

Exploring the RADEC and 5E Learning Models on Pre-service Mathematics Teachers Academic Achievement in Geometry in Federal Colleges of Education, Southwest Nigeria

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ABSTRACT

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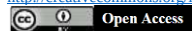
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This study examined the effectiveness of RADEC and 5E learning models on pre-service Mathematics teachers' academic achievement in Geometry in Federal Colleges of Education, Southwest Nigeria. The population for this study comprise of the seventy-six (76) 200 level pre-service teachers in the Mathematics departments of the five (5) Federal Colleges of Education in Southwest, Nigeria. A multi-stage sampling procedure was employed in the selection of sample in this study. Simple random sampling method was used to select three (3) Federal Colleges of Education and purposive sampling method was used to select the intact class which is total enumeration of 200 level pre-service Mathematics teachers in the three (3) randomly selected from the colleges of education will constitute the sample size of sixty-two (62). Three research instruments were used: Geometry Achievement Test (GAT) (KR20 = 0.97), Geometry Lesson Plan (GLP) and Geometry Lesson Notes (GLN). Three hypotheses were formulated and tested using Analysis of Covariance (ANCOVA) at 0.05 level of significance. The results showed that there was a significant main effect of RADEC and 5E learning models on pre-service teachers' achievement in geometry ($F(2, 60) = 13.54$; $p < 0.05$, partial $\eta^2 = 0.39$); there was no significant main effect of gender on pre-service teachers' achievement in geometry ($F(1, 60) = 0.17$; $p > 0.05$, partial $\eta^2 = 0.004$) and that there was no significant interaction effect of treatment and gender on pre-service teachers' achievement in geometry ($F(2, 60) = 0.706$; $p > 0.05$, partial $\eta^2 = 0.032$). Based on the findings, it was recommended among others that Colleges of education should incorporate RADEC and 5E learning models in the teaching of geometry

Keywords: RADEC Learning Model, 5E Learning Model, Geometry, Pre-service Mathematics teachers, Academic Achievement

Introduction

Mathematics is a fundamental discipline that plays a pivotal role in Nigeria's socio-economic development, driving innovation, technological advancement, and scientific progress. As a cornerstone of mathematics education, geometry is a crucial component of teacher education programs, essential for cultivating problem-solving, critical thinking, and spatial reasoning skills. Geometry, in particular, provides a framework for understanding spatial relationships, patterns, and structures, making it a vital tool for various fields, including engineering, architecture, and design (Malik & Salman, 2022).

Geometry is a branch of Mathematics, and is indeed the oldest of all sciences, going back at least to the times of Euclid, Pythagoras, and other "natural philosophers" of ancient Greece. Initially, Geometry was studied to understand the physical world we live in, and the tradition continues to this day (Ojediran & Oludipe, 2024). Witness, for example the spectacular success of Einstein's theory of general relativity, a purely geometric theory that describes gravitation in terms of the curvature of a four-dimensional space-time. However, Geometry transcends far beyond physical applications, and it is not unreasonable to say that geometric ideas and methods have always permeated every field of Mathematics. The need to explore innovative teaching approaches that can improve students' understanding and achievement in Mathematics and geometry in particular has become imperative



(Tiamiyu, Salman, & Issau, 2023). RADEC (Read, Answer, Discuss, Explain, and Create) and 5E (Engage, Explore, Explain, Elaborate, and Evaluate) are to be considered in this study as an innovative strategies to improve the learning of the subject matter.

The RADEC learning model represents a multifaceted pedagogical approach designed to foster deep learning and critical thinking across diverse educational contexts. It is intricately structured around five core phases: Read, Answer, Discuss, Explore, and Create, each strategically contributing to a holistic learning experience (Malik & Salman, 2022). The Read phase initiates the learning process by immersing students in foundational knowledge, which involves engaging with various resources such as texts, articles, and multimedia content to establish a solid understanding of the subject matter. This phase emphasizes information absorption and comprehension. Subsequently, the Answer phase transitions learners from passive recipients of information to active processors, which involves students responding to targeted questions and prompts that encourage critical thinking and knowledge recall (Bisandu, Datiri, & Yakube, 2024). The integration of concept mapping can provide nursing students with the framework to address the Answer phase. The third phase, Discuss, cultivates collaborative learning through structured dialogues and debates, which enable students to articulate their understanding, challenge assumptions, and consider diverse perspectives. This phase emphasizes communication and interpersonal skills development. The Explore phase encourages independent investigation and discovery, offering students opportunities to delve deeper into specific areas of interest, conduct experiments, and gather empirical evidence. The integration of theoretical inquiry with hands-on experiences is an important component of this phase. The Create phase represents the culmination of the learning process, where students synthesize their knowledge and insights to produce original artifacts, projects, or solutions (Fuentes, et al. 2025).

