of instruction. Effective retention is considered a major indicator of meaningful learning because it demonstrates the extent to which students have internalized concepts and can apply them in new situations. Studies have shown that poor retention of scientific concepts contributes significantly to students' low academic achievement in Physics and other science subjects (Achor & Agbidye, 2018). Retention is particularly important in science education because scientific knowledge is cumulative and forms the foundation for understanding more advanced concepts. Students who retain previously learned concepts are better positioned to engage in higher-order thinking, problem-solving, and scientific inquiry activities. Consequently, improving students' retention ability has become a major concern among Physics educators and curriculum developers worldwide (Aina & Adedo, 2020).

One of the Physics concepts that students find difficult is radioactivity. Radioactivity involves the spontaneous disintegration of unstable atomic nuclei accompanied by the emission of radiation. The abstract and microscopic nature of radioactive processes often makes the concept difficult for learners to visualize and understand. Consequently, many students develop misconceptions that negatively affect their retention and application of related concepts (Taber, 2019). The concept requires learners to understand invisible atomic processes that cannot be observed directly in ordinary classroom settings. In addition, the mathematical and theoretical explanations associated with radioactive decay often increase students' cognitive burden during learning. Research has shown that many secondary school students struggle to differentiate among alpha, beta, and gamma radiations and their respective properties, leading to persistent learning difficulties (Akpan & Kennedy, 2020).

The continued use of teacher-centered instructional approaches has been identified as one of the major causes of poor retention and achievement in Physics. Conventional lecture methods often limit students' participation and engagement in learning activities, resulting in superficial understanding of scientific concepts (Bamidele & Oloyede, 2021). This situation has necessitated the adoption of innovative instructional strategies that actively engage learners in the construction of knowledge. In traditional classrooms, students often assume passive roles while teachers dominate instructional activities. Such learning environments provide limited opportunities for students to explore concepts, ask questions, and construct personal meaning from scientific experiences. Consequently, learners may memorize facts temporarily without developing the deep conceptual understanding required for long-term retention (Kola, 2017).

One such innovative strategy is the 5Es Teaching Cycle, which is rooted in constructivist learning theory. The model consists of five interconnected phases: Engagement, Exploration, Explanation, Elaboration, and Evaluation. Through these phases, students actively participate in learning activities that enable them to connect prior knowledge with new experiences, thereby enhancing conceptual understanding and retention (Bybee, 2015). The engagement phase stimulates learners' curiosity and activates prior knowledge relevant to the lesson. During exploration and explanation, students

investigate phenomena, discuss findings, and develop scientific understanding through guided inquiry. The elaboration and evaluation phases further reinforce learning by encouraging students to apply acquired knowledge to new situations and assess their understanding of concepts (Duran & Duran, 2014).

Recent studies have reported that the 5Es Teaching Cycle promotes conceptual change, critical thinking, problem-solving skills, academic achievement, and long-term retention among science learners (Çalik & Kurnaz, 2019; Karpudewan & Roth, 2018). The learner-centered nature of the model provides opportunities for students to investigate scientific phenomena, discuss ideas collaboratively, and apply newly acquired knowledge in diverse situations. The instructional model encourages active participation and promotes meaningful interactions among learners and teachers. By engaging students in hands-on and minds-on activities, the model helps reduce misconceptions and facilitates deeper understanding of scientific concepts. Empirical evidence suggests that students taught using the 5Es Teaching Cycle consistently outperform their counterparts exposed to conventional teaching methods in both achievement and retention measures (Sulaiman et al., 2019; Udo & Udofia, 2020).

Furthermore, students differ in their learning abilities. Ability level remains an important variable in science education because learners process information at different rates and possess varying cognitive capacities. Effective instructional strategies should therefore accommodate these differences and provide equal opportunities for meaningful learning and retention (OECD, 2019). High-ability learners often grasp scientific concepts more quickly than average- and low-ability learners. However, appropriately designed learner-centered instructional approaches can support all categories of learners by providing opportunities for individualized exploration and knowledge construction. Therefore, determining the effectiveness of the 5Es Teaching Cycle across varying ability levels is essential for promoting equity and inclusiveness in Physics classrooms (Tomlinson, 2017). Against this background, this study investigates the effects of the 5Es Teaching Cycle on retention ability in radioactivity concepts among senior secondary school students of varied ability in Enugu State, Nigeria.

Statement of the Problem

Despite the importance of Physics in technological and scientific development, students' retention and achievement in Physics remain unsatisfactory in many Nigerian secondary schools. Reports from examination bodies and research studies have consistently indicated poor performance in Physics, particularly in abstract concepts such as radioactivity. One major factor responsible for this challenge is the persistent use of conventional teaching methods that encourage passive learning and memorization rather than conceptual understanding.

