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Virtual Reality Assisted Learning: Assessing Students' Academic Performance in Learning the Earth's Structure in Tanzanian Secondary Schools

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Abstract: *Although there is evidence from around the world that virtual reality can help students understand abstract concepts in geography classes, Tanzanian schools still struggle greatly with integrating VR into the teaching and learning process. Therefore, this research examined how secondary school students in Tanzania's Chamwino District learnt about the Earth's structure through the use of virtual reality (VR). Using a mixed-methods approach, the study employed a quasi-experimental design that included teacher interviews, questionnaires, classroom observations, and pre- and post-test assessments. The study involved 66 respondents (six teachers and 60 students) from three schools. With post-test mean scores (M = 60.60, SD = 15.56) significantly higher than pre-test mean scores (M = 46.15, SD = 13.51), the quantitative data demonstrated a considerable increase in academic performance. The difference between the pre- and post-scores was statistically significant (t=9.14, P<0.001). Nevertheless, issues including a lack of infrastructure, insufficient training for teachers, and the exclusion of virtual reality from the national curriculum were also noted by participant1s with varying opinions. Teachers indicated a significant willingness to embrace virtual reality (VR) despite these limitations, as long as funds and support for professional development are made available. According to the study's findings, virtual reality has the potential to revolutionize Tanzanian education, and its inclusion in the national curriculum is hereby suggested. The study recommended that Virtual Reality has the potential to transform the landscape of geography education in Tanzania. It promotes active, student-centered learning and provides innovative means for making abstract concepts accessible. However, realizing this potential requires addressing the systemic challenges of infrastructure, training, and policy.*

Keywords: *Virtual Reality, The structure of the Earth, Teaching, Learning, Academic Performance,* Geography

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1. Introduction

Over the past two decades, the teaching and learning process has undergone a substantial transformation due to the incorporation of technology in education, particularly in sub-Saharan Africa (Walimbwa, 2023). It involves the extensive use of digital tools and resources, from computers and tablets to instructional software and online learning environments. This shift in technology was essential in helping students prepare for the world's rapid change (Matthew, Kazaure, & Okafor, 2021). As a result, the current study concentrated on teaching and learning about the Earth's structure using virtual reality (VR) technology.

Virtual reality (VR) is a computer-generated environment that may replicate physical presence in actual or imagined worlds, according to Jaron Lanier, a pioneer in the subject (Lanier, 1987). He highlighted how VR offers immersive experiences that allow consumers to actively engage with the virtual world. Similar to this, Slater (2009) defined virtual reality (VR) as a technology that allowed people to interact and experience computer-generated worlds as though they were there in real life. He emphasized how crucial virtual reality is for creating a sense of "presence," or immersion.

Physical geography concepts such as the structure of the Earth are cornerstones of the geography curriculum in Tanzania. It is thought to be essential to comprehend the Earth's structure since it reveals information about the composition, internal workings, and geological past of the planet. The structure of the Earth has unique characteristics; each of these strata shapes the planet's surface and impacts living systems and natural occurrences. Understanding geological processes like plate tectonics, volcanic activity, and seismic movements—all of which have a direct influence on human and environmental systems—was made easier for students by studying these strata.

Understanding the composition of the Earth provides a strong basis for future research in fields like geography, geology, and environmental science (Hamidi, 2022). Additionally, this knowledge improves students' perception of Earth as a dynamic system, stimulates scientific curiosity, and helps them develop critical thinking abilities (Chen, 2021). However, this topic's abstract character presents serious teaching difficulties. Since the Earth's underlying layers cannot be seen directly, students frequently struggle to imagine and visualize them. The intricacy, size, and interconnectedness of these systems are sometimes difficult to communicate using traditional teaching aids like 2D diagrams and physical models. On the contrary, there is limited knowledge on how VR can support students' learning of such abstract concepts in sub-Saharan African secondary schools, Tanzania included.

According to research by Angelina et al. (2019), 87.4% of participants felt that virtual reality (VR) might be used to enhance interactive learning. This demonstrates how well-liked and successful VR is seen to be as a teaching tool. Consequently, it was determined that virtual reality held promise for promoting immersive and participatory learning, particularly in the context of intricate subjects like the Earth's structure. In essence, through VR, students might develop a deeper and more accurate understanding of Earth's internal dynamics within the safety and convenience of their classroom environments. In this regard, the present study investigated the effect of virtual reality on teaching and learning the topic of the structure of the Earth among secondary school students in Chamwino District, Tanzania.

