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EFFECTS OF 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

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 study adopted the pretest, posttest control group quasi-experimental research design. The population for this study comprises 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. 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 - total enumeration of 200 level pre-service Mathematics teachers in the three (3) randomly selected Federal Colleges of Education constituted the sample size of sixty-two (62). Three research instruments were used: Geometry Achievement Test (GAT) with reliability coefficient (KR-20) of 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. In the results, 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 to learning styles on pre-service teachers' achievement in geometry ($F_{(2, 60)} = 0.21$; $p > 0.05$, partial $\eta^2 = 0.010$); the interaction effect of treatment and learning styles on pre-service Mathematics teachers' achievement in geometry was not significant ($F_{(4,58)} = 0.096$; $p > 0.05$, partial $\eta^2 = 0.009$). It was recommended 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, learning styles, academic achievement.

Introduction

Mathematics education is an essential element of contemporary education, significantly influencing cognitive development and future opportunities for individuals. Mathematics is a foundational subject that supports several disciplines, including Science, Technology, Engineering, and Mathematics (STEM) subjects. The importance of Mathematics education cannot be overstated, as it provides students with the skills and knowledge necessary to succeed in an increasingly complex and technological world. Since the 19th century, the discourse surrounding Mathematics education in the Western world has been extensive and has engaged prominent mathematicians (Campbell, 2023). This debate encompasses all age groups of learners, from primary school to university level Mathematics education.

A considerable number of students in primary and secondary schools face difficulties in comprehending certain aspects of the Mathematics curriculum. Like learners having obstacles in studying Mathematics, teachers also have issues in delivering effective instruction within the Nigerian educational system. This has posed problems for parents, students, educators, and education professionals. Educators are currently confronted with the challenge of delivering effective instruction that leads to improved student performance in both internal and external assessments (Abdurrahman & Nofriyandi, 2022; Ojediran & Oludipe, 2024).

Geometry is a critical component of Mathematics education, providing students with the skills and knowledge necessary to understand and describe spatial relationships (Adolphus, 2024). Geometry is used in various fields, including architecture, engineering, and design. However, geometry can be a challenging subject for many students, requiring a strong understanding of mathematical concepts and spatial reasoning. Geometry is the study of size, form and position of two and three dimensional shapes and objects. Geometry should be learnt from primary school till university level (Carlana, 2019; Mainali, 2022)). This suggests that geometry is considered as an important part of technical drawing because of its importance to technology. Learning geometry is a fundamental skill to master other areas in technical drawing (Brantuo, Atta, Klu, & Atta, 2023). Geometry delivers the following benefits: helps pupils develop the essential abilities of analysis, comparison and generalization; useful in portraying and solving problems in other technical drawing fields and in real world situations (Galitskaya & Drigas, 2023). As vital as this field of geometry is, students' achievement and interest in this area has been on the wane. Various ideas including patterns generation, graphics, physics and applications were included in Geometry.

Meanwhile, much is expected from Mathematics, although earlier studies have revealed that the development of the cognitive aspect of the subject is high but the pedagogical lapses is with the transfer of the acquired knowledge to areas of affective and psychomotor, in terms of attitude and academic achievement (Giannoukos, 2024; Cheng et al., 2024). The quest for effective instructional strategies to enhance academic achievement in Mathematics education has been a persistent concern for educators and researchers. In Nigeria, the performance of students in Mathematics, particularly in geometry, has been a subject of concern. The need to explore innovative teaching approaches that can improve students' understanding and achievement in Mathematics has become imperative (Alim, Fauzan, Arwana, & Musdi, 2023). This is where RADEC (Read, Answer, Discuss, Explain, and Create) and 5E (Engage, Explore, Explain, Elaborate, and Evaluate) learning models come in handy.

The RADEC learning model, which stands for Read, Answer, Discuss, Explain, and Create, is an innovative educational framework designed to enhance student engagement and learning outcomes through active participation. Developed as a response to traditional teaching methods that often limit student involvement and critical thinking, RADEC emphasizes a

structured approach that encourages students to actively interact with the learning material and with each other (Dan, 2021). By integrating various pedagogical strategies, the model promotes deeper understanding and fosters essential 21st-century skills, including critical thinking, creativity, and collaboration, making it particularly notable in contemporary educational discourse. Tracing its origins to research advocating for active learning methodologies, RADEC has evolved to address the diverse needs of learners, ensuring that education is more student-centered. Studies have shown that implementing the RADEC model can significantly boost student motivation and engagement, leading to improved academic performance across various subjects. Its adaptability across primary, secondary, and higher education contexts demonstrates its versatility and relevance in modern educational practices, which are increasingly focused on promoting interactive and inclusive learning environments (Almasri, 2022; Olutola, Olatoye & Olatoye, 2023)