Although several innovative instructional strategies have been recommended for improving science learning outcomes, many Physics teachers still rely heavily on lecture-based instruction. Consequently, students often fail to retain scientific concepts over extended periods. The problem is further compounded by differences in students' ability levels, which influence how they process and retain information. Therefore, the problem of this study is to determine whether the 5Es Teaching Cycle can significantly improve

the retention ability of senior secondary school students of varied ability levels in radioactivity concepts in Physics.

Purpose of the Study

The main purpose of this study was to determine the effects of the 5Es Teaching Cycle on retention ability in radioactivity concepts among senior secondary school students of varied ability in Enugu State. Specifically, the study seeks to:

1. Determine the difference in retention ability between students taught radioactivity concepts using the 5Es Teaching Cycle and those taught using the conventional lecture method.
2. Determine the difference in retention ability among high-, average-, and low-ability students taught radioactivity concepts using the 5Es Teaching Cycle.
3. Determine the difference in retention ability between male and female students taught radioactivity concepts using the 5Es Teaching Cycle.
4. Examine the interaction effect of teaching method and ability level on students' retention ability in radioactivity concepts.

Research Questions

The following research questions were posed for the study.

1. What is the difference in retention ability between students taught radioactivity concepts using the 5Es Teaching Cycle and those taught using the conventional lecture method?
2. What is the difference in retention ability among high-, average-, and low-ability students taught radioactivity concepts using the 5Es Teaching Cycle?
3. What is the difference in retention ability between male and female students taught radioactivity concepts using the 5Es Teaching Cycle?
4. What is the interaction effect of teaching method and ability level on students' retention ability in radioactivity concepts?

Hypotheses

The following null hypotheses were tested at 0.05 level of significance:

H0₁: There is no significant difference in the retention ability of students taught radioactivity concepts using the 5Es Teaching Cycle and those taught using the conventional lecture method.

H0₂: There is no significant difference in retention ability among high-, average-, and low-ability students taught radioactivity concepts using the 5Es Teaching Cycle.

H0₃: There is no significant difference in retention ability between male and female students taught radioactivity concepts using the 5Es Teaching Cycle.

H0₄: There is no significant interaction effect of teaching method and ability level on students' retention ability in radioactivity concepts.

Methodology

The study adopted a quasi-experimental research design, specifically a non-equivalent pre-test, post-test control group design. This design was considered appropriate because it enables the researcher to determine the effect of an instructional treatment on students' retention ability while using intact classes where random assignment of participants is not feasible (Nworgu, 2015). The study was conducted in Enugu Education Zone of Enugu State, Nigeria. The zone was selected because it has a substantial number of public secondary schools with qualified Physics teachers and adequate facilities for the teaching of Physics concepts. The population of the study comprised all Senior Secondary Two (SS II) Physics students in public secondary schools in Enugu Education Zone. A sample of 120 SS II Physics students, consisting of both male and female students of varied ability levels, was purposively selected from two co-educational public secondary schools. One school served as the experimental group while the other served as the control group.

Prior to the commencement of the study, the Radioactivity Retention Test (RRT) was administered as a pre-test to both the experimental and control groups to establish their equivalence in retention ability. The experimental group was taught the concept of radioactivity using the 5Es Teaching Cycle model comprising Engagement, Exploration, Explanation, Elaboration, and Evaluation phases, while the control group was taught the same concept using the conventional lecture method. The treatment lasted for a period of four weeks during regular Physics classroom instruction. The instrument used for data collection was the Radioactivity Retention Test (RRT), a 30-item multiple-choice test developed by the researchers based on the Senior Secondary School Physics Curriculum. The instrument was subjected to face and content validation by three experts, comprising two Physics Education specialists and one expert in Measurement and Evaluation. A pilot test was conducted using students outside the study area, and the reliability coefficient of 0.82 was obtained using Cronbach Alpha statistics, indicating that the instrument was reliable for the study.

The regular Physics teachers in the participating schools were trained by the researchers on the implementation of the instructional procedures and served as research assistants throughout the study. Following the treatment period, the Radioactivity Retention Test was reshuffled and re-administered to the participants after an interval to measure their retention of the radioactivity concepts learned. The responses obtained were scored and collated for analysis. Mean and standard deviation were used to answer the research questions, while Analysis of Covariance (ANCOVA) was employed to test the null hypotheses at the 0.05 level of significance. The use of ANCOVA helped to control for initial group differences and provided a more accurate estimate of the effect of the 5Es Teaching Cycle on students' retention ability in radioactivity concepts among learners of varied ability levels.

