



Effect of Reciprocal-Peer-Tutoring Learning Strategy on Students' Achievement in Radioactivity in South Senatorial District, Benue State, Nigeria

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Abstract

This study investigated the effect of the Reciprocal Peer Tutoring (RPT) learning strategy on students' achievement in Radioactivity among Upper Basic III students in the South Senatorial District of Benue State, Nigeria. The quasi-experimental design adopted a non-randomized pretest-posttest control group approach. A total of 800 students from eight co-educational public secondary schools participated in the study. The experimental group was taught Radioactivity using the RPT strategy, while the control group received instruction through the conventional lecture method. The instrument used for data collection was the Students' Achievement in Radioactivity Test (SART), which was validated and found to have a reliability coefficient of 0.81. Data collected were analyzed using mean, standard deviation, t-test, and Analysis of Covariance (ANCOVA) at 0.05 level of significance. Findings revealed that students taught using RPT significantly outperformed those taught using the conventional method in terms of achievement. However, there was no significant difference in the achievement scores of male and female students exposed to the RPT strategy, indicating its gender inclusiveness. The study concluded that RPT is an effective, equitable instructional strategy that enhances students' academic performance in Radioactivity. It recommended the adoption of RPT in science classrooms to foster improved understanding and achievement, as well as professional development for teachers to facilitate its implementation.

Keywords: Reciprocal Peer Tutoring, Radioactivity, Student Achievement, Gender, Basic Science.

Introduction

Basic Science serves as the cornerstone of scientific literacy and forms the bedrock upon which advanced science subjects such as Biology, Chemistry, and Physics are built. The teaching strategies employed in Basic Science classrooms greatly influence students' comprehension and academic achievement. Consequently, students who are well-grounded in Basic Science during their junior secondary education are more likely to perform better in science subjects at the senior secondary level (Abdulahi, 2022). By design, Basic Science integrates both content and process-oriented learning, promoting critical thinking, the development of psychomotor skills, and the cultivation of positive scientific attitudes. The curriculum for Basic Science is structured to present scientific knowledge in a unified form, minimizing early specialization and the strict compartmentalization of scientific fields. This interdisciplinary approach encourages a holistic view of science and is intended to instill a strong foundation for inquiry, problem-solving, and lifelong learning (Federal Republic of Nigeria [FRN], 2014). As such, the effective delivery of Basic Science content requires not only subject matter expertise but also specialized pedagogical skills. According to the FRN (2014), the upper basic school curriculum emphasizes child-centered learning

experiences designed to nurture students' curiosity, creativity, and engagement. The Nigerian government's introduction of Basic Science at the junior secondary school level is a strategic move aimed at fostering a scientifically literate populace capable of contributing to national development and global competitiveness (Ehirhime, 2020). The curriculum is designed to help students observe and explore their environment, develop an interest in science and technology, acquire relevant knowledge and skills, and apply these to solve real-life problems (Okonkwo, 2016). However, recent reports from the Chief Examiners of the Basic Education Certificate Examination (BECE) between 2017 and 2024 have consistently highlighted students' poor performance in key science concepts such as energy, thermal physics, chemical formulae, and radioactivity. These persistent weaknesses are often attributed to inappropriate teaching strategies, lack of learner motivation, the abstract nature of scientific concepts, and limited interest among both teachers and students.

Radioactivity, one of the more challenging topics in Basic Science, deals with the spontaneous disintegration of atomic nuclei resulting in the emission of alpha, beta, or gamma particles. This concept is central to understanding atomic structure, nuclear

