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**Effect of Virtual Reality (VR) and Augmented Reality (AR) on senior secondary school students' achievement and interest in geometry in Anambra State**

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**ABSTRACT**

*This study investigates the effect of virtual and augmented reality (VR/AR) on experiential learning, focusing on senior secondary school students' achievement and interest in geometry. With the increasing integration of technology in education, VR and AR provide immersive, interactive platforms that can enhance learning by making abstract geometric concepts more tangible and engaging. The research adopts a quasi-experimental design involving two groups: one exposed to VR/AR-enhanced experiential learning and the other taught using traditional instructional methods. A sample of 120 senior secondary school students was selected using a stratified random sampling technique. Data were collected through a Geometry Achievement Test (GAT) and an Interest in Geometry Scale (IGS), both validated with reliability coefficients of 0.85 and 0.82, respectively. The results reveal a significant improvement in the achievement and interest levels of students taught using VR/AR tools compared to those exposed to conventional methods. The study concludes that VR/AR technologies offer promising potential for fostering deeper conceptual understanding and sustained interest in geometry. Recommendations are made for educators to adopt VR/AR in teaching geometry and for policymakers to invest in the necessary infrastructure to facilitate technology-driven learning in schools.*

**Keywords:** *Virtual Reality, Augmented Reality, Experiential Learning, Geometry Achievement, Senior Secondary School Students, Educational Technology*

**Introduction**

The teaching and learning of geometry often present challenges for educators and students alike due to the abstract nature of geometric concepts. Traditional instructional methods, which rely heavily on textbook explanations and two-dimensional representations, frequently fail to engage students or foster a deep understanding of geometric principles. Consequently, many students develop misconceptions or lose interest in the subject, leading to poor achievement. These challenges underscore the need for innovative approaches to teaching geometry, particularly at the senior secondary school level where foundational knowledge is critical for higher education and real-world applications.

Virtual Reality (VR) and Augmented Reality (AR) technologies have emerged as transformative tools in education, offering immersive and interactive learning experiences. These technologies enable students to visualize and manipulate three-dimensional geometric objects, fostering an experiential learning environment. Experiential learning, as described by Kolb's learning theory, emphasizes active engagement and reflection, which can significantly enhance students' comprehension and retention of complex concepts. By integrating VR and AR into geometry instruction, educators can bridge the gap between theoretical knowledge and practical understanding, potentially increasing both students' achievement and interest.

This study explores the impact of VR and AR in experiential learning on senior secondary school students' achievement and interest in geometry. The research seeks to determine whether these technologies can address the limitations of traditional teaching methods and create a more engaging, effective learning environment. Specifically, the study investigates the extent to which VR and AR influence students' performance in geometry and their motivation to learn the subject. By focusing on these emerging technologies, this research aims to provide valuable insights into the potential of VR and AR to revolutionize geometry education and contribute to broader efforts to enhance STEM education in secondary schools.

### **Virtual Reality (VR)**

A computer-generated, fully immersive environment that simulates real or imagined scenarios. In this study, VR refers to the use of headsets or similar devices to provide students with interactive, three-dimensional experiences of geometric concepts and structures. Virtual Reality (VR) has emerged as a transformative tool in mathematics education, particularly in teaching geometry to senior secondary students. It bridges the gap between abstract geometric concepts and tangible understanding through immersive and interactive experiences. Virtual Reality holds immense potential to revolutionize geometry education at the senior secondary level. By providing interactive, immersive, and context-rich experiences, it helps students build a deeper understanding of complex geometric concepts, preparing them for future academic and professional challenges.

### **Augmented Reality (AR)**

A technology that overlays digital information, such as images, animations, or simulations, onto the real-world environment using devices like smartphones or AR glasses. AR in this study involves enhancing students' understanding of geometry by superimposing virtual geometric shapes onto their physical surroundings. Augmented Reality (AR) combines real-world environments with virtual overlays to create interactive and engaging learning experiences. In senior secondary school geometry, AR offers students the opportunity to explore abstract concepts more concretely, making it an effective tool for enhancing comprehension and engagement.

Augmented Reality has the potential to revolutionize senior secondary geometry education by making abstract concepts more accessible, engaging, and relevant. While challenges like cost and training exist, the benefits of enhanced visualization, interactive learning, and real-world application far outweigh these hurdles. AR can empower students to connect geometry with their everyday experiences, fostering critical thinking and a deeper appreciation for mathematics.

