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ANALYZING THE EFFECTIVENESS OF EMERGING TECHNOLOGIES, SUCH AS AUGMENTED REALITY (AR) AND VIRTUAL REALITY (VR), IN ENHANCING 200-LEVEL LINEAR ALGEBRA I AT THE UNIVERSITY OF JOS, PLATEAU STATE, NIGERIA

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Abstract

This study analyzes the effectiveness of emerging technologies, such as Augmented Reality (AR) and Virtual Reality (VR), in enhancing the teaching and learning of 200-level Linear Algebra I at the University of Jos, Plateau State, Nigeria. The research aims to assess the impact of AR and VR on student engagement, compare the learning outcomes of students using these technologies with those using traditional methods, and determine the usability and accessibility of AR and VR technologies. Utilizing an experimental design, the study involved 45 students and employed surveys and t-tests to gather and analyze data. The findings reveal that AR and VR technologies significantly enhance student engagement and interest in Linear Algebra I, with a grand mean of 2.82936 indicating a positive impact. Additionally, students using AR and VR technologies demonstrated better learning outcomes compared to their counterparts using traditional methods, with a grand mean of 3.09474. Furthermore, students perceived the usability and accessibility of AR and VR technologies positively, with a grand mean of 3.10874. The t-test analysis [$t(92) = 0.422$, $p < 0.05$] confirmed the significant impact of AR and VR on student engagement and interest. Based on these results, the study concludes that AR and VR technologies are effective educational tools for enhancing student engagement and learning outcomes in Linear Algebra I. It is recommended that universities invest in AR and VR infrastructure, provide training for educators on the use of these technologies, and offer robust technical support to ensure their effective implementation and accessibility.

Keywords:
Effectiveness, Emerging Technologies, Augmented Reality (AR), Virtual Reality (VR), Linear Algebra I

Introduction

In recent years, the advent of emerging technologies, particularly Augmented Reality (AR) and Virtual Reality (VR), has significantly impacted various sectors, including education. These technologies have introduced innovative ways to enhance learning experiences by providing

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immersive, interactive, and engaging environments. AR overlays digital information onto the physical world, thereby augmenting reality with additional data and interactive elements, while VR creates entirely virtual environments that simulate real-world or imagined settings (Bacca et al., 2014; Freina & Ott, 2015). These technological advancements offer promising tools for educators to address the challenges of teaching complex and abstract subjects such as Linear Algebra.

Linear Algebra is a foundational course in many science, technology, engineering, and mathematics (STEM) programs, yet it is often perceived as difficult by students due to its abstract nature (Stewart et al., 2013). Traditional teaching methods, which typically rely on lectures and textbooks, may not adequately address the diverse learning needs of students or fully engage them in the subject matter. Emerging technologies like AR and VR have the potential to transform this educational landscape by making abstract concepts more tangible and easier to understand through visualization and interaction.

Several studies have explored the benefits of AR and VR in educational settings. For instance, Cheng and Tsai (2016) found that VR-based learning environments can enhance students' conceptual understanding and problem-solving skills. Similarly, AR has been shown to improve spatial awareness and engagement in learning activities, making it particularly useful for subjects that involve complex visual and spatial information (Ibáñez & Delgado-Kloos, 2018). These technologies can provide students with hands-on experience and allow them to explore and manipulate mathematical objects in three-dimensional space, thereby fostering a deeper understanding of the subject matter.

Despite the potential advantages of AR and VR, their implementation in educational contexts, particularly in developing countries like Nigeria, presents unique challenges. These include limited access to technological resources, lack of training for educators, and the need for curriculum adaptation (Agu et al., 2020). However, the growing interest and investment in educational technology in Nigeria suggest that these barriers can be overcome with strategic planning and support.