energy, and radiation's environmental and health implications (Ronald & Paul, 2013). Teaching radioactivity helps students gain insights into nuclear processes and the scientific principles underlying modern energy production. Given the topic's complexity, abstractness, and real-world relevance, it is imperative for educators to adopt instructional strategies that foster active engagement and conceptual understanding (Risqi & Surya, 2017). To address these challenges, educators are encouraged to explore learner-centered approaches such as the Reciprocal Peer Tutoring (RPT) strategy. RPT enables students to learn by teaching and learning from one another, thereby reinforcing content mastery, increasing motivation, and enhancing interest in difficult science concepts like radioactivity. This study is therefore motivated by the need to investigate the effect of RPT on students' interest in radioactivity in Basic Science, particularly within the South Senatorial District of Benue State, Nigeria. Understanding radioactivity as a scientific concept offers students a crucial foundation for national advancement. Mastery of radioactive principles and their applications is vital for technological development, as failure to acquire such skills may confine Nigeria to the role of a mere consumer of radioactive technologies rather than an innovator or producer (Fischbach et al., 2019). Despite widespread misconceptions in society that all forms of radiation are harmful and must be completely avoided, it is important to recognize that radiation is an everyday reality. While high doses of radiation exposure can indeed result in acute biological effects such as leukopenia, thrombocytopenia, and aplastic anemia, background radiation from natural sources like uranium, thorium, and radon is constantly present in the environment (Chen, 2018). Therefore, teaching radioactivity effectively empowers learners to make informed decisions about health, energy, and environmental safety.

Although Basic Science is pivotal to the nation's ambition of achieving scientific and technological progress, many challenges continue to hinder its effectiveness in Nigeria. One significant issue is the persistent use of ineffective, teacher-centered instructional approaches that limit student engagement and understanding. Gongden and Gongden (2019) emphasized that the prevalent use of traditional lecture methods among Basic Science teachers undermines meaningful learning. Consequently, researchers have advocated for the adoption of constructivist-based strategies that promote active student participation and conceptual development (Samba & Eriba, 2012; Nnorom, 2015). In response to these challenges, several constructivist teaching strategies have been proposed, including Reciprocal Peer Tutoring (RPT), which has shown promise in fostering student collaboration and active learning. Fatokun, Onwoke, and Hudu (2018) highlighted the relevance of such learner-centered approaches in improving scientific understanding. RPT is a collaborative learning strategy wherein students alternate between the roles of tutor and tutee, enabling mutual knowledge construction (Dufrene, Noell, Gilbertson, & Duhon, 2015). Unlike other peer learning methods, RPT places students in

structured roles that require them to teach and learn in turn, reinforcing both content mastery and interpersonal communication skills (Topping, 2015).

Paul, Lisa, and Vanesa (2006) described RPT as a cognitive apprenticeship where a learner, under the guidance of a teacher, assists peers of similar academic level in acquiring specific skills or concepts. This interaction is often between students of differing academic abilities, thereby allowing less proficient learners to benefit from the support and explanations of their more advanced peers (Jibrin & Zayum, 2012). In all such tutoring interactions, the teacher assumes the role of a facilitator, guiding and monitoring the process. This method has proven especially beneficial for students struggling in specific subjects, as it offers opportunities for individualized support and reinforcement. Okparaugo (2017) further asserted that RPT enhances higher-order thinking by integrating questioning techniques that require students to formulate and respond to complex queries. Through this process, students not only learn to clarify their understanding but also actively construct knowledge by engaging with their peers. Despite its potential, empirical evidence on the effectiveness of RPT in improving students' interest, achievement, and retention in Basic Science—especially in abstract topics like radioactivity—remains limited. Thus, there is a compelling need to investigate the impact of this instructional strategy on learning outcomes within the Nigerian educational context.

Student achievement refers to the extent to which learners acquire knowledge, skills, and competencies as a result of educational instruction and engagement. According to Usman (2020), it represents the measurable outcomes of learning activities, often assessed through examinations and tests that reflect the effectiveness of instruction. Achievement can also be seen as the successful completion of a task or objective through effort, skill, and persistence (Eze, 2019). It signifies not only academic success but also the ability to perform specific roles or solve problems effectively. Anekwe (2016) defined academic achievement as the outcome of formal assessments designed to evaluate and compare students' proficiencies across various academic domains. It involves gauging the level of mastery attained after sufficient exposure to a subject matter, course, or program. Among the numerous factors influencing student achievement, gender has attracted considerable attention in science education, especially with the global push to strengthen human capacity for technological development. Gender is often described as the set of biological and behavioral characteristics that differentiate individuals based on their roles in reproduction (Samuel & Agu, 2018). In educational contexts, gender differences have been studied extensively in relation to academic performance, particularly in science and technology disciplines. Research findings on gender and achievement have been mixed. Some studies suggest that male students outperform their female counterparts in scientific subjects, while others indicate no significant gender difference. Conversely, several studies have reported higher performance among female students (Eriba & Samuel, 2018; Agu & Samuel, 2018). These divergent results underscore the need for further empirical