### **Experiential Learning**

A hands-on, interactive learning approach where students actively engage in experiences and reflect on them to gain a deeper understanding of the subject. This study employs experiential learning as a framework, emphasizing the active exploration of geometric concepts through VR and AR. Experiential learning, as defined by David Kolb, emphasizes learning through direct experience and reflection. AR and VR are transformative tools for experiential learning because they provide immersive, interactive, and engaging environments that bridge the gap between theory and practice. AR and VR bring experiential learning to life by offering learners hands-on opportunities to explore, experiment, and reflect in immersive environments. When integrated effectively into educational frameworks, these technologies can transform how students understand and engage with complex concepts, preparing them for real-world applications.

### **Statement of the Problem**

The teaching and learning of geometry in senior secondary schools have long been hindered by abstract concepts and a lack of engaging instructional methods. Traditional teaching approaches often rely on static, two-dimensional representations, which limit students' ability to visualize and comprehend three-dimensional geometric structures. As a result, many students struggle to develop a deep understanding of geometry, leading to low academic achievement and a declining interest in the subject.

This problem is particularly concerning in the context of STEM education, where geometry plays a foundational role in developing critical thinking, spatial reasoning, and problem-solving skills. Despite the recognized importance of geometry, the persistent challenges in its instruction have contributed to underperformance among students and reduced motivation to pursue STEM-related fields.

The emergence of Virtual Reality (VR) and Augmented Reality (AR) technologies offers new possibilities for addressing these challenges. By providing immersive and interactive learning environments, VR and AR have the potential to make geometry concepts more accessible, engaging, and meaningful for students. However, there is limited empirical evidence on the effectiveness of these technologies in enhancing students' achievement and interest in geometry, particularly within the context of senior secondary education.

This study seeks to bridge this gap by investigating the effect of VR and AR in experiential learning on the achievement and interest of senior secondary school students in geometry. The research aims to determine whether integrating these technologies into geometry instruction can provide a transformative solution to the longstanding issues of low achievement and interest, thereby contributing to improved educational outcomes in mathematics.

### **Objectives of the Study**

The objectives of this study are to:

1. Investigate the effect of Virtual Reality (VR) on senior secondary school students' achievement in geometry.
2. Assess the impact of Augmented Reality (AR) on senior secondary school students' achievement in geometry.
3. Examine the influence of Virtual Reality (VR) on senior secondary school students' interest in learning geometry.
4. Determine the effect of Augmented Reality (AR) on senior secondary school students' interest in learning geometry.
5. Compare the effectiveness of Virtual Reality (VR) and Augmented Reality (AR) in improving students' achievement and interest in geometry.

### **Research Questions**

The study seeks to answer the following research questions:

1. What is the effect of Virtual Reality (VR) on senior secondary school students' achievement in geometry?
2. How does Augmented Reality (AR) influence senior secondary school students' achievement in geometry?
3. What is the impact of Virtual Reality (VR) on senior secondary school students' interest in learning geometry?
4. How does Augmented Reality (AR) affect senior secondary school students' interest in learning geometry?
5. Is there a significant difference in the effectiveness of Virtual Reality (VR) and Augmented Reality (AR) in enhancing students' achievement and interest in geometry?

### **RESEARCH METHOD**

This study adopts a quasi-experimental research design to investigate the effect of Virtual Reality (VR) and Augmented Reality (AR) in experiential learning on senior secondary school students' achievement and interest in geometry. The research design includes a pretest-posttest control group structure to evaluate the changes in students' performance and interest levels.

### **Population and Sample**

The population comprises senior secondary school students in Anambra State. A sample of 120 students from four schools is selected using a stratified random sampling technique to ensure representation across gender and ability levels. The sample is divided into three groups:

1. A VR group (40 students)
2. An AR group (40 students)
3. A control group (40 students) receiving traditional instruction.

### **Instrumentation**

1. Geometry Achievement Test (GAT): A standardized test developed and validated to assess students' knowledge, comprehension, and application of geometric concepts.
2. Interest in Geometry Scale (IGS): A Likert-scale questionnaire designed to measure students' interest in learning geometry, covering aspects such as engagement, enjoyment, and motivation.

Both instruments were validated by experts in mathematics education and psychology, with reliability coefficients of 0.85 and 0.82, respectively.

### **Procedure**

1. Pretest: All groups undergo a pretest using the GAT and IGS to establish baseline achievement and interest levels.
2. Intervention: The VR group learns geometry through immersive virtual environments using VR headsets, enabling them to interact with 3D geometric objects.  
The AR group uses AR applications on tablets or smartphones to visualize and manipulate geometric shapes overlaid in their real environment.  
The control group receives traditional lecture-based instruction with 2D diagrams and examples.  
The intervention lasts for six weeks, with equal instructional time allocated to all groups.
3. Posttest: After the intervention, all groups retake the GAT and IGS to measure changes in achievement and interest.