1.1 Statement of the Problem

The integration of technologies into educational settings has gained significant attention in recent years. The role of technology in secondary education is to reshape pedagogical practices, boost students' engagement, and foster a more interactive learning environment (MoEST, 2023). Despite that, the teaching of Earth's structure in many Tanzanian secondary schools, including those in Chamwino District, is predominantly theoretical, utilizing traditional methods like static textbook images, chalkboard illustrations, and lectures. These methods are ineffective in conveying the dynamic and layered nature of Earth's interior, resulting in students struggling to visualize and grasp the scale and complexity of these abstract concepts. The absence of interactive and experiential learning tools contributes to student disengagement and prevents the development of a profound, long-term understanding of the topic.

Virtual Reality technology provides educational solutions by enriching current reality with multimedia elements, fostering interactive and experiential learning environments, and is particularly beneficial for subjects such as Geography (Fitria, 2023).

In Tanzania, scholars advocate the use of VR/AR in improving and enhancing interactive learning, as the application of technology in learning not only impacts students' learning performance through visualizations and interactivity but also underscores the importance of considering cost–effective and geographical barriers (Angelina et al., 2019). Virtual Reality has emerged as an innovative tool with the potential to transform educational practices across various subjects. It can bring a distant or inaccessible environment into their normal environment. Technology offers a deeper understanding of the geographical, cultural, and historical aspects. However, this technology remains largely unexplored with poor application in the teaching and learning process in the Chamwino District.

Therefore, the study explored the effects of Virtual Reality in teaching and learning the structure of the Earth, also explained the influence of the particular technology towards academic performance, and it ended by showing the challenges and opportunities towards the implementation.

2. Literature Review

Applications of virtual reality (VR), which is a three-dimensional computer depiction of a real or imagined location, have grown in popularity and are being used in a variety of contexts, including education and the humanities. This section highlights the use of virtual reality in teaching and learning contexts in both theoretical and empirical literature bases.

2.1 The effect of virtual reality on students' learning

Virtual reality (VR)-enhanced courses have been shown to improve pleasant emotions and engagement. They also make memorization easier than traditional instructional materials like textbook readings and films. Additionally, teaching with VR technology increases instructor efficiency. For instance, research by Kumlu and Özkul (2021) at Kocaeli University in Turkey demonstrates how important it is to use technology, just as it is in other academic disciplines like engineering, architecture, and medicine, which may make the lesson more enjoyable for students. Further, this is considered one of the innovations that should be used is virtual reality (VR), which encourages students to participate and be inspired to learn.

Furthermore, Fitria (2023), who conducted the library search, indicated that the usage of virtual reality enhances the effectiveness and interest of teaching and learning by adding new simulated environments to current visuals, writings, and sounds. Students may learn about certain topics in engaging, interactive, and hands-on ways with the use of technology. Furthermore, Yu-ju and Hung-chun's (2021) study, which involved 39 Yemeni university students, examines how virtual reality affects self-efficacy and intrinsic desire to use virtual technology. The study's findings showed that, despite receiving unfavorable feedback, VR-supported learning enhanced students' self-efficacy for creative thinking and enhanced their competencies. In summary, students view studying through virtual reality as a revitalizing and soothing experience.

According to Nshimiyimana and Ndayambaje (2025), it was concluded that virtual reality simulations were an effective way to enhance Earth Science instruction since they greatly enhanced students' conceptual understanding and spatial reasoning. As a result, while seeing 3D video animations of the layers of the Earth's interior, students may learn about the Earth's structure through virtual reality. Added to this is the East African research that sought to investigate the use of virtual reality (VR) in scientific education, offering suggestions for incorporating VR into the curriculum and methods for overcoming barriers. Therefore, technology may be utilized to make learning meaningful.

According to research by Kumbo et al. (2024) in Dar es Salaam, Tanzania, the usage of virtual reality and augmented reality enhances learning by providing immersive and interactive experiences that boost learning outcomes and student learning. Additionally, Miso et al. (2019) proposed that to improve education, technology and education must be combined. The study evaluated the use of virtual reality and augmented reality as instruments to enhance interactive learning. The study also discovered that these technologies have the power to affect pupils' motives and areas of interest. However, the cost-effectiveness of these technologies is an issue that requires more investigation, especially in areas such as academic performance in studying Earth's structure.