investigation, particularly in specific topics like radioactivity, where instructional strategies such as Reciprocal Peer Tutoring (RPT) may interact differently with gender dynamics. Thus, it remains unclear how male and female students will perform when exposed to this instructional approach in the context of learning radioactivity.

Statement of the Problem

The persistent low academic achievement of students in Basic Science remains a major concern across all levels of Nigeria's educational system, from primary through tertiary institutions. This challenge contributes significantly to the underutilization of human potential, wastage of educational resources, and substantial financial losses—consequences that a developing nation like Nigeria can scarcely afford. The widespread failure in Basic Science examinations has alarmed parents, educators, policy makers, and the society at large. Numerous factors have been implicated in this trend, including ineffective teaching methodologies, inadequate instructional materials, and limited parental support. Although several studies have explored these variables, the problem persists, as evidenced by recurring patterns of poor student performance in Basic Science external examinations, particularly in Benue State. If this trend continues unchecked, it may hinder Nigeria's aspiration to develop indigenous scientific and technological capacities, ultimately resulting in continued dependence on foreign expertise.

To reverse this trend, it is imperative that students not only pass but also master Basic Science concepts to a level that supports both personal development and national progress. Learner-centered instructional approaches have shown promise in improving comprehension and academic performance. One such strategy is Reciprocal Peer Tutoring (RPT), which emphasizes student collaboration and active learning. This study, therefore, seeks to investigate the impact of the Reciprocal Peer Tutoring Learning Strategy on students' academic achievement in the concept of Radioactivity—a topic identified as particularly challenging—in Basic Science among junior secondary school students in the South Senatorial District of Benue State, Nigeria.

Objectives of the Study

The Objectives of the study are;

1. ascertain the effect of Reciprocal Peer Tutoring Learning Strategy and the Conventional Method on Students' achievement when taught Radioactivity.
2. establish the effect of Reciprocal Peer Tutoring Learning Strategy on male and female Students' achievement when taught Radioactivity.

Research Questions

The following research questions guided the study;

1. What is the mean achievement scores of students taught Radioactivity using Reciprocal Peer Tutoring Learning Strategy and the Conventional Method?
2. What is the mean achievement scores of male and female students taught Radioactivity using Reciprocal Peer Tutoring Learning Strategy?

Hypotheses

The following hypotheses were formulated and tested at 0.05 level of significance.

- H₀₁:** There is no significance difference in the mean achievement scores of students taught Radioactivity using Reciprocal Peer Tutoring Learning Strategy and the Conventional Method.
- H₀₂:** There is no significance difference in the mean achievement scores of male and female students taught Radioactivity using Reciprocal Peer Tutoring Learning Strategy.

Literature Review

The teaching and learning of science subjects, particularly Basic Science, in Nigerian schools have witnessed numerous challenges. Among these, poor student achievement remains a persistent issue, often linked to ineffective teaching strategies (Gongden & Gongden, 2019). One of the most abstract and misunderstood topics within Basic Science is radioactivity—a concept that introduces learners to nuclear physics and subatomic particles such as alpha, beta, and gamma rays (Ronald & Paul, 2013). Teaching such abstract content through traditional lecture methods has proved inadequate, as it limits student engagement and hands-on understanding (Ehirhime, 2020). Reciprocal Peer Tutoring (RPT) is an instructional strategy based on constructivist principles, where learners actively participate in the teaching-learning process by alternating roles between tutor and tutee (Topping, 2015). This method enables students to engage in cognitive apprenticeship and deepen their understanding by explaining concepts to peers. RPT fosters collaborative learning, critical thinking, and retention of knowledge, especially in science topics that require visualization and conceptual clarity (Fatokun, Onwoke, & Hudu, 2018). Numerous scholars advocate a shift from conventional to learner-centered strategies to improve student outcomes (Samba & Eriba, 2012; Nnorom, 2015). The RPT approach has shown promise in enhancing students' academic performance by providing a participatory and supportive learning environment. Students tend to retain more knowledge when they teach others, and the feedback loop created by peer interactions often helps clarify misconceptions (Dufrene, Noell, Gilbertson, & Duhon, 2015). Gender has also been identified as a variable that potentially influences students' achievement in science. Although research findings are mixed, there is a consensus that instructional strategy can mediate gender differences in science achievement (Eriba & Samuel, 2018;