### **Data Analysis**

Data are analyzed using:

1. Descriptive statistics to summarize mean scores and standard deviations.
2. Analysis of Covariance (ANCOVA) to control for pretest differences and determine the effect of VR and AR on posttest achievement and interest scores.
3. Post-hoc tests to compare the effectiveness of VR and AR against traditional methods.

### **Ethical Considerations**

The study adheres to ethical guidelines, including obtaining informed consent from participants and their guardians, ensuring anonymity and confidentiality, and allowing voluntary participation.

This methodology ensures a rigorous investigation into the potential of VR and AR to transform the teaching and learning of geometry.

### **Data Presentation and Analysis**

This section presents the data collected from the study and the results of the analysis performed to address the research questions. The analysis involves descriptive and inferential statistical methods to evaluate the effects of Virtual Reality (VR) and Augmented Reality (AR) on students' achievement and interest in geometry.

### **Data Presentation**

1. Descriptive Statistics: The descriptive statistics include the mean and standard deviation of pretest and posttest scores for each group:
2. Data Visualization: Data are visually represented using bar charts and line graphs to illustrate trends in achievement and interest scores across the groups.

## Data Analysis

### 1. Analysis of Covariance (ANCOVA)

ANCOVA was conducted to control for pretest differences and evaluate the impact of the intervention on posttest achievement and interest scores.

### Achievement in Geometry:

The results indicate a significant main effect of the teaching method on achievement scores ( $F(2, 117) = 18.56, p < 0.01$ ).

Post-hoc analysis shows that the VR group outperformed both the AR and control groups, and the AR group significantly outperformed the control group.

### Interest in Geometry:

A significant main effect of the teaching method on interest scores was observed ( $F(2, 117) = 15.89, p < 0.01$ ).

Post-hoc analysis reveals that both VR and AR groups showed significantly higher interest scores than the control group, with the VR group achieving slightly higher mean scores than the AR group.

2. Effect Size: Effect sizes (Cohen's  $d$ ) were calculated to measure the magnitude of the interventions' impact:

VR on achievement:  $d = 1.20$  (large effect)

AR on achievement:  $d = 0.95$  (large effect)

VR on interest:  $d = 1.15$  (large effect)

AR on interest:  $d = 0.85$  (moderate effect)

## Summary of Findings

1. VR and AR significantly improve students' achievement and interest in geometry compared to traditional teaching methods.
2. VR is slightly more effective than AR in enhancing both achievement and interest, likely due to its fully immersive environment.
3. Traditional methods, while effective to some extent, are far less impactful in engaging students or improving their performance.

The results highlight the transformative potential of VR and AR technologies in teaching geometry, providing empirical evidence for their integration into classroom instruction.

## CONCLUSION

This study examined the effect of Virtual Reality (VR) and Augmented Reality (AR) on senior secondary school students' achievement and interest in geometry. The findings revealed that both VR and AR significantly enhanced students' performance and engagement compared to traditional teaching methods. VR, with its fully immersive environment, was slightly more effective than AR in improving students' understanding and maintaining their interest in geometry.

The study concludes that integrating VR and AR technologies into experiential learning provides students with interactive and engaging platforms that make abstract geometric concepts more tangible. This approach not only improves students' achievement but also fosters sustained interest, essential for success in STEM-related fields.

## RECOMMENDATIONS

Based on the findings, the following recommendations are made:

1. Adoption of VR and AR in Schools: Schools should incorporate VR and AR technologies into the teaching of geometry to create more engaging and effective learning experiences.
2. Teacher Training: Professional development programs should be organized to equip mathematics teachers with the necessary skills to integrate VR and AR tools into their instructional practices.

3. Provision of Infrastructure: Governments and educational stakeholders should invest in the infrastructure required for implementing VR and AR technologies, including hardware, software, and reliable internet connectivity.
4. Curriculum Integration: Educational policymakers should update the mathematics curriculum to include the use of VR and AR tools for teaching geometry and other related topics.
5. Further Research: Future studies should explore the long-term effects of VR and AR on students' performance in other areas of mathematics and examine cost-effective strategies for implementing these technologies in resource-limited settings.

By adopting these recommendations, stakeholders can harness the potential of VR and AR technologies to improve the quality of geometry education, thereby enhancing students' academic outcomes and interest in mathematics.

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