The 5E learning model is an integration of various teaching methods as it presents a concept through five pathways that facilitate learning (Oladosun, 2024). The 5E learning model, a pedagogical framework rooted in constructivist learning theory, provides a structured yet flexible approach to designing engaging and effective learning experiences. It emphasizes student activity in constructing knowledge, which challenges educators to discover a learning model that actively helps students acquire knowledge by teach independently. Originating from the Biological Sciences Curriculum Study in the late 1980s, the 5E model has gained widespread recognition and application in various educational settings and disciplines, particularly science education (Bokhorst-Heng, & Marshall, 2023). The model can be used in science courses to increase the quality of practices and to design science courses based on structural approach and cognitive psychology (Owan, Eno & Esuong, 2022). Furthermore, Bybee argues that the use of this approach helps students redefine, organize, examine, and change the ideas they already have through interacting with their peers and environment (Bokhorst-Heng & Marshall, 2023). The 5E learning model helps and serves teachers in that it provides an example of the application of the structuralist approach in course processing and provides good reform-based instruction. He also stated that the model could help to develop the curriculum. The technology-enriched 5E learning model is a good tool for students to acquire 21st-century skills as well as for teachers to teach a specific concept. In his study on the 5E learning model, the students in this model were more active and motivated than the students in lecture-based classrooms and that these students could find opportunities to share their knowledge and experiences (Bryant, et al., 2023).

Teacher preparation is an essential component of the educational system, as it is the foundation upon which future educators are built (Kohar, 2020). Mathematics teacher educators also play a crucial role in shaping the next generation of Mathematics teachers by providing them with the knowledge, skills, and dispositions necessary to be successful in the classroom. Teacher educators need to stay abreast of current research and best practices in Mathematics education and incorporate these into their

teacher preparation programmes (Sidee, 2024). Furthermore, teacher educators should model effective teaching practices in their own classrooms, demonstrating how to create engaging and challenging learning experiences for students. This includes a keen awareness of the nuances inherent in Mathematics education, equipping prospective teachers with the skills to navigate the challenges and opportunities that arise in the classroom. The ability to adapt teaching strategies to accommodate the diverse learning styles and needs of students is paramount (Campbell, 2023).

The moderator variable considered in this work is gender. Gender is a socio-cultural ascription of roles on the basis of masculinity or femininity. It is the social or cultural construct, characteristics, behaviours and roles which society ascribes to females and males. Gender disparities in Mathematics education fields have been attributed to family formation and child rearing, gender stereotyping, lifestyles choices, religion, careers preferences, personal choices among others (Alonge, 2022). These factors make certain careers and professions (engineering, architecture, and technical education programmes in which Mathematics is a core subject) are regarded as belonging to the male gender while others such as teaching, nursing, catering and home economics, typing and the arts are regarded as belonging to the female gender. The demand for skilled work force in the technological field will be difficult, if not impossible to meet, if the nature's future technological workforce does not reflect the diversity of the population.

The study is supported by the social load theory which was propounded by Herbert Kelman in the year 1950, a burgeoning area of research, posits that an individual's cognitive resources are affected by the perceived effort and contributions of others within a collaborative learning environment, potentially influencing academic outcomes, particularly in cognitively demanding subjects like Geometry (Justicia-Galiano, et al., 2022). Geometry, with its dependence on spatial reasoning, abstract thinking, and problem-solving skills, poses a unique challenge for students, often requiring great cognitive engagement. When students perceive an inequitable allocation of effort within a group, where some members are viewed as "free-riders," it can lead to increased irritation, diminished motivation, and ultimately, a higher cognitive load for the more conscientious members (Jacob & Linus, 2024).