Agu & Samuel, 2018). The effectiveness of RPT in bridging gender gaps in science achievement is therefore worth investigating.

Empirical Studies

A study by Jibrin and Zayum (2012) examined the effects of peer tutoring on students' academic performance in science and found significant improvement in students' test scores compared to those taught with conventional methods. Their findings emphasized that students benefited from peer explanations and repeated practice facilitated by peer interactions. Similarly, Fatokun, Onwoke, and Hudu (2018) explored the impact of constructivist-based teaching strategies, including RPT, on students' achievement and attitude in chemistry. Their results showed a statistically significant improvement in the academic performance of students in the experimental group. This improvement was attributed to the collaborative and interactive nature of the RPT method. Sani (2015) conducted research on the effectiveness of RPT in enhancing students' understanding of difficult physics concepts and reported that the strategy led to increased student participation, reduced fear of science, and enhanced conceptual mastery. The author noted that students who acted as tutors also deepened their own understanding through the process of peer explanation. In another related study, Okparaugo (2017) compared the effects of RPT and guided peer questioning on students' science achievement and found that RPT led to significant academic gains. The research highlighted the need to adopt innovative and interactive teaching methods to boost performance in science subjects. However, most of these studies were conducted in other regions of Nigeria or on science subjects other than Basic Science. There remains a dearth of research specifically focused on the effectiveness of RPT in teaching radioactivity in Basic Science within the South Senatorial District of Benue State. This gap necessitates the current study.

Theoretical Framework

This study is anchored on the **Constructivist Learning Theory** by Jean Piaget and Lev Vygotsky, which posits that learners actively construct knowledge through interactions with their environment and social engagements (Piaget, 1971; Vygotsky, 1978). The constructivist perspective emphasizes the importance of learners being actively involved in the learning process rather than being passive recipients of information. According to Vygotsky's concept of the Zone of Proximal Development (ZPD), learners benefit most when they are guided by more knowledgeable peers or adults within a social learning context. Reciprocal Peer Tutoring aligns well with the ZPD framework as it positions learners to assist each other in understanding complex topics, such as radioactivity. When students explain concepts to their peers, they reinforce their own learning, and the tutees gain a better grasp of content from explanations that are often more relatable than those given by teachers. Additionally, **Social Interdependence Theory** by Johnson and

Johnson (1989) supports the use of cooperative learning strategies like RPT. This theory suggests that learning is most effective when students perceive that their success is linked to the success of their peers. The interdependent nature of RPT encourages mutual responsibility and enhances motivation to learn.