2.2 Virtual reality and students' academic performance

Virtual reality offers more advantages than traditional teaching approaches in terms of student learning, information retention, skill development, and teamwork. Zhao G. et al.'s study (2021) sought to examine the effectiveness of traditional and virtual reality instruction in medical education. The research included a meta-analysis. The findings revealed that the pass rates of students who received instruction using virtual reality and those who received traditional medical education differed significantly. Additionally, the study found that virtual reality should be included in medical schools' teaching and learning processes.

Moreover, Xin (2022) compared the performance between the control group and the test group on how VR technology can facilitate learning. The results show that the emotional engagement (3.366) and cognitive engagement (3.854) in the experimental group under the Virtual Reality environment are higher than those (3.325 and 3.618, respectively) in the control group. This connects to Jong et al's study in 2020, their study that aimed to integrate immersive technology in physical geography, suggesting that learner–immersed virtual Interactive expedition (LIVIE) had a different degree of positive effects on subject achievement.

While investigating the mobile Virtual Reality application instruction content in Geography education by Ozdemir and Ozturk (2022), the study involved 20 students in the control group (who used a traditional teaching method) and 20 students in the experimental group (who used a VR interactive learning method). The result was that the academic scores of the students in the experimental group were higher than in the control group.

2.3 Challenges in implementing virtual reality for teaching

Despite virtual reality's promise to improve the teaching and learning process, integrating this technology is difficult because of a variety of issues, as several researchers have demonstrated. These issues include: Alalwan et al. (2020) noting insufficient skill, poor educational design, inability to focus, lack of time, and restricted environmental resources on the use of VR. Notwithstanding these difficulties, the study clarified the value of virtual reality in the classroom.

Moving on to Abadia and colleagues (2024). According to the report, virtual reality (VR) is mostly utilized to enhance cognitive, emotional, and skill results, give remote access to learning experiences, and replicate experiences that are frequently offered in conventional classrooms. One of the biggest obstacles to the widespread adoption of virtual reality (VR) in online education is hardware, with internet availability being mentioned as the main barrier. Common issues have also been brought forward, including software design, hardware costs, bodily side effects, and the quantity of teacher training needed. According to the study of the prospects that have been reported, the growing accessibility of virtual reality technologies indicates the possibility of overcoming these hardware-related obstacles, since smartphones are still seen to be the most accessible.

Another study that looked into how well virtual reality tools could help teach and learn science subjects in East African nations showed that several obstacles need to be addressed, including a lack of funding for purchasing technology, inadequate teacher professional development, and a lack of a specific education policy on virtual reality instruction (Silaji & Msudi, 2024). There are a number of difficulties in incorporating virtual reality (VR) into secondary school curricula, especially when instructing difficult topics like earth science. These issues affect both teachers and students and span the domains of technology, pedagogy, and infrastructure. Generally, despite the challenges, the empirical evidence suggests that VR has the potential to enhance the teaching and learning process on the structure of the Earth concept within Chamwino and Tanzania in general.

Virtual reality is widely acknowledged as a cutting-edge teaching technology, but little is known about its efficacy and practical implementation in Tanzanian secondary schools, especially in remote areas like Chamwino. When teaching the Structure of the Earth, there is not enough scientific data to determine how virtual reality affects student learning and academic achievement. Additionally, current research ignores the ways in which infrastructural constraints, teacher preparedness, and curriculum development affect VR uptake in this particular setting. Thus, by offering contextualized, localized insights on the advantages and difficulties of utilizing virtual reality (VR) for geography instruction in Tanzania, this work closes a significant research gap.

2.4 Theoretical framework

The experiential learning theory (Kolb, 1984), which highlights the value of experiences in the learning process, was applied in this study. The four stages of experiential learning theory include concrete experience, abstract conceptualization, reflective observation, and active experimentation, according to Kolb. (1984). The following are some ways that the theory may be combined with the use of virtual reality to teach and learn about the Earth's structure.