This study examines the impact of RADEC and 5E learning models on pre-service mathematics teachers' geometry achievement in Federal Colleges of Education, Southwest Nigeria. Specifically, the study investigates the effects of these models on students' understanding of geometric concepts and overall academic achievement in geometry while simultaneously examining the moderating roles of gender

Statement of the Problem

Geometry as a cornerstone of Mathematics education, cultivates spatial reasoning, problem-solving abilities, and logical deduction. Its significance resonates throughout various disciplines, including engineering, architecture, and computer science. Despite its importance, geometry education presents persistent challenges, often attributed to abstract concepts. Mathematics is the only subject widely disliked and abysmally understood by Nigerian students, not only in primary or secondary school, even in tertiary institution in Nigeria, students are not studying the subject by their choice in most cases. The teaching and learning of geometry in Colleges of Education in Nigeria faces significant challenges, impacting the preparedness of pre-service Mathematics teachers. Effective instructional strategies are therefore paramount in fostering a deeper understanding and appreciation of geometry among students. Recently, there has been a growing interest in students activities based instructional models that could enhance student academic achievement in Geometry. Two of such models are the RADEC (Read, Answer, Discuss, Explain, and Create) and 5E (Engage, Explore, Explain, Elaborate, and Evaluate) models.

This study aims to address a critical gap in Mathematics education research by investigating the effects of the RADEC and 5E learning models in enhancing geometry achievement among pre-service Mathematics teachers.

Aim and Objectives of the Study

This study aims to examine the effectiveness of RADEC and 5E learning models on pre-service Mathematics teachers' academic achievement in Geometry in Federal Colleges of Education, Southwestern Nigeria. Specifically, the objectives of the study are to:

- i. determine the main effect main effect of treatment on pre-service teachers' achievement in geometry.
- ii. examine the main effect of gender on pre-service teachers' achievement in geometry.
- iii. determine the interaction effect of treatment and gender on pre-service teachers' achievement in geometry.

Hypotheses

The following hypotheses were tested at 0.05 level of significance:

H₀₁: There will be no significant main effect of treatment (RADEC and 5E learning Models) on pre-service Mathematics teachers' achievement in geometry.

H₀₂: There will be no significant main effect of gender on pre-service Mathematics teachers' achievement in geometry.

H₀₃: There will be no significant interaction effect of treatment and gender on pre-service Mathematics teachers' achievement in geometry.

Methodology

The study adopted the pretest, posttest control group quasi-experimental research design. This study employed two experimental groups and one control group; the experimental groups was be exposed to treatment in RADEC and 5E learning models, while the control group was exposed to the conventional method of teaching.

The population for this study comprise of the seventy-six (76) 200 level pre-service teachers in the Mathematics departments of the five (5) Colleges of Education in Southwest, Nigeria. The Colleges of Education are; Federal College of Education (Special), Oyo; Federal College of Education Osiele, Abeokuta, Ogun State; Federal College of Education, Iwo, Osun State; Federal College of Education, Ilawe Ekiti, Ekiti State and Federal College of Education (Technical), Akoka, Lagos, Lagos State. The 200 Level students were used because they are in their second academic session in their colleges. They are taking Geometry as a course (MAT 214 - Geometry) and they had also been exposed to EDU 113- Principles and Methods of Teaching which has to do with learning strategies at their 100 level. In addition to these, 200 level students have also being taught MAT 114 – Mathematics Methodology which will enhance this study.

A multi-stage sampling procedure was employed in the selection of sample in this study. The first stage was selection of three (3) Federal Colleges of Education among the five (5) Federal Colleges of Education in Southwest, Nigeria using simple random sampling method. Then, purposive sampling method was used to select the intact class (total enumeration) of 200 level pre-service Mathematics teachers in the three (3) randomly selected Federal Colleges of Education constituted the sample size. The total enumeration is sixty-two (62) respondents which served as the sample for the study. The selection was based on their relative far distances from one another and their location in the Southwest. The major criteria for selection of the Federal Colleges of Education are that they are federal government owned and the departments are operating the current NCCE minimum standard and with lecturers with minimum M.Ed. in Mathematics. The researcher believes that if pedagogical changes must be effected

when teachers on the field are not forthcoming, the best place to go is colleges of education where pre-service teachers are being produced. The colleges were grouped into Experimental Group A (RADEC Learning Model), Experimental Group B (5E Learning Model) and Control group.