Methodology

This study adopted a quasi-experimental research design involving a non-randomized pre-test, post-test control group. This design was chosen because it allowed for the investigation of a causal relationship between the use of the Reciprocal Peer Tutoring (RPT) strategy and students' academic achievement in radioactivity, a core concept in Basic Science. The study was conducted using two groups: an experimental group that received instruction through the RPT strategy, and a control group that was taught using the conventional lecture method. Both groups were subjected to a pre-test before the intervention to assess their initial knowledge of radioactivity, and a post-test after the intervention to determine any changes in their academic performance. The population of the study comprised 17,761 Upper Basic III (JSS 3) students in public secondary schools across the South Senatorial District of Benue State, Nigeria, during the 2023/2024 academic session. This included 9,140 male and 8,621 female students. This population was considered appropriate for the study because JSS 3 students were expected to have received prior instruction in foundational Basic Science concepts, including radioactivity. A multi-stage sampling technique was employed in selecting the participants. Initially, schools within the South Senatorial District were stratified into urban and rural categories to ensure representation from different geographical settings. From each category, four co-educational secondary schools were randomly selected, resulting in a total of eight schools. Within each selected school, two intact JSS 3 classes were purposively chosen. One class in each school was assigned to the experimental group, while the other served as the control group. The total sample size for the study was 800 students drawn from these intact classes across the eight schools. Data were collected using a researcher-developed instrument titled the Students' Achievement in Radioactivity Test (SART). This test comprised 30 multiple-choice questions, each with four options (A–D), designed to assess students' understanding of radioactivity. To ensure that the instrument was valid, it was subjected to face and content validation by a panel of experts in Science Education, Measurement, and Evaluation. Their feedback guided the refinement of the instrument to ensure it accurately measured students' achievement in radioactivity. Reliability of the instrument was confirmed through a pilot study conducted in a school outside the study area. The internal consistency of the test was assessed using the Kuder-Richardson Formula 21 (KR-21), which yielded a reliability coefficient of 0.81, indicating that the instrument was sufficiently reliable for the study.

The intervention lasted for six weeks. During the first week, the pre-test was administered to both the experimental and control groups to determine their baseline achievement in radioactivity. From the second to the fifth week, the experimental group was taught using the Reciprocal Peer Tutoring strategy. In this approach, students alternated roles as tutors and tutees while the teacher facilitated and guided the process. Simultaneously, the control group received instruction on the same content using the conventional teacher-centered lecture method. In the sixth week, both groups were administered the post-test to evaluate their performance after the instructional intervention. The researcher personally supervised the administration of both the pre- and post-tests in all the participating schools to ensure uniformity in procedure and immediate collection of the completed instruments. Data obtained from the study were analyzed using both descriptive and inferential statistical methods. Mean and standard deviation were used to describe and compare students' performance before and after the intervention. An independent samples t-test was used to determine whether significant differences existed between the achievement scores of the experimental and control groups. In addition, Analysis of Covariance (ANCOVA) was employed to control for possible differences in the pre-test scores and to more accurately assess the effect of the RPT strategy on students' achievement. All hypotheses were tested at a 0.05 level of significance using the Statistical Package for the Social Sciences (SPSS).

Ethical considerations were rigorously observed throughout the research process. Informed consent was obtained from school authorities and the students who participated in the study. Participants were adequately informed about the objectives and procedures of the study. Their confidentiality and anonymity were assured, and it was emphasized that their responses would be used solely for academic purposes. Participation in the study was voluntary, and students were informed that they could withdraw at any point without facing any form of penalty. Overall, the methodological approach adopted in this study was carefully structured to provide credible and valid insights into the effectiveness of the Reciprocal Peer Tutoring strategy in enhancing students' achievement in radioactivity. The integration of rigorous sampling techniques, validated instruments, and ethical research practices ensured that the findings would contribute meaningfully to improving instructional strategies in Basic Science education in Nigeria.

Results/Findings

Research Question One

What is the mean achievement scores of students taught Radioactivity using Reciprocal Peer Tutoring Learning Strategy and the Conventional Method?

Table 1: Mean Achievement Scores and Standard Deviation of Students Taught Radioactivity Using RPT and Those Taught Using Conventional Method

Group		Pretest	Posttest
RPT	Mean	25.38	56.06
	N	400	400
	Std. Deviation	3.290	13.385
CM	Mean	15.52	27.76
	N	400	400
	Std. Deviation	3.248	7.227