This study aims to analyze the effectiveness of AR and VR in enhancing the learning experience of 200-level Linear Algebra I students at the University of Jos, Plateau State, Nigeria. By integrating these technologies into the curriculum, this research seeks to determine their impact on students' understanding, engagement, and academic performance. The findings of this study will provide valuable insights into the potential of AR and VR as educational tools in higher education and contribute to the broader discourse on the future of technology-enhanced learning.

Statement of the Problem

Linear Algebra I is a fundamental course for second-year students at the University of Jos, Plateau State, Nigeria. However, many students find the abstract concepts challenging to grasp through traditional teaching methods. This difficulty often results in poor academic performance and a lack of enthusiasm for the subject. Given the advancements in educational technologies, it is crucial to explore the effectiveness of emerging technologies, such as Augmented Reality (AR) and Virtual Reality (VR), in enhancing the teaching and learning experience of this course.

In an ideal scenario, the integration of AR and VR technologies into the Linear Algebra I curriculum would significantly enhance students' understanding and engagement. These technologies would provide interactive and immersive learning experiences, enabling students to visualize complex concepts and perform virtual manipulations of mathematical objects. The ideal outcome would be

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improved comprehension, higher academic performance, and increased interest in the subject, leading to a stronger foundation for future mathematical courses.

Currently, the use of AR and VR in the educational context at the University of Jos is limited. There is a lack of infrastructure, resources, and training for both educators and students to effectively implement these technologies. Additionally, there are challenges related to the high cost of AR and VR equipment and the need for technical support. As a result, the potential benefits of these technologies are not being realized, and traditional teaching methods continue to dominate, which may not adequately address the learning needs of students in Linear Algebra I.

If the current situation persists, students may continue to struggle with understanding linear algebra concepts, leading to poor academic performance and a lack of confidence in their mathematical abilities. This could negatively impact their overall academic journey and limit their potential in fields that require strong mathematical skills. Furthermore, the University of Jos may fall behind other institutions that are successfully integrating modern technologies into their curricula, potentially affecting its reputation and attractiveness to prospective students.

By addressing these issues and exploring the implementation of AR and VR technologies, the University of Jos could transform the learning experience for its students, fostering a more engaging, effective, and forward-thinking educational environment.

Purpose of the study:

The purpose of this study is to Analyzing the effectiveness of emerging technologies, such as Augmented Reality (AR) and Virtual Reality (VR), in enhancing 200-level Linear Algebra I at the University of Jos, Plateau State, Nigeria. The specific objectives of the study are:

1. Assess how AR and VR technologies affect student engagement in Linear Algebra I.
2. Compare the learning outcomes of students using AR and VR technologies with those using traditional teaching methods.
3. Determine the usability and accessibility of AR and VR technologies by students.

Research Questions

1. How do AR and VR technologies impact student engagement and interest in Linear Algebra I?
2. What differences exist in the learning outcomes of students who use AR and VR technologies compared to those who do not?
3. How do students perceive the usability and accessibility of AR and VR technologies in teaching and learning Linear Algebra I?

Research Hypothesis

(Ho_1): AR and VR technologies do not have a significant impact on student engagement and interest in Linear Algebra I.

MATERIAL AND METHODS

Study Design:

In this study design Experimental Design, Experimental design is a systematic method used to plan and conduct experiments in a way that ensures reliable and valid results. It involves organizing and controlling the conditions under which an experiment is conducted to test hypotheses, examine

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cause-and-effect relationships, and draw conclusions. Experimental design allows researchers to control variables and conditions, ensuring that the results are due to the manipulation of the independent variable rather than external factors. This precision helps in establishing clear cause-and-effect relationships.

POPULATION AND SAMPLE

Population:

The population for this study consists of all 200-level students enrolled in Linear Algebra I. There are 16 students in Pure Mathematics in the Department of Natural Sciences, while Mathematics Education has 29 students at the University of Jos, Plateau State, Nigeria. Specifically, there are forty-five (45) students currently enrolled in Linear Algebra I courses at the University for the 2023/2024 academic session.