The three instruments used in this study were made up of one response (measurement) instrument and two stimulus (instructional guides) instruments. The response instrument is Geometry Achievement Test (GAT) and the stimulus instruments are Geometry Lesson Plan (GLP) and Geometry Lesson Notes (GLN). The instruments was given to three (3) Lecturers in the Department of Science Education and two (2) experts in the field measurement and evaluation to look at the content, construct, and face validity of the instruments. A trial testing of the instrument was carried out on intact class of 200 level pre-service Mathematics students in Federal College of Education, (Technical) Akoka, Lagos State. Kuder-Richardson Formular (KR-20) was used to determine it reliability coefficient. The reliability coefficient of $r=0.97$ was obtained. Data were collected using procedural steps.

The data collected was analysed using inferential statistics of Analysis of Covariance (ANCOVA). The rationale for the use of the statistical tools employed in this study was based on the nature of the hypotheses tested at a 0.05 level of significance.

Results

The results were arranged based on the stated hypotheses as follow;

Ho1: There will be no significant main effect of treatment on pre-service teachers' achievement in geometry

Table 1: Analysis of Covariance (ANCOVA) of Post-Achievement by Treatment, Learning Style and Gender

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1005.592	18	55.866	12.235	0.001	0.837
Intercept	777.440	1	777.440	170.262	0.001	0.798
Pre-Achievement	454.501	1	454.501	99.537	0.001	0.698
Treatment	123.684	2	61.842	13.544*	0.001	0.386
Learning Style	1.930	2	0.965	0.211	0.810	0.010
Gender	.756	1	0.756	0.166	0.686	0.004
Treatment x Learning Style	1.754	4	0.439	0.096	0.983	0.009
Treatment x Gender	6.443	2	3.222	0.706	0.499	0.032
Learning Style x Gender	3.716	2	1.858	0.407	0.668	0.019
Treatment x Learning Style x Gender	52.962	4	13.1241	2.900*	0.033	0.212
Error	196.344	43	4.566			
T5tal	60908.000	62				
Corrected Total	1201.935	61				

R Squared=.84(Adjusted R Squared = 0.77)*denotes significant $p < 0.05$

Source: Fieldwork, 2026

Table 1 revealed that there was a significant main effect of treatment on pre-service teachers' achievement in geometry ($F_{(2, 60)} = 13.54$; $p < 0.05$, partial $\eta^2 = 0.39$). The table indicated the effect size of 39.0%. This means that 39.0% of the total 77.0% variation observed ($\text{Adjusted}R^2 = 0.77$) in pre-service teachers' achievement in geometry in this ANCOVA model was due to the significant main effect of the treatment.

Ho2: There was no significant main effect of gender on pre-service teachers' achievement in geometry.

Table 2: Analysis of Covariance (ANCOVA) Showing Main Effect of Gender on Pre-service Teachers' Achievement in Geometry

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1005.592	18	55.866	12.235	0.001	0.837
Intercept	777.440	1	777.440	170.262	0.001	0.798
Pre-Achievement	454.501	1	454.501	99.537	0.001	0.698
Treatment	123.684	2	61.842	13.544*	0.001	0.386
Learning Style	1.930	2	0.965	0.211	0.810	0.010
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Treatment x Learning Style x Gender	52.962	4	13.1241	2.900*	0.033	0.212
Error	196.344	43	4.566			
Total	60908.000	62				
Corrected Total	1201.935	61				

R Squared=.84(Adjusted R Squared = 0.77)*denotes significant $p < 0.05$

Source: Fieldwork, 2026

Table 2 indicated that there was no significant main effect of gender on pre-service teachers' achievement in geometry ($F_{(1, 60)} = 0.17$; $p > 0.05$, partial $\eta^2 = 0.004$). This means that gender had no effect on pre-service teachers' achievement in geometry.

Ho3: There was no significant interaction effect of treatment and gender on pre-service teachers' achievement in geometry.