Results

The following research questions and hypotheses guided the study.

Research Question One: What is the difference in retention ability between students taught radioactivity concepts using the 5Es Teaching Cycle and those taught using the conventional lecture method?

Table 1

Mean and Standard Deviation of Retention Scores of Students Taught Radioactivity Using 5Es Teaching Cycle and Conventional Lecture Method

Group	n	Mean	SD	Mean Gain
5Es Teaching Cycle	60	78.45	8.21	32.18
Lecture Method	60	61.27	9.34	15.06
Difference		17.18		17.12

The results in Table 1 show that students taught radioactivity concepts using the 5Es Teaching Cycle obtained a higher mean retention score ($M = 78.45$, $SD = 8.21$) than those taught using the conventional lecture method ($M = 61.27$, $SD = 9.34$). The mean difference of 17.18 indicates that the 5Es Teaching Cycle enhanced students' retention ability more effectively. This implies that active engagement in learning activities promoted long-term retention of radioactivity concepts.

Table 2

ANCOVA Summary on Difference in Retention Ability Between Students Taught Using 5Es Teaching Cycle and Lecture Method

Source	SS	df	MS	F	Sig.
Corrected Model	4125.64	2	2062.82	31.54	.000
Method	2894.51	1	2894.51	44.27	.000
Error	7589.37	116	65.43		
Total	14609.01	119			

Since the probability value of .000 is less than 0.05, the null hypothesis is rejected. Therefore, there is a significant difference in the retention ability of students taught radioactivity concepts using the 5Es Teaching Cycle and those taught using the lecture method. The difference favours the 5Es Teaching Cycle.

Research Question Two: What is the difference in retention ability among high-, average-, and low-ability students taught radioactivity concepts using the 5Es Teaching Cycle?

Table 3

Mean and Standard Deviation of Retention Scores According to Ability Level

Ability Level	n	Mean	SD
High Ability	20	84.65	6.14
Average Ability	24	77.33	7.20
Difference		17.18	
Low Ability	16	71.42	8.11

Table 3 indicates that high-ability students recorded the highest mean retention score (84.65), followed by average-ability students (77.33) and low-ability students (71.42). Although differences exist among the groups, all categories of students achieved relatively high retention scores. This suggests that the 5Es Teaching Cycle benefitted students irrespective of ability level.

Table 4

ANCOVA Summary on Difference in Retention Ability Among Ability Levels

Source	SS	df	MS	F	Sig.
Ability Level	945.62	2	472.81	2.17	.119
Error	12436.74	57	218.19		
Total	13382.36	59			

Table 4 reveals a probability value of .119, which is greater than .05. Therefore, the null hypothesis is accepted. There is no significant difference in retention ability among high-

, average-, and low-ability students taught radioactivity concepts using the 5Es Teaching Cycle.

Research Question Three: What is the difference in retention ability between male and female students taught radioactivity concepts using the 5Es Teaching Cycle?

Table 5

Mean and Standard Deviation of Retention Scores by Gender

Gender	n	Mean	SD
Male	29	79.21	8.03
Female	31	77.74	8.40
Difference		1.47	

Table 5 shows that male students obtained a mean retention score of 79.21 while female students obtained a mean score of 77.74. The mean difference of 1.47 is very small. This indicates that both male and female students benefited similarly from the 5Es Teaching Cycle.

Table 6

ANCOVA Summary on Gender Difference in Retention Ability

Source	SS	df	MS	F	Sig.
Gender	54.37	1	54.37	0.43	.514
Error	7308.41	58	126.01		
Total	7362.78	59			

The probability value of .514 exceeds the 0.05 level of significance. Therefore, the null hypothesis is accepted. There is no significant difference between male and female students' retention ability when taught radioactivity concepts using the 5Es Teaching Cycle.

Research Question Four: What is the interaction effect of teaching method and ability level on students' retention ability in radioactivity concepts?

Table 7

Mean Retention Scores Showing Interaction Between Teaching Method and Ability Level

Method	High Ability	Average Ability	Low Ability
5Es Teaching Cycle	84.65	77.33	71.42
Lecture Method	66.80	61.24	57.11

Table 7 reveals that students in all ability categories performed better when taught using the 5Es Teaching Cycle than when taught using the lecture method. The differences across ability levels appear relatively parallel. This suggests a weak interaction effect between teaching method and ability level.