Both RADEC learning model and Mathematics encourage activity based learning. Hence, the 5E learning model is adopted in this study in view of its potential for achievement in Geometry. The 5E model is another instructional approach that focuses on inquiry-based learning and hands-on activities. 5E model was developed by Robert Bybee. The foundation of this model was affected by works of German philosopher Freidrich Herbart. Furthermore, in his view, this model is based on the ground of John Dewey and Jean Piaget. As a very frequently used model in constructivist learning approach, 5E learning cycle model's name comes from the number of its phases and the initials of each phase. These five phases are; Engage/Enter, Explore, Explain, Elaborate and Evaluate. The 5E learning model is a constructivist model which provides learning a new concept or comprehension deeply a known concept. This model which increases students' merak of research, by satisfying expectations of students, consists of active research's skills and activities that are necessary for knowledge and comprehension (Grove, Guiry & Croft, 2025). The 5E model targets at the discovery and the association with previous knowledge of new concepts by students. With the aid of planned and applied learning-teaching activities, students form themselves their own knowledge about a specific problem.

Pre-service Mathematics teachers are students in formal teacher education programmes that prepare them to work as math teachers at different levels of education, from elementary to secondary. These individuals are distinguished by their participation in accredited teacher preparation programmes, where they undertake coursework, field experiences, and other activities designed to cultivate the knowledge, skills, and dispositions essential for proficient Mathematics instruction (Ishak, Din & Hasran, 2020). A crucial portion of their preparation is having a comprehensive grasp of mathematical topics, teaching approaches, and the diverse requirements of students in Mathematics classrooms. Pre-service teachers must develop a comprehensive understanding of mathematical concepts, methods, and problem-solving strategies, with the ability to represent mathematical ideas in multiple formats and establish connections among distinct mathematical fields (Isa, 2025). This includes not only knowing the material to be taught but also building a more comprehensive understanding of primary Mathematics, therefore allowing for a clear and exact explanation of essential concepts (Dew, Galassi & Galassi, 2023).

A moderator variable in this work is learning styles. Learning styles have been used successfully to predict students' academic achievement in Geometry. Strong positive correlations between learning styles and academic performance are a frequently replicated finding in numerous studies and in several meta-analyses. Learning styles has been shown to be one of the best predictors of academic success (Kennedy & Galstaun, 2023). Particularly strong correlations have been identified in analyses combining values from different learning styles (Fiangga,et al., 2025).

Learning styles refer to the varied ways individuals choose to learn and absorb information. Learning style is the preferred way in which students' process and retain information. Different learning styles, such as visual, auditory, and kinesthetic, may influence how students respond to different instructional models. In educational settings, knowing different types is vital for developing effective teaching tactics, particularly in language acquisition. One of the key learning styles is visual learning, where pupils prefer to utilize images, diagrams, and other visual aids to understand concepts. This strategy can dramatically affect language acquisition Mathematics, by boosting vocabulary retention and comprehension through visual context. Visual learners can benefit from flashcards, films, and pictorial representations of mathematical topics. The inclusion of learning styles into Mathematics training can assist address individual disparities among students (Fernández-Ros, et. al., 2022; Dereje, 2023; Usman & Sabitu, 2025).

This study is supported by Piaget's Constructivist Theory. Constructivism has been described as a philosophy, an epistemology, a cognitive perspective, and a pedagogical orientation. Piaget's constructivist paradigm emphasizes that the teacher is not a transmitter of knowledge but rather a facilitator and giver of experiences from which learners will tap and learn (Olaitan. & Moroluyo, 2024). At the same time, learners are not simply absorbers of knowledge; rather they are active participants in generating their own meaning on the basis of firmly held preconceptions (Schell & Janicki, 2023; Udeani, 2024). The implementation of Piaget constructivist philosophy in Geometry instruction shows tremendous promise for boosting academic attainment. Geometry, with its emphasis on spatial thinking, visualization, and problem-solving, lends itself well to constructivist teaching methodologies. By involving students in hands-on exercises, collaborative projects, and real-world applications, Teachers may build a better knowledge of geometric concepts and principles. For instance, Euclidean Geometry provides a logical framework for geometric ideas, making it a significant achievement for mathematicians (Tavares, Vieira & Pedro, 2021).