The theory provided educators with a solid basis for integrating teaching and learning technology that enables students to experience real-world scenarios; the idea was therefore pertinent to the study. Because technology offers interactive and visual representations, it can improve understanding of complicated subjects and increase students' active participation. that encourage students to develop their skills and make learning more accessible by overcoming logistical and geographic obstacles.

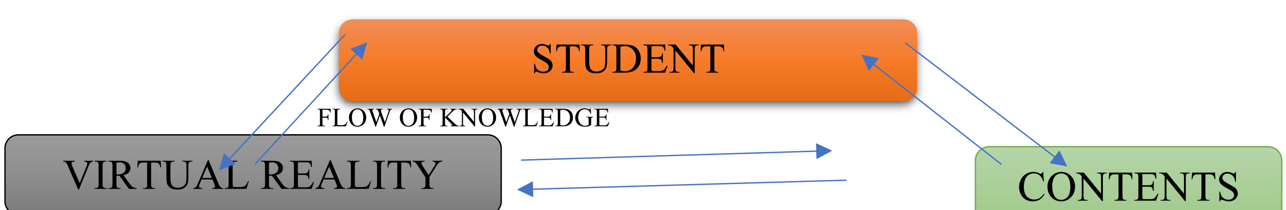

Figure 1: Experiential learning theory

The study included a theory that encourages teachers to embrace teaching and learning theory, as experiential learning theory directly addresses the use of technology.

3. Methodology

3.1. Study context

Teachers and students from three public secondary schools in the Dodoma Region of Tanzania's mainland participated in the study. While having enough resource assistance was a criterion used to choose the schools, this study also took under-resourced schools into account. One of the seven districts (Chamwino) of Tanzania's Dodoma Region. The geographic coordinates of Chamwino District are 6°05'55" South latitude and 36° 02' 17" East longitude. It is approximately 9,132 square kilometres in size. District of Chamwino, 2024. About 486,176 people were living there as of the 2022 Census (Census, 2022). Teachers and the government would be able to adapt geography teaching methods in a more participatory manner with the use of the data collected from Chamwino Secondary Schools.

3.2 Research approach and design

This study used a mixed-methods approach to carefully investigate how virtual reality (VR) affects secondary school teaching and learning of Earth's structure. For this investigation, a convergent parallel mixed techniques design was used. Creswell and Plano (2017) described the convergent parallel mixed methods design in which quantitative and qualitative data are gathered and examined simultaneously, with the results then combined to offer a thorough comprehension of the study issue.

3he design entailed simultaneously collecting quantitative and qualitative data, then analyzing each sort of data independently using the proper techniques (Leech et al., 2010). Lastly, the design made it possible for me to analyze the combined results and make generalizations about how the two datasets support or contradict one another, how they help me better understand the research question, and how they give me a more thorough understanding of a phenomenon

3.3Study participants, sampling procedures, and sample size

The target population is the larger population to whom the research study findings are to be generalized (Johnson & Christen, 2014). This study involved 03 Heads of Schools and 06 Geography teachers who were obtained through a purposive sampling technique. Also, the 60 Form Three students were selected randomly. The geography teachers were used because they are the ones who teach and facilitate the structure of the Earth. The form three students were used because they are the ones who learn this topic according to the current Geography syllabus, and the head of the school is responsible for management in the teaching and learning process.

3.4 Data collection tools and procedures

This research was conducted between May and June 2025. This process of data collection was preceded by the piloting of research tools and testing of their validity and reliability. The actual data collection involved a series of stages as described below:

Stage 1: Interviews with geography teachers

The principles of direct interactions with respondents, as guided by Yin (2018), were ensured. At a roughly average of 45 minutes, interviews with six teachers were conducted at different free time. The main question was exploring their experiences and perceptions of using Virtual Reality in the classroom.

Stage 2: Classroom observations

In this aspect, the classroom observation was taken into account as watching and recording behavior, events, and phenomena as guided by Flick (2018). The study involved Classroom observations to monitor how Virtual Reality is integrated into lessons and how students interact with the technology. The method enabled the researcher to observe the effective use of Virtual Reality during the learning process.