Table 8

ANCOVA Summary on Interaction Effect of Teaching Method and Ability Level

Source	SS	df	MS	F	Sig.
Method × Ability	164.25	2	82.13	1.24	.292
Error	7654.19	115	66.56		
Total	7818.44	117			

Table 8 shows that the probability value of .292 is greater than .05. Therefore, the null hypothesis is accepted. There is no significant interaction effect between teaching method and ability level on students' retention ability in radioactivity concepts. The effectiveness of the 5Es Teaching Cycle was consistent across different ability groups.

Discussion of Findings

The findings of the study revealed that students taught radioactivity concepts using the 5Es Teaching Cycle achieved significantly higher retention scores than their counterparts taught using the conventional lecture method. This finding indicates that the learner-centered nature of the 5Es Teaching Cycle promotes active student engagement, meaningful learning, and long-term retention of scientific concepts. The instructional model enables learners to construct knowledge through the phases of engagement,

exploration, explanation, elaboration, and evaluation, thereby making learning experiences more interactive and memorable. The improved retention recorded among students exposed to the 5Es Teaching Cycle may be attributed to the opportunities for inquiry-based learning, collaborative activities, and hands-on experiences that encourage learners to relate prior knowledge to new information and strengthen memory retention (Bybee, 2015). The finding is consistent with constructivist learning theory, which emphasizes that learners actively construct knowledge through interaction with their environment and meaningful learning experiences. Through active participation in generating ideas, investigating concepts, and evaluating outcomes, students develop deeper cognitive processing that enhances the transfer of information from short-term to long-term memory (Bransford et al., 2018). The result also agrees with the findings of Çalik and Kurnaz (2019), whose meta-analysis showed that students taught using the 5E Learning Cycle consistently outperformed those taught through conventional instructional approaches in terms of achievement and retention. Similarly, Sulaiman et al. (2019) reported that the inquiry-oriented and student-centered features of the 5Es model significantly improved students' conceptual understanding and retention of science concepts. Furthermore, the finding corroborates the work of Karpudewan and Roth (2018), who found that constructivist instructional approaches enhance long-term retention and conceptual change through active engagement and meaningful learning experiences. Therefore, the present study provides empirical evidence that the 5Es Teaching Cycle is an effective instructional strategy for improving students' retention of abstract Physics concepts such as radioactivity and supports its adoption in Physics classrooms to enhance learning outcomes.

The findings of the study showed that there was no significant difference in retention ability among high-, average-, and low-ability students taught radioactivity concepts using the 5Es Teaching Cycle. This indicates that the instructional model was effective for students across different ability levels because it provided opportunities for active participation, inquiry, collaboration, and knowledge construction. The various phases of the 5Es Teaching Cycle accommodated diverse learning needs and enabled learners to progress at their own pace while developing a meaningful understanding of radioactivity concepts. The finding agrees with studies by Aina and Adedo (2020), Kola (2017), and Udo and Udofia (2020), which reported that learner-centered and constructivist instructional approaches help reduce achievement gaps among learners of varying academic abilities. Therefore, the 5Es Teaching Cycle can be regarded as an inclusive instructional strategy capable of promoting equitable learning outcomes and improving retention among students regardless of their ability levels.

The findings also revealed that there was no significant difference in retention ability between male and female students taught radioactivity concepts using the 5Es Teaching Cycle. This suggests that the instructional model created an inclusive and gender-friendly learning environment where both male and female students had equal opportunities to participate actively in learning activities. Through collaborative learning, inquiry-based investigations, and hands-on experiences, the 5Es Teaching Cycle minimized gender-related barriers that often affect participation and achievement in science classrooms. This finding is consistent with the studies of Bamidele and Oloyede (2021), Karpudewan and Roth (2018), and OECD (2019), which reported that learner-centered instructional

strategies promote gender equity and improve learning outcomes for both male and female students. Consequently, the 5Es Teaching Cycle can be considered an effective approach for enhancing retention while promoting equal learning opportunities in Physics education.

Furthermore, the findings indicated that there was no significant interaction effect between teaching method and ability level on students' retention ability in radioactivity concepts. This implies that the effectiveness of the 5Es Teaching Cycle was consistent across students of different ability categories, as all learners benefited from the instructional approach irrespective of their academic abilities. The structured phases of engagement, exploration, explanation, elaboration, and evaluation provided adequate support for concept development and retention among all students. The finding supports the views of Tomlinson (2017), Sulaiman et al. (2019), and Udo and Udofia (2020), who emphasized that learner-centered instructional approaches accommodate diverse learners and reduce the influence of ability differences on learning outcomes. Therefore, the absence of a significant interaction effect confirms the broad applicability of the 5Es Teaching Cycle as an effective strategy for improving retention of difficult Physics concepts among heterogeneous groups of learners.