In recent years, 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, while simultaneously examining the moderating roles of learning style.

Statement of the Problem

Geometry being an important integral 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 Fedral 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. Recenty, 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 investigated the effectiveness of RADEC and 5E learning models on pre-service Mathematics teachers' academic achievement in Geometry in Federal Colleges of Education, Southwestern Nigeria.

Objectives of the Study

This main objective of this study is 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 learning style on pre-service teachers' achievement in geometry.
iii. examine the interaction effect of treatment and learning style on pre-service teachers' achievement in geometry.

Hypotheses

The following hypotheses were tested at 0.05 level of significance:

$H_0$1: There is no significant main effect of treatment (RADEC and 5E learning Models) on pre-service Mathematics teachers' achievement in geometry.

$H_0$2: There is no significant main effect of learning style on pre-service Mathematics teachers' achievement in geometry.

$H_0$3: There is no significant interaction effect of treatment and learning style 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 were taught using the treatment (RADEC and 5E learning models), while the control group was taught using the conventional method of teaching. The population for this study comprise of the whole seventy-six (76) 200 level pre-service teachers in the Mathematics departments of the five (5) Federal 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. The population of 200 level pre-service Mathematics in Federal Colleges of Education in southwest Nigeria is as follow;

Table 1: Population of the Study

S/N	Name of school	Population
1	Federal College of Education (Special), Oyo, Oyo State	**22**
2	Federal College of Education Osiele, Abeokuta, Ogun	**26**
3	Federal College of Education, Iwo, Osun State	**14**
4	Federal College of Education (Technical), Akoka, Lagos State	**13**
5	Federal College of Education, Ilawe Ekiti, Ekiti State	**0**
	Total	**76**

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 Formula 20 (KR-20) was used to determine it reliability coefficient. The reliability coefficient of r=0.97 was obtained. Data were collected using the following procedural steps:

Week 1 - Pre-experimental activities and Training of Research Assistants
Week 2 - Pretest Administration
Week 3 -7 - Treatment Administration
Week 8 - Posttest Administration
Total - 8 weeks

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 presented based on the hypotheses stated as follow;

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

Table 2: 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	.001	.837
Intercept	777.440	1	777.440	170.262	.001	.798
Pre-Achievement	454.501	1	454.501	99.537	.001	.698
Treatment	123.684	2	61.842	13.544*	.001	.386
Learning Style	1.930	2	.965	.211	.810	.010
Gender	.756	1	.756	.166	.686	.004
Treatment x Learning Style	1.754	4	.439	.096	.983	.009
Treatment x Gender	6.443	2	3.222	.706	.499	.032
Learning Style x Gender	3.716	2	1.858	.407	.668	.019
Treatment x Learning Style x Gender	52.962	4	13.l241	2.900*	.033	.212
Error	196.344	43	4.566			
T5tal	60908.000	62				
Corrected Total	1201.935	61				

R Squared=.84(Adjusted R Squared=.77)*denotes significant p<.05

Source: *Fieldwork, 2026*

Table 2 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 $\eta^2 = 0.39$). Table 2 indicated the effect size of 39.0%. This means that 39.0% of the total 77.0% variation observed (AdjustedR^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 is no significant main effect of learning style on pre-service teachers' achievement in geometry

Table 3 Analysis of Covariance (ANCOVA) Showing Main Effect of Learning Style 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	.001	.837
Intercept	777.440	1	777.440	170.262	.001	.798
Pre-Achievement	454.501	1	454.501	99.537	.001	.698
Treatment	123.684	2	61.842	13.544*	.001	.386
Learning Style	1.930	2	.965	.211	.810	.010
Gender	.756	1	.756	.166	.686	.004
Treatment x Learning Style	1.754	4	.439	.096	.983	.009
Treatment x Gender	6.443	2	3.222	.706	.499	.032
Learning Style x Gender	3.716	2	1.858	.407	.668	.019
Treatment x Learning Style x Gender	52.962	4	13.l241	2.900*	.033	.212
Error	196.344	43	4.566			
Total	60908.000	62				
Corrected Total	1201.935	61				

R Squared=.84(Adjusted R Squared=.77)*denotes significant p<.05

Source: *Fieldwork, 2026*

Table 3 showed that there was no significant main effect to learning style on pre-service teachers' achievement in geometry ($F_{(2, 60)} = 0.21$; $p > 0.05$, partial $\eta^2 = 0.010$). This means that learning style had no effect on pre-service teachers' achievement in geometry.