Stage 3: Pre- and post-tests

Pre and post-tests are essential for the evaluation of learning and teaching approaches in the context of the analysis of the effect of Virtual Reality on learning the structure of the Earth in secondary schools in Chamwino district. Before the lesson, a pre-test was done to determine the level of understanding of the students over the topic of the structure of the Earth, before the use of Virtual Reality. Also, the post-test was conducted to assess the achievement attained by the learner after the integration of Virtual Reality in the lesson. The test was constructed on the Structure of Earth topic based on Bloom’s Taxonomy. This ensured assessing both low and higher cognitive aspects.

3.5 Validity and reliability

3.5.1 Reliability

Using SPSS 25.0, the Cronbach's coefficient alpha for a four-point rating scale was calculated to assess the internal reliability of the scale's constituent elements (Cronbach &

Shavelson, 2004). The Cronbach's coefficient alpha of 0.8 demonstrated the items' sufficient internal consistency. Cronbach and Shavelson (2004) state that Cronbach's alpha values should be in the range of 0 and 1, where 1 indicates exceptional consistency (see Table 1 below).

Table 1: Questionnaire items reliability

Reliability Statistics			
Cronbach's Alpha	Part 1	Value	.812
		N of Items	2[a]
	Part 2	Value	.750
		N of Items	2[b]
	Total N of Items		4
Correlation Between Forms			.774
Spearman-Brown Coefficient	Equal Length		.873
	Unequal Length		.873
Guttman Split-Half Coefficient			.869
a. The items are: Content and Learning Experience, Video resources.			
b. The items are: Comparison with Textbooks, Academic performance.			

3.5.1 Validity for test items

Furthermore, the results of Bartlett's Test of Sphericity were statistically significant, with a p-value of.000, degrees of freedom (df) = 6, and an approximate Chi-Square value of 135.140. The correlation matrix is not an identity matrix, indicating that the variables are correlated and appropriate for component analysis-based structure discovery, according to the significance (p <.05).

The substantial Bartlett's Test and the high KMO value indicate that the instrument was appropriate for usage in this situation and that the dataset is eligible for additional exploratory or confirmatory factor analysis. By suggestions made by Field (2018) and Tabachnick & Fidell (2013), this confirms the precision of the results about Objective One and upholds the study's scientific rigor (see Table 2).

Table 2: Validity Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.809
Bartlett's Test of Sphericity	Approx. Chi-Square	135.140
	Df	6
	Sig.	.000

Source: Field data (2025)

In addition, content validity was used to ensure the trustworthiness of interview questions were experts in the field of education, geography in particular, assessed the tools and provided feedback for improvements.

3.5 Data Analysis

Both qualitative and quantitative data were gathered separately. More precisely, the qualitative data were evaluated using the six steps suggested by Braun et al. (2017). Before starting any significant analysis, the research team listened to the taped content many times to finish the transcription procedure. The next step was to read and reread the interview transcripts to become acquainted with the data. After this was completed, the coding process was executed. Coding was used to reduce the amount of interview data, making it easier to handle (Cresswell, 2008). To ensure code consistency and guide the coding process, the hybrid codebook was developed. Coding was done line by line, phrase by phrase, sentence by sentence, or paragraph by paragraph. The codes were then exported to an Excel file after being extracted. This Excel worksheet employed pivot analysis to generate categories (themes).

To ascertain the importance of virtual reality on student learning outcomes, the quantitative data were examined using both descriptive and inferential (paired t-test) statistics. Thematic analysis was used in qualitative analysis to find recurring themes and trends in instructors' and students' experiences with and views of virtual reality. The analysis gave a more thorough understanding of the impact of virtual reality in teaching and learning about the

Earth's structure and helped to contextualize the quantitative results.

3.6Ethical considerations

The United Republic of Tanzania, the President's Office, the Regional Administration, and the Local Government granted the study team permission to enter the Regions and Districts after receiving approval from St. John's University of Tanzania (SJUT). This was followed by assurance of respondents' anonymity and freedom to participate or withdraw from the study. Added to this were consent forms signed or verbal agreement.

4. Results and Discussion

The demographic profile of the respondents is presented first in this section. The research findings about the impact of virtual reality (VR) on teaching and learning the Structure of the Earth among secondary school pupils in Tanzania's Chamwino District are further discussed, and data are presented in depth. The chapter is organized around the specific goal of the present study, which compares student performance before and after VR training to determine how virtual reality affects students' learning.