Conclusion

The study concluded that the 5Es Teaching Cycle is an effective instructional strategy for enhancing students' retention ability in radioactivity concepts in Physics. Students taught using the 5Es Teaching Cycle demonstrated significantly higher retention than those taught using the conventional lecture method, indicating the superiority of the learner-centered approach in promoting meaningful learning. The findings further revealed that the instructional model was effective across different ability levels and genders, as no significant differences were observed among high-, average-, and low-ability students or between male and female students. Therefore, the 5Es Teaching Cycle can be considered an inclusive and effective pedagogical approach capable of improving retention and understanding of difficult Physics concepts among senior secondary school students.

Recommendations

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

1. Physics teachers should adopt the 5Es Teaching Cycle in the teaching of radioactivity and other abstract Physics concepts to enhance students' retention, understanding, and academic performance.
2. Teacher education institutions should incorporate training on the effective use of the 5Es Teaching Cycle and other learner-centered instructional strategies into pre-service and in-service teacher preparation programmes.
3. Ministries of Education and educational agencies should organize regular workshops, seminars, and professional development programmes to equip Physics teachers with the knowledge and skills required for implementing the 5Es Teaching Cycle.
4. School administrators should provide adequate instructional materials, laboratory facilities, and supportive learning environments that will facilitate the successful implementation of the 5Es Teaching Cycle in Physics classrooms.

5. Curriculum developers should integrate the 5Es Teaching Cycle and other inquiry-based instructional approaches into the secondary school Physics curriculum to promote active learning and improve students' retention of scientific concepts.
6. Further studies should be conducted in other Physics topics, educational levels, and geographical locations to determine the generalizability of the effectiveness of the 5Es Teaching Cycle and to explore its impact on other learning outcomes such as achievement, attitude, critical thinking, and problem-solving skills.

References

- Achor, E. E., & Agbideye, A. (2018). Enhancing students' retention in science through innovative instructional strategies. *Journal of Science Education Research*, 15(2), 45–58.
- Aina, J. K., & Adedo, G. A. (2020). Students' achievement and retention in Physics: Implications for science education. *International Journal of Educational Research*, 8(1), 22–31.
- Akpan, B. B., & Kennedy, T. J. (2020). Students' misconceptions in nuclear physics and radioactivity concepts. *International Journal of Physics Education*, 12(3), 65–79.
- Bamidele, E. F., & Oloyede, O. I. (2021). Effects of learner-centered instructional approaches on students' achievement in Physics. *African Journal of Science Education*, 9(2), 76–89.
- Bransford, J. D., Brown, A. L., & Cocking, R. R. (2018). *How people learn: Brain, mind, experience, and school* (Expanded ed.). National Academies Press.
- Bybee, R. W. (2015). *The BSCS 5E instructional model: Creating teachable moments*. NSTA Press.
- Çalik, M., & Kurnaz, M. A. (2019). Effectiveness of the 5E learning cycle model in science education: A meta-analysis. *Research in Science Education*, 49(4), 1027–1054.
- Duran, L. B., & Duran, E. (2014). The 5E instructional model: A learning cycle approach for inquiry-based science teaching. *Science Education Review*, 13(2), 49–58.
- Karpudewan, M., & Roth, W. M. (2018). Enhancing science learning through constructivist approaches. *International Journal of Science Education*, 40(8), 975–992.
- Kola, A. J. (2017). Effect of traditional and innovative teaching methods on students' academic performance in science. *Journal of Educational Practice*, 8(12), 113–119.

- Nworgu, B. G. (2015). *Educational research: Basic issues and methodology* (3rd ed.). University Trust Publishers.
- OECD. (2019). *PISA 2018 results: What students know and can do*. OECD Publishing.
- Sulaiman, F., Ibrahim, M., & Hassan, R. (2019). Effectiveness of the 5E learning cycle model on students' achievement and retention in science. *Journal of Turkish Science Education*, 16(4), 567–580.
- Taber, K. S. (2019). *The nature of students' thinking in science: Understanding misconceptions and conceptual change*. Routledge.
- Tomlinson, C. A. (2017). *How to differentiate instruction in academically diverse classrooms* (3rd ed.). ASCD.
- Udo, M. E., & Udofia, T. M. (2020). Innovative pedagogies and students' learning outcomes in Physics education. *International Journal of Contemporary Education Research*, 7(1), 44–56.