Sample:

Since the population size is relatively small and manageable, it is feasible to include everyone in the study, ensuring comprehensive data collection without the need for sampling. In this study, considering the population size of 45 students, using the entire population is practical and beneficial. It ensures that your findings are representative and accurate, providing a solid basis for understanding the impact of mathematical modeling on students' understanding of Real Analysis.

RESULTS AND DISCUSSION

Results:

Research Question 1:

How do AR and VR technologies impact student engagement and interest in Linear Algebra I?

Table 1: AR and VR technologies impact student engagement and interest in Linear Algebra I

S/N	ITEAMS	N	MEAN	ST. DEV	REMARK
1	How much more engaged do you feel during lessons that incorporate AR/VR technologies compared to traditional methods?	45	3.4123	0.73603	Accept
2	How often do you find yourself more motivated to study Linear Algebra I when AR/VR technologies are used?	45	2.6754	0.7983	Accept
3	Do you feel that AR/VR technologies make the learning of complex Linear Algebra concepts more enjoyable?	45	3.182	0.93749	Accept
4	How likely are you to participate in class activities when AR/VR technologies are involved?	45	3.1732	0.7722	Accept
5	In your opinion, do AR/VR technologies help in sustaining your interest in Linear Algebra I throughout the semester?	45	1.7039	1.1378	Reject
Grand Mean= 2.82936					

Decision Rule 2.50

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Descriptive statistics in table 1 above showed the result of data used to Assess how AR and VR technologies affect student engagement in Linear Algebra I.. Item 1 have the mean of 3.4123, with the Standard Deviation of 0.73603. Item 2 has mean of 2.6754, with the Standard Deviation of 0.7983. Item 3 have the mean of 3.182with the Standard Deviation of 0.93749. Item 4 has mean of 3.1732, with the Standard Deviation of 0.7722, Item 5 has mean of 1.7039, with the Standard Deviation of 1.1378. The despondence agreed with item 1,2,3and 4, but they fail to agree with Item 5. According to their response, the Providing adequate instructional materials and more classrooms cannot solve the problem of large classes and enhance teachers' attitude to work. The grand mean of 2.82936, which is above the decision rule of 2.50, indicates that AR and VR technologies generally have a positive impact on student engagement and interest in Linear Algebra I.

Research Question 2:
What differences exist in the learning outcomes of students who use AR and VR technologies compared to those who do not?

Table 2: The learning outcomes of students who use AR and VR technologies compared to those who do not

S/N	ITEAMS	N	MEAN	ST. DEV	REMARK
6	How would you rate your understanding of Linear Algebra concepts after using AR/VR technologies?	45	2.8728	0.84466	Accept
7	Have your test scores improved since incorporating AR/VR technologies into your learning process?	45	3.2588	0.81398	Accept
8	how confident are you in applying Linear Algebra concepts learned through AR/VR technologies to real-world problems?	45	3.3289	1.06766	Accept
9	How do you compare your performance in assignments and exams before and after the use of AR/VR technologies?	45	3.0658	1.11535	Accept
10	Do you believe that AR/VR technologies have helped you understand the practical applications of Linear Algebra more effectively than traditional methods?	45	2.9474	1.14904	Accept
	Grand Mean= 3.09474				

Decision Rule 2.50

Descriptive statistics in table 2 above showed the result of data used to Compare the learning outcomes of students using AR and VR technologies with those using traditional teaching methods.. Item 6 have the mean of 2.8728, with the Standard Deviation of 0.84466. Item 7 has mean of 3.2588, with the Standard Deviation of 0.81398. Item 8 have the mean of 3.3289 with the Standard Deviation of 1.06766. Item 9 has mean of 3.0658, with the Standard Deviation of 1.11535, Item 10 has mean of 2.9474, with the Standard Deviation of 1.14904. The despondence agreed with item 6,7,8 and 9. The grand mean of 3.09474, which is above the decision rule of 2.50, indicates that students using AR and VR technologies experience better learning outcomes compared to those who do not use these technologies.