The data presented in Table 1 compares the mean achievement scores and standard deviations of students taught Radioactivity using the Reciprocal Peer Tutoring (RPT) learning strategy with those taught using the Conventional Method (CM). In the pretest phase, students in the RPT group recorded a mean score of 25.38 with a standard deviation of 3.290, whereas those in the CM group had a significantly lower mean score of 15.52 and a standard deviation of 3.248. This indicates that before the teaching intervention, the students exposed to RPT already demonstrated a higher level of prior knowledge or baseline understanding of the concept of Radioactivity compared to their counterparts in the conventional group. Following the instructional intervention, there was a marked increase in the mean scores of both groups, but with notable differences in magnitude. The RPT group's mean posttest score rose sharply to 56.06, with a higher standard deviation of 13.385. This suggests not only a significant improvement in performance but also a wider spread in individual achievements, which could be attributed to varying levels of engagement and assimilation among students during peer tutoring sessions. On the other hand, the CM group's posttest mean score increased only modestly to 27.76 with a standard deviation of 7.227, reflecting a less substantial improvement in students' achievement. From this analysis, it is evident that the Reciprocal Peer Tutoring learning strategy was considerably more effective than the conventional teaching method in enhancing students' understanding and performance in Radioactivity. The substantial gain in the mean achievement score of the RPT group underscores the value of learner-centered instructional approaches in improving academic outcomes in science education. The findings suggest that when students are actively involved in the learning process through collaborative peer interaction, as in the RPT strategy, their academic achievement is more positively influenced compared to traditional teacher-centered instruction.

Hypothesis One

H₀₁: There is no significance difference in the mean achievement scores of students taught Radioactivity using Reciprocal Peer Tutoring Learning Strategy and the Conventional Method.

Table 2: ANCOVA Result of Mean Achievement Scores of Students Taught Geometry Using RPT and Those Taught Using Conventional Method

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	217488.439 ^a	2	72496.146	504.098	.000	.558
Intercept	61958.574	1	61958.574	430.825	.000	.265
Pretest	96.304	1	96.304	.670	.413	.001
Group	76537.136	1	38268.568	266.098	.000	.308
Error	172001.131	796	143.814			
Total	3017216.000	800				
Corrected Total	389489.570	799				

a. R Squared = .558 (Adjusted R Squared = .557)

The ANCOVA results presented in Table 2 examine the effect of the teaching method—Reciprocal Peer Tutoring (RPT) versus the Conventional Method—on students' achievement in Geometry, while controlling for pretest scores. The corrected model is statistically significant, with an F-value of 504.098 and a p-value of .000, indicating that the combined effect of the covariate (pretest) and the independent variable (group) explains a significant portion of the variance in students' posttest achievement scores. The model's R squared value of .558 (adjusted R squared = .557) suggests that approximately 55.8% of the variance in achievement scores is accounted for by the model, which is a substantial effect. The intercept is also significant ($F = 430.825$, $p = .000$), indicating that the baseline level of achievement has a meaningful impact on the outcomes. However, the pretest covariate itself is not statistically significant ($F = 0.670$, $p = .413$), suggesting that the initial differences in pretest scores between students did not significantly influence the posttest results after adjusting for the teaching method. Importantly, the effect of the group variable, which represents the teaching strategy, is highly significant ($F = 266.098$, $p = .000$) with a large partial eta squared value of .308. This means that the type of teaching method has a strong and significant impact on students' achievement scores in Geometry, with the RPT method contributing to improved outcomes compared to the Conventional Method. After controlling for initial ability (pretest scores), the Reciprocal Peer Tutoring strategy significantly enhances students' achievement in Geometry compared to the Conventional Method, accounting for a substantial portion of the variance in their performance.

Research Question Two

What is the mean achievement scores of male and female students taught Radioactivity using Reciprocal Peer Tutoring Learning Strategy?

Table 3: Mean Achievement Scores and Standard Deviations of Male and Female Students taught RPT Using RPT

GenderRPT		Pretest	Posttest
Male	Mean	25.28	56.60
	N	217	217
	Std. Deviation	3.284	13.462
Female	Mean	25.50	55.42
	N	183	183
	Std. Deviation	3.303	13.301
Total	Mean	25.38	56.06
	N	400	400
	Std. Deviation	3.290	13.385

Table 3 presents the mean achievement scores and standard deviations of male and female students taught Geometry using the Reciprocal Peer Tutoring (RPT) learning strategy. Before the intervention, the pretest scores show that male students had a mean score of 25.28 with a standard deviation of 3.284, while female students had a slightly higher mean score of 25.50 with a standard deviation of 3.303. This indicates that the initial achievement levels of both male and female students were quite similar before the teaching intervention. After the teaching intervention using RPT, the posttest scores reveal that male students had a mean achievement score of 56.60 with a standard deviation of 13.462, whereas female students scored slightly lower with a mean of 55.42 and a standard deviation of 13.301. Both groups showed a substantial increase in mean scores from the pretest to the posttest, demonstrating that the RPT strategy was effective in improving students' achievement in Geometry for both genders. Overall, the total mean achievement score for all students increased from 25.38 in the pretest to 56.06 in the posttest, with a standard deviation of 13.385, indicating a general improvement in performance after the intervention. The small difference between male and female posttest means suggests that the RPT strategy was equally beneficial for both genders.