4.1Respondents' demographic findings

4.1.1 Students' gender

There were 60 responses in all, 32 of whom were men (53.3%) and 28 of them were women (46.7%). With a little male predominance, this distribution shows that the participants' gender representation is reasonably balanced. This indicates that male and female students had almost equal opportunities to take part in the study.

Table 3: Students' gender profile

Gender	**Freq.**	**%**
Female	32	53.3
Male	28	46.7
Total	**60**	**100**

Source: Field Data

Gender-balanced involvement is important from the standpoint of educational technology since it guarantees that the impacts of virtual reality (VR) on teaching and learning are not skewed towards one gender group over another. According to Chou and ChanLin (2015), gender-specific patterns in technology-enhanced learning settings may differ; hence, equal representation is crucial for deriving thorough results. Furthermore, this study's gender inclusivity aligns with UNESCO's (2023) guidelines, which highlight fair access to digital learning resources for both male and female students in impoverished nations like Tanzania (see Table 3).

4.1.2 Students' age distribution

In order to investigate the impact of virtual reality (VR) on teaching and learning the Structure of the Earth, the research also looked at the age distribution of the 60 student participants. The findings showed that respondents were mostly 18 years old (36.7%), followed by 16 years old (35.0%), 17 years old (18.3%), 15 years old (6.7%), and a minority of 19 years old (3.3%) (see Table 4).

Table 4: Students' age profile

Age (Years)	Freq.	%
18		36.7
16		35.0
17		18.3
15		6.7
19		3.3
Total		100

Source: Field Data

According to Tanzania's national education framework, which typically places students in lower secondary school between the ages of 14 and 18, this distribution represents the normal age range of Form Three pupils in Tanzanian secondary schools. A small number of respondents were between the ages of 19 and 15, which might be explained by early or late school admission or grade repetition, which are frequent in rural and peri-urban educational settings (United Republic of Tanzania, 2021).

Given that cognitive growth, maturity, and technological experience might affect learners' openness to innovations like virtual reality, age is a significant variable in the research of educational technology. Students between the ages of 15 and 18 are in the formal operational stage of cognitive development, according to Piaget's theory. They can think abstractly and hypothetically, which are abilities required to understand the intricate, three-dimensional models seen in virtual reality settings (Flavell, 1963).

This sample's age distribution supports Kolb's (1984) experiential learning theory, which emphasizes hands-on activities and reflection approaches that are cognitively accessible to learners in this age range, and it also makes the findings more generalizable by enabling an inclusive evaluation of how VR impacts learners across a typical adolescent developmental span.

4.3 The comparison of students' performance before and after the application of virtual reality

4.3.1 Pre-test performance analysis results

A pre-test measuring students' baseline knowledge of the subject of "Structure of the Earth" was given before the introduction of Virtual Reality (VR)-enhanced teaching. Table 5 indicates the results obtained.

Table 5: Summary of Pre–Test results (Grades)

SCORES	A	B	C	D	F	TOTAL
MALE	00	01	19	10	02	32
FEMALE	00	04	11	07	06	28
TOTAL	00	05	30	17	08	60

Source: Field data (2025)

Out of a potential 100, the results revealed a broad variety of scores, with the lowest being 17 and the highest being 70. With a mean score of 46.15 and a standard deviation of 13.51, the sample's academic performance varied moderately. According to the results, the majority of students received scores below 50, indicating a poor comprehension of the Earth's structure when taught using traditional means, including textbooks, static pictures, and lectures. Just a tiny percentage of pupils had scores higher than 60. In particular, the majority of students were grouped between 30 and 50 marks, with noteworthy frequencies at 37, 42, 44, 45, and 46. Only 5.0% of students achieved the maximum observed value of 65.

This distribution supports the abstract character of the subject, which sometimes presents difficulties for students because of its mental and spatial complexity. According to Fitria (2023) and Jong et al. (2020), pupils only have a surface-level understanding of the Earth's interior since traditional educational techniques find it difficult to communicate the 3D structure and dynamic processes of the planet's interior. This performance level also emphasizes the need for cutting-edge teaching strategies that may close the gap between abstract material and student involvement, such as virtual reality. The poor pre-test scores act as a standard by which the VR intervention's efficacy is subsequently evaluated.