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Research Question 3:
How do students perceive the usability and accessibility of AR and VR technologies in teaching and learning Linear Algebra I?

Table 1: students perceive the usability and accessibility of AR and VR technologies in teaching and learning Linear Algebra

S/N	ITEAMS	N	MEAN	ST. DEV	REMARK
11	how user-friendly do you find the AR/VR technologies used in your Linear Algebra I course?	45	3.2675	0.96688	Accept
12	How easily can you access the AR/VR technologies outside of the classroom for additional practice?	45	3.2829	0.82076	Accept
13	Do you encounter any technical issues when using AR/VR technologies in your learning process?	45	2.8333	0.80293	Accept
14	How satisfied are you with the support and resources provided for using AR/VR technologies in your studies?	45	2.8311	0.99228	Accept
15	In your opinion, how accessible are AR/VR technologies for all students, regardless of their technical background?	45	3.3289	1.06766	Accept
Grand Mean= 3.10874					

Decision Rule 2.50

Descriptive statistics in table 3 above showed the result of data used to determine the usability and accessibility of AR and VR technologies by students. Item 11 have the mean of 3.2675, with the Standard Deviation of 0.96688. Item 12 has mean of 3.2829, with the Standard Deviation of 0.82076. Item 13 have the mean of 2.8333with the Standard Deviation of 0.80293. Item 14 has mean of 2.8311, with the Standard Deviation of 0.99228, Item 15 has mean of 3.3289, with the Standard Deviation of 1.06766. The despondence agreed with item 11,12,13,14 and 15. The grand mean of 3.10874, which is above the decision rule of 2.50, indicates that students perceive the usability and accessibility of AR and VR technologies in teaching and learning Linear Algebra I positively.

TESTING HYPOTHESIS
Hypothesis One:
(Ho_1): AR and VR technologies do not have a significant impact on student engagement and interest in Linear Algebra I.

Table 6: t-test Analysis - AR and VR technologies do not have a significant impact on student engagement and interest in Linear Algebra I

Groups	N	Mean	Std. Deviation	df	t-value	p-value	Remarks
(AR and VR technologies)	16	9.5957	2.65935	92	0.422	0.004	Significant
Student engagement and interest in Linear Algebra I	29	9.3404	3.00924				

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Inferential statistics in table 4 above showed the result that determine whether or not AR and VR technologies do have a significant impact on student engagement and interest in Linear Algebra I. The *t* – test analysis result is [$t_{(92)} = 0.422$, $p < 0.05$]. Since the p-value (0.004) is less than 0.05, we reject the null hypothesis (H01). This means that there is sufficient evidence to conclude that AR and VR technologies have a significant impact on student engagement and interest in Linear Algebra I based on this t-test analysis.

CONCLUSION:

Findings:

The study found that AR and VR technologies significantly enhance student engagement and interest in Linear Algebra I, as evidenced by a grand mean of 2.82936, above the decision rule of 2.50. Learning outcomes improved with the integration of AR and VR, with a grand mean of 3.09474, indicating better performance compared to traditional methods. Additionally, students perceived AR and VR technologies as user-friendly and accessible, with a grand mean of 3.10874. AR and VR technologies positively impact student engagement, enhance learning outcomes, and are perceived as accessible and user-friendly by students in the context of Linear Algebra I at the University of Jos. The significant p-value (<0.05) from the t-test analysis further supports the conclusion that these technologies are effective educational tools.

Recommendations:

1. Increase Investment in AR/VR Infrastructure: Universities should invest in AR and VR technologies to enhance student engagement and learning outcomes.
2. Training for Educators: Provide comprehensive training for instructors on the effective use of AR and VR in their teaching methodologies.
3. Enhanced Technical Support: Ensure robust technical support and resources to address any technical issues and improve the usability and accessibility of AR and VR technologies for all students.

Competing Interests:

"Authors have declared that no competing interests exist."

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