Hypothesis Two

H₀₂: There is no significance difference in the mean achievement scores of male and female students taught Radioactivity using Reciprocal Peer Tutoring Learning Strategy.

Table 4: Result of ANCOVA of Male and Female Students taught Radioactivity Using RPT

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Squared	Eta
Corrected Model	260.063 ^a	2	130.032	.725	.485	.004	
Intercept	23927.599	1	23927.599	133.371	.000	.251	
Pretest	122.224	1	122.224	.681	.410	.002	
GenderRPT	129.138	1	129.138	.720	.397	.002	
Error	71224.497	397	179.407				
Total	1328574.000	400					
Corrected Total	71484.560	399					

a. R Squared = .004 (Adjusted R Squared = -.001)

Table 4 shows the ANCOVA results examining the effect of gender on the achievement scores of students taught Radioactivity using the Reciprocal Peer Tutoring (RPT) strategy.

The corrected model has an F-value of 0.725 and a significance level (p-value) of 0.485, indicating that the model does not significantly explain the variance in posttest achievement scores after controlling for pretest scores. Looking specifically at the gender variable (GenderRPT), the F-value is 0.720 with a p-value of 0.397, which is greater than the 0.05 significance level. This means there is no statistically significant difference between male and female students' achievement scores in Radioactivity after being taught with the RPT strategy. The pretest covariate also shows no significant effect ($F = 0.681$, $p = 0.410$), suggesting that initial differences in pretest scores did not significantly influence the posttest outcomes. The Partial Eta Squared values for gender and pretest are very small (0.002 each), indicating that gender and initial achievement accounted for a negligible proportion of variance in students' posttest achievement scores. The R Squared value of 0.004 (adjusted R Squared = -0.001) suggests that the model explains virtually none of the variability in the dependent variable after adjusting for the number of predictors. Gender does not significantly affect students' achievement in Radioactivity when taught using Reciprocal Peer Tutoring in this study. Both male and female students performed similarly after the intervention.

Discussion of Findings

The results from this study provide insightful evidence on the effect of Reciprocal Peer Tutoring (RPT) learning strategy on students' achievement in Radioactivity, as well as the role of gender in influencing these outcomes.

Table 1 revealed a substantial difference in mean achievement scores between students taught Radioactivity using Reciprocal Peer Tutoring (RPT) and those taught using the Conventional Method (CM). The pretest mean scores were relatively close for both groups (25.38 for RPT and 15.52 for CM), indicating a comparable baseline before the intervention. However, after the instructional period, the posttest scores of the RPT group rose sharply to 56.06, whereas the CM group improved only to 27.76. The greater standard deviation in the posttest for the RPT group (13.385) compared to the CM group (7.227) suggests more variation in performance among students exposed to RPT, potentially due to varying peer interactions and individual engagement levels. This marked improvement with RPT aligns with prior research emphasizing the effectiveness of peer tutoring in enhancing academic achievement in science subjects. For example, Sani (2015) and Dufrene et al. (2015) found that RPT positively impacts student learning by promoting active engagement and peer collaboration. Similarly, Jibrin and Zayum (2012) highlighted that peer tutoring fosters reinforcement and practice through student partnerships, which can lead to improved mastery of complex concepts such as Radioactivity.