Additionally, the performance revealed that no male or female pupils received an "A," only one boy received a "B," and a small number of ladies received a "4." The substantial student body of Thirty (30) received a "C" grade. Seventeen (17) students received a "D," while eight (08) students received an "F." As a result, using conventional teaching methods, the pre-test results revealed notable learning gaps, poor conceptual grasp, and a general lack of desire. These results supported the use of virtual reality (VR) as an immersive learning tool to raise students' academic performance and understanding in geography classes.

4.3.2 Post-test performance analysis results

The same 60 Form Three pupils were given a posttest following the introduction of Virtual Reality (VR)-based training on the subject of "Structure of the Earth." The findings show that students' academic performance has significantly improved compared to their pre-test results. With a mean score of 60.60 and a standard deviation of 15.56, the post-test results varied from 25 to 90. This implies that the majority of students' performance was over the 100-mark midpoint. While some students achieved scores as high as 70 (8.3%), 81 (5.0%), and 90 (1.7%), a noteworthy group of pupils received 65 marks (15%). Less than 10% of pupils received a score below 40, which represents a significant change from the poor baseline found in the pre-test. Table 6 shows the data obtained during the field study.

Table 6: Summary of post–test results (Grade)

SCORES	A	B	C	D	F	TOTAL
FEMALE	05	10	06	04	03	28
MALE	05	14	12	00	01	32
TOTAL	10	24	18	04	04	60

Source: Field data (2025)

This increase in scores amply illustrates VR's beneficial effects as a teaching tool. Students were able to see and engage with three-dimensional representations of the Earth's strata throughout the virtual reality lecture, which promoted greater comprehension and memory of the material. The immersive experience encouraged not just cognitive engagement but also emotional and behavioral participation, as was shown in the classroom and validated by student comments.

Results by Zhao et al. (2021) and Ozdemir & Ozturk (2022), which highlight that students taught with VR perform noticeably better than those taught using traditional techniques, are supported by the post-test distribution. These findings are also in line with the experiential learning theory (Kolb, 1984), which holds that students can acquire greater understanding by actively and fully participating. The results of the post-test given to the students following the use of virtual reality in teaching and learning about the Earth's structure. According to the results, five (05) male and five (05) female students received Grade "A," while twenty-four students received Grade "B." Only four students received Grade "D," with three (03) females and one (01) boy receiving Grade "F."

As a result, the post-test results offer strong proof that virtual reality may be a revolutionary teaching tool, especially for abstract scientific subjects like the Earth's interior structure. The significant increase in scores throughout the sample suggests that virtual reality (VR) not only raises student participation but also produces quantifiable academic benefits.

4.3.3 A t-test for students' performance before and after the use of virtual reality

The same group of 60 Form Three pupils took a pre-test and a post-test to evaluate the effect of virtual reality (VR) on academic achievement. The purpose of the examinations was to gauge their comprehension of the "Structure of the Earth" subject both before and after they were exposed to VR-based training. The t-test results for the students' tests taken before and after virtual reality were implemented are shown in Table 7:

Table 7: Comparison of Pre- and Post-Test Scores on Students' Academic Performance

Test	**Means**	**Std. Deviation**	**T**	**p-value**
Pre-test	46.15	13.51	9.14	0.001
Post-test	60.60	15.56		

Therefore, the comparison of pre- and post-test scores provides strong evidence that Virtual Reality has a positive effect on learning outcomes. The increase in scores across the sample confirms that Virtual Reality can serve as a powerful pedagogical tool to supplement and, in some contexts, surpass traditional teaching approaches in enhancing students' mastery of the Structure of the Earth.

4.4 Challenges in implementing virtual reality

Results reveal that although VR presents promising potential to enhance instruction, several interrelated challenges hinder its effective application in the classroom setting. Choosing pertinent instructional objectives and lesson preparation were two of the main issues that were noted. Observations in the classroom revealed that teachers frequently failed to match VR material to particular learning objectives or geographic abilities. The educational goals were frequently vague or unconnected to the VR experience's interactive elements. This was corroborated by teacher interviews, in which a number of participants acknowledged that they found it difficult to create goals that effectively used VR. One participant commented,

> "The VR content is visually impressive, but it's hard to align it with my lesson plan and geography competencies without training," said one educator. (The fifth teacher, interviewed on May 27, 2025.)