Ho3: There is no significant interaction effect of treatment and learning style on pre-service teachers' achievement in geometry

Table 4: Analysis of Covariance (ANCOVA) Showing Interaction Effect of Treatment and Learning Style 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	.001	.837
Intercept	777.440	1	777.440	170.262	.001	.798
Pre-Achievement	454.501	1	454.501	99.537	.001	.698
Treatment	123.684	2	61.842	13.544*	.001	.386
Learning Style	1.930	2	.965	.211	.810	.010
Gender	.756	1	.756	.166	.686	.004
Treatment x Learning Style	1.754	4	.439	.096	.983	.009
Treatment x Gender	6.443	2	3.222	.706	.499	.032
Learning Style x Gender	3.716	2	1.858	.407	.668	.019
Treatment x Learning Style x Gender	52.962	4	13.l241	2.900*	.033	.212
Error	196.344	43	4.566			
Total	60908.000	62				
Corrected Total	1201.935	61				

R Squared=.84(Adjusted R Squared=.77)*denotes significant p<.05

Source: *Fieldwork, 2026*

Table 4 showed that the interaction effect of treatment and learning style on pre-service teachers' achievement in geometry was not significant ($F_{(4,58)} = 0.096$; $p > 0.05$, partial $\eta^2 = 0.009$). This indicates that treatment and learning style had no effect on pre-service teachers' achievement in geometry.

Discussion of Findings

The finding revealed that there was a significant main effect of treatment on pre-service teachers' achievement in geometry. This finding is in line with the finding of Dew, Galassi and Galassi (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 (Galitskaya & Drigas, 2023). 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 Brantuo, Atta, Klu, & Atta, (2023).

This finding revealed that there was no significant main effect to learning style on pre-service teachers' achievement in geometry. Research indicated that while some specific teaching

methods significantly enhance geometry achievement, the overall learning style might not exhibit a standalone effect without considering some moderating variables such as the integration of technology or student engagement (Brantuo, Atta, Klu, & Atta, 2023). Indeed, studies consistently demonstrate that innovation integration in Mathematics education, especially in geometry, significantly enhances student achievement and conceptual understanding. This is particularly evident in studies where innovative tools, such as GeoGebra or augmented reality, have been shown to outperform traditional constructivist methods in improving geometric understanding (Galitskaya & Drigas, 2023). Such innovation can facilitate the exploration of abstract geometrical concepts and foster thinking skills, thereby bridging the gap between theoretical knowledge and practical application. This aligns with findings suggesting that while the overall learning styles might not show a direct significant effect, specific innovative interventions within mathematics education can notably influence student outcomes by fostering positive attitudes and increased motivation towards learning (Alim, Fauzan, Arwana, & Musdi, 2023).

The finding revealed that there was no significant interaction effect of treatment and Learning on pre-styles on pre-service teachers' achievement in geometry. This outcome aligns with other research indicating that progression through teacher education programmes may not inherently lead to substantial improvements in pre-service teachers' geometric understanding, such as their ability to relate quadrilateral properties (Almasri, 2022). The lack of a significant interaction effect implies that neither the specific instructional approach nor the learning styles provided a unique advantage when combined, contrasting with studies demonstrating the efficacy of technology-integrated methods in improving geometry achievement (Adolphus, 2024). Therefore, the observed outcomes suggest that the influence of teaching experience on learning outcomes remains independent of the specific instructional methodology employed. This outcome aligns with other research indicating that progression through teacher education programmes may not inherently lead to substantial improvements in pre-service teachers' geometric understanding, such as their ability to relate quadrilateral properties (Ishak, Din & Hasran, 2020).

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. Also, it was further revealed that there was no significant main effect to learning styles on pre-service teachers' achievement in geometry and the interaction effect of treatment and learning styles 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. It was concluded from the study that pre-service Mathematics teachers performed better in geometry when RADEC and 5E learning models are used by the lecturers to teach them.

Recommendations

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

1. Federal Colleges of Education should incorporate RADEC and 5E learning models in the teaching of geometry.
2. Mathematics lecturers in the Federal Colleges of Education should focus on developing teaching strategies that are effective across various learning styles, rather than tailoring instruction to specific learning style to optimise academic achievement in geometry.

3. Mathematics lecturers Federal Colleges of Education should explore alternative teaching strategies that can effectively integrate with various learning styles to improve academic achievement in geometry, as the current treatment do not show a unique interaction effect.

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