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Impact of Virtual Reality Instruction on Secondary School Students' Conceptual Understanding of Physics Concepts in Dutsin-Ma, Katsina State Nigeria

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ABSTRACT

Background and Purpose: The purpose of this research was to find out how virtual reality instruction affected students' conceptual understanding of physics concepts.

Method: This study used a quasi-experimental approach with control groups before and after the test. 117 SSII physics students comprise the study's sample. chosen at random from two public co-educational secondary schools in the Dutsin-Ma Education Zone. The Physics Conceptual Understanding Test (PCUT) with a reliability of 0.781 was used. Means, standard deviations, and a t-test with independent samples were used to analyze the data (P = 0.05).

Result: In fostering students' conceptual understanding of physics concepts, virtual reality instruction was found to be more effective than the teacher-centered method. The result shows no significant differences in the conceptual knowledge of male and female students.

Conclusion: To enhance their conceptual understanding of physics, it was suggested that teachers expose their physics students to virtual reality instruction. It was also suggested that it be incorporated into teacher training institutions' curricula to enhance the conceptual understanding of both male and female students.

1. Introduction

Physics is one of the most significant fields of study. A branch of natural science focusing on the study of matter, including its mobility, behavior, and interactions with energy and force in space and time. A few of the fields in which physics is used directly or indirectly include mining, forestry, meteorology, astronomy, economics, philosophy, sociology, psychology, veterinary medicine, pharmaceuticals, chemistry, biology, agriculture, and military experience. As a result, Ukoh (2012) believes that physics plays a role in almost every aspect of life, from technology to arithmetic and biochemistry, as well as animals and inanimate objects.

Despite the importance of physics for secondary school students, it has been observed that physics is still taught in traditional ways in our secondary schools. This method stifles students› conceptual acquisition, hampering their development of physics conceptual understanding. Despite this, Wulan Sari (2012) claims that the current system is examination-based. Also, Dimitrios *et al.* (2013) believes that traditional, sophisticated teacher-centered methods were used to teach students rather than modern student-oriented applications and techniques. As a result, rather than learning to understand and apply concepts and laws in everyday life, students learn by rote to memorize concepts for examination purposes. However, in all subjects, including physics, rote learning hurts students' abilities and impedes the development of conceptual understanding (Dimitrios *et al.*, 2013).

The goal of educational interventions and policy changes is becoming more important. Poor physics performance and conceptual understanding do not discriminate between boys and girls. Males outperformed females in any course that required calculation, according to some researchers (Awoniyi, 2000). Another study discovered that female students outperform male students in science (Madu, 2004). Allcoat and Von Mühlenen (2018) also found improvement in students' performance scores regardless of gender when exposed to science process-based learning activities. The disparities in the learning based on gender might explain the differences in the conceptual understanding

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of the student. Because of their gender, students do not benefit from science in general (Ogunleye, 2002). Consequently, Ogunleye (2002) advocated for teaching and learning methods that are founded on a thorough understanding of how students learn. Thus, it is critical to expose students to the range of skills and motivate them with what is required to reach their full potentials. Any teaching strategy that improves students' conceptual understanding must be used to compensate for learning deficiencies. The majority of students view physics as an abstract and difficult topic since it deals with things that cannot be seen or touched. Students' conceptual grasp of physics principles and their ability to apply them in practical contexts will both improve under teachers who can create an atmosphere where students can engage freely.

In 2020, the Virtual Reality conference attracted a record number of submissions, up around 10% from the year before, 2019. The fastest-selling VR headset at the moment is the Oculus Quest 2, the most recent commercial standalone VR headset that was introduced in 2020. The development, use, testing, and distribution of interactive VR applications may now be done more affordably because of recent developments in VR technology. There has never been more activity in the VR research community (Lang, 2021). The use of technology in the classroom, such as computer games and simulations, has the potential to be beneficial in such cases. Computer games, for example, Chwen Jen (2016), have been shown to play an important role in science education, and computer simulations supplement traditional teaching methods by simulating novel physics ideas (Savage *et al.*, 2000). Using immersive, interactive, and multisensory virtual environments, a virtual reality (VR)-based instructional strategy fosters deeper understanding and retention by allowing students to actively interact with a simulated world rather than passively absorbing information (Markowitz *et al.*, 2018). This approach seeks to create a sense of "presence," or the sensation of actually being in the virtual environment, which can greatly increase motivation and engagement (Makransky *et al.*, 2021).

Virtual reality (VR) technology has produced a plethora of potential new applications, and interactive technology is developing at an exceptionally rapid pace. Commercial VR headsets are used extensively for entertainment, and many people's VR experiences come from playing video games and other widely available media because these are well-known and heavily promoted, which increases their appeal. However, VR offers greater application potential, given the considerable developments in the technology, including the technology currently available in a smartphone device; in virtual environments, immersion and engagement are seen to be inextricably related. explored what it means for a learner to be immersed, examined immersion and engagement in 3D virtual environments, and described how 3D virtual environments can be utilized to improve learner engagement. Markowitz *et al.* (2018) and Makransky *et al.* (2021) talked about the relationship between immersion, presence, and engagement in 3D virtual environments. Users may see and interact with virtual surroundings and objects thanks to virtual reality (VR) technologies. With the use of a headset, modern VR enables users to see and, in certain situations, hear the 3D environment.

Furthermore, virtual reality (VR) immerses students in a virtual environment by utilizing computational methods to create a simulated learning environment that can be accessed in the field of view (Crosier *et al.*, 2010). It has several distinguishing features that set it apart from other computer technologies currently in use in schools, including the visualization skills and ability to interact with objects as realia, the ability to explore risky situations, the provision of a platform for displaying complex and difficult three-dimensional concepts, the possibility of inspirational benefits from the innovation, and the opportunity for self-studying (Crosier *et al.*, 2010). As a result, students' conceptual understanding of physics could be improved by employing appropriate teaching methods and strategies. The use of novel technologies, such as virtual reality-based instruction incorporating games and simulations, may improve students' conceptual understanding. As a result, the researcher sought to investigate the impact of a virtual reality instruction technique on senior high school physics students in Dutsin-Ma, Katsina State, Nigeria. As a result, the study's objectives are as follows:

- To identify the difference in the students' conceptual understanding of physics subjects taught using virtual reality versus those taught using the teacher-centered method.
- To determine whether there is a difference in conceptual understanding of physics between male and female students using virtual reality training.

The study included all public secondary school students who took physics in the Dutsin-ma Education Zone. With an average age of 16–17 years, Senior Secondary School (SS-II) students were used. The variables' gender differences were also examined. Furthermore, the investigation was limited to the concept of momentum, the law of conservation of momentum, and Newton's laws of motion.

2. Methodology

In a quasi-experimental approach, pre- and post-test controls are used. The study