Another one said,

> "I'm not sure how to connect the two during the lesson because sometimes the VR materials don't match the textbook structure. Training is very important to me." (The third teacher, interviewed on May 23, 2025).

These observations point to a deficiency in pedagogical expertise in creating learning goals that successfully use technology, such as virtual reality. The results imply that the usage of VR runs the danger of being a flimsy addition rather than a revolutionary teaching tool in the absence of adequate instructional preparation.

The sparse use of inquiry-based and student-centered learning techniques in VR-integrated classes was another significant issue. Data from observations revealed that most instruction was teacher-centered and that students acted as passive information consumers. There were not many opportunities for students to use the VR platform hands-on to research, work together, or build knowledge. These findings were corroborated by teachers in interviews. "VR helps in visualization, but I have limited time to organize group activities or explorations during class," one educator noted. "I would like to make the lesson more interactive, but I don't have any examples of how to lead such sessions using VR," another person wrote. The sixth instructor was interviewed on May 27, 2025. These findings point to a serious pedagogical weakness in the integration of virtual reality into frameworks for active, interactive learning. According to Makokha and Onguny (2023), deliberate teaching practices that frame students as active learners are necessary to fully realize VR's promise to foster critical thinking and investigation.

Therefore, even if integrating virtual reality into geography classes in secondary schools has the potential to revolutionize education, a number of pedagogical, operational, and systemic problems limit its actual use. In addition to having access to technology, teachers also require organized training that improves their proficiency with VR integration. Institutional policies should also give priority to curriculum adaptation, teacher mentoring, and ICT troubleshooting support staff. For VR to become an inclusive and long-lasting educational breakthrough, school administrators, curriculum creators, teacher training institutions, and legislators will need to work together to address these issues.

5. Conclusion and Recommendations

5.1 Conclusion

The results of this study unequivocally show that virtual reality, or reality, significantly and favorably affects geography students' learning, particularly when it comes to abstract and difficult topics like the Structure of the Earth. VR promotes experiential learning and deeper cognitive engagement by providing immersive, interactive, and multimodal learning experiences. Tectonic plate movements and the layers of the Earth's interior, which are usually abstract when taught just through textbooks, were among the challenging ideas that students were able to visualize. As demonstrated by the study's descriptive statistics and inferential findings, this resulted in higher understanding, better memory retention, and an overall improvement in academic achievement.

Notwithstanding these encouraging results, the study found a number of obstacles to the successful use of virtual reality in Tanzanian secondary schools. These include the lack of professional development programs, the lack of VR tools in schools, the lack of institutional funding for developing technologies, and the lack of exposure and confidence among instructors.

5.2 Recommendations

1. For the Ministry of Education and policy makers

To realize the full potential of Virtual Reality (VR) in Tanzanian secondary education, the Ministry of Education and national policy makers should take the lead in mainstreaming the technology. First, there is a need to formally integrate Virtua Reality into the national geography curriculum, particularly for topics that require visualization and experiential understanding. These policies should also address ethical and safety considerations for students using immersive technologies.

Another crucial step is the allocation of dedicated national budgets to support the procurement of VR kits, school-based infrastructure, and continuous teacher training. Such investments should be embedded within broader digital learning strategies and coordinated with the Tanzania Institute of Education and teacher training institutions. This top-down approach will ensure consistency, scalability, and sustainability of VR integration in both urban and rural educational contexts.

2. For practice (Teachers)

For every educational innovation to be successfully adopted, teachers are essential. They are thus urged to actively look for chances for professional growth in educational technology, such as short online courses, in-person seminars, or collaborations with educational non-governmental organizations. Teachers can start with inexpensive or mobile-based VR simulations to get experience and boost their confidence even in the absence of full-scale VR gear. In order to foster critical thinking, investigation, and cooperative learning, educators should be encouraged to create inquiry-based and immersive lesson plans that make use of virtual reality. That engages students for deeper comprehension of complex ideas in such lectures. Instructors should also match assessment strategies to VR learning objectives.

3. For researchers and educational innovators

The future of virtual reality in education is being shaped in large part by researchers and developers. Future research should look at how VR-based instruction affects students' behavior and academic performance over time in a variety of areas and educational levels. This involves investigating the long-term effects of immersive settings on learner autonomy, cognitive load, and information retention.

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