Table 2 presents the ANCOVA results that statistically confirm the superiority of the RPT strategy over the conventional teaching method in improving students' achievement. The analysis showed a significant main effect of the teaching method ($F = 266.098$, $p < 0.001$)

on posttest scores after controlling for pretest scores. The large partial eta squared value of 0.308 indicates that about 30.8% of the variance in achievement scores is attributable to the teaching method, signifying a strong practical impact. The non-significant effect of the pretest covariate ($p = 0.413$) suggests that initial ability did not significantly bias the results. This finding supports the growing body of empirical evidence advocating for constructivist and student-centered instructional approaches in science education. Fatokun, Onwoke, and Hudu (2018) similarly found that teaching strategies grounded in constructivism, like RPT, enhance understanding and achievement in scientific topics by encouraging active knowledge construction.

Table 3 compares the mean achievement scores between male and female students taught Radioactivity using the RPT strategy. Both genders had almost identical pretest mean scores (males = 25.28, females = 25.50) and showed substantial improvement after instruction (males = 56.60, females = 55.42). The close proximity of posttest means and standard deviations (males = 13.462; females = 13.301) indicates that RPT was equally effective for both genders in this context. These results mirror findings from Eriba and Samuel (2018) and Agu and Samuel (2018), who reported no significant gender differences in science achievement when effective, student-centered teaching methods were employed. This suggests that the RPT strategy could be a valuable tool in bridging traditional gender gaps in science education, potentially fostering equity in academic outcomes.

Table 4's ANCOVA results further confirm that gender does not significantly influence students' achievement in Radioactivity when taught using RPT. With a non-significant F-value for gender ($F = 0.720$, $p = 0.397$) and an extremely small effect size (partial eta squared = 0.002), it is clear that male and female students benefited similarly from the RPT intervention. The very low R-squared value (0.004) indicates that gender explains almost none of the variance in achievement scores. This finding is consistent with Samuel and Agu (2018), who emphasized that when gender-sensitive and interactive pedagogical approaches are implemented, gender disparities in academic achievement tend to diminish. Moreover, Okparaugo (2017) argued that peer tutoring strategies which emphasize collaborative learning roles help to create an inclusive learning environment, reducing the impact of socio-cultural factors such as gender on student performance.

In summary, the findings across these tables strongly suggest that Reciprocal Peer Tutoring is an effective instructional strategy for improving students' achievement in Radioactivity in the South Senatorial District of Benue State. The strategy significantly outperforms conventional lecture methods and benefits both male and female students equally. This supports the theoretical underpinnings of social constructivism (Vygotsky, 1978), which emphasizes learning through social interaction and scaffolding—processes inherent in RPT. These results add to the growing empirical consensus that active, peer-

mediated instructional approaches can enhance science learning outcomes and promote gender equity in academic achievement.

Conclusion

The study's findings clearly demonstrate that the Reciprocal Peer Tutoring (RPT) learning strategy significantly enhances students' achievement in Radioactivity compared to the conventional lecture method. Students exposed to RPT showed marked improvement in their performance, confirming that active peer engagement and collaborative learning facilitate deeper understanding of scientific concepts. Additionally, the results indicate that the positive effects of RPT are consistent across both male and female students, suggesting that this strategy effectively promotes gender equity in academic achievement. This aligns with theoretical perspectives emphasizing social interaction as a key driver of learning, as well as empirical evidence supporting student-centered instructional approaches. Therefore, the adoption of Reciprocal Peer Tutoring in science classrooms, particularly in challenging topics like Radioactivity, holds great promise for improving academic outcomes and fostering inclusive education. Educators and policymakers should consider integrating RPT into teaching practices to enhance students' learning experiences and contribute to the overall development of science education in Benue State and similar contexts.

Recommendations

Based on the findings of this study, it is recommended that;

1. Science educators in Benue State and similar educational contexts adopt the Reciprocal Peer Tutoring (RPT) learning strategy as a regular instructional approach, especially when teaching complex topics such as Radioactivity.
2. Teachers should receive professional development and training on effectively implementing RPT to maximize its benefits for student achievement.
3. School administrators and policymakers should support the integration of peer tutoring programs by providing necessary resources and creating an enabling environment that encourages collaborative learning.
4. Additionally, since RPT was shown to be effective for both male and female students, efforts should be made to promote this inclusive strategy to bridge any existing gender gaps in science education.

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