Table 3: Analysis of Covariance (ANCOVA) Showing Interaction Effect of Treatment and Gender on Pre-service Teachers' Achievement in Geometry

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1005.592	18	55.866	12.235	0.001	0.837
Intercept	777.440	1	777.440	170.262	0.001	0.798
Pre-Achievement	454.501	1	454.501	99.537	0.001	0.698
Treatment	123.684	2	61.842	13.544*	0.001	0.386
Learning Style	1.930	2	.965	0.211	0.810	0.010
Gender	.756	1	0.756	0.166	0.686	0.004
Treatment x Learning Style	1.754	4	0.439	0.096	0.983	0.009
Treatment x Gender	6.443	2	3.222	0.706	0.499	0.032
Learning Style x Gender	3.716	2	1.858	0.407	0.668	0.019
Treatment x Learning Style x Gender	52.962	4	13.1241	2.900*	0.033	0.212
Error	196.344	43	4.566			
Total	60908.000	62				
Corrected Total	1201.935	61				

R Squared=.84(Adjusted R Squared =0.77)*denotes significant $p < 0.05$

Source: Fieldwork, 2026

Table 3 indicated that there was no significant interaction effect of treatment and gender on pre-service teachers' achievement in geometry ($F_{2,60} = 0.706$; $p > 0.05$, partial $\eta^2 = 0.032$). This means that treatment and gender combined had no effect on pre-service teachers' achievement in geometry.

Discussion

The finding revealed that there was a significant main effect of treatment on pre-service teachers' achievement in geometry. This finding is consistent with finding of Tiamiyu, et. al., (2023) which highlighted the differential impact of inquiry-based and constructivist approaches on teacher education outcomes. Specifically, the partial eta squared value of 0.39 suggests that 39% of the variance in pre-service teachers' geometry achievement can be attributed to the learning model employed, underscoring the practical significance of this pedagogical distinction (Malik & Salman, 2022). This substantial effect size aligns with studies reporting moderate to large impacts of specific instructional methods on student achievement, particularly in mathematics and science education by Fuentes, et. al. (2025).

The study revealed that there is no significant main effect of gender on pre-service Mathematics teachers' achievement in geometry. This means that gender did not affect pre-service Mathematics teachers' achievement in geometry. Consistent with this finding, studies by Oladosun, (2024) and Sidee, (2024) similarly reported no significant differences in spatial thinking skills or knowledge and perceptions between male and female pre-service teachers. The findings of Bryant, et al. (2023), Kohar, (2020) and Alonge, (2022) are in agreement with the findings that revealed that male students perform better than female students in mathematics. However, the result of this present study complies with a findings that revealed no significant effect on male and female students' achievement in mathematics.

The interaction effect of treatment and gender on pre-service mathematics teachers' achievement in geometry was not significant. The treatment and gender had no effect because, in finding, it was revealed that the post-achievement mean score in the geometry of students in the RADEC learning model was not significantly different from those in the 5E learning model and not significantly different from those exposed to the Conventional Strategy. Also, the difference in the post-achievement mean scores of students in the treatment and those in the conventional strategy was not significant. This indicates that the significant difference observed in the result was not due to the difference between the treatment groups but between the treatment groups and the control group as students' post-achievement scores in geometry are concerned. This outcome aligns with previous research indicating a lack of significant interaction between instructional strategies and gender in influencing geometry achievement among pre-service teachers (Bokhorst-Heng & Marshall, 2023).

Conclusion

This study determined the effects of RADEC and 5E learning models on academic achievement of pre-service Mathematics teachers in geometry in Federal Colleges of Education, Southwest, Nigeria. The study showed that there was a significant main effect of treatment on pre-service teachers' achievement in geometry and there was no significant main effect of gender on pre-service Mathematics teachers' achievement in geometry. It was further revealed that there was no significant main effect to learning model on pre-service teachers' achievement in geometry and the interaction effect of treatment and learning models on pre-service teachers' achievement in geometry was not significant. This indicates that treatment and learning models had no effect on pre-service teachers' achievement in geometry.

Recommendations

Based on the findings of this study, the following recommendations were made;

1. Colleges of Education should incorporate RADEC and 5E learning models in the teaching of geometry.
2. Mathematics educators should continue to adopt gender neutral teaching approach, ensuring that both male and females are equally supported in their learning and treated equally.
3. Gender dynamics of students should be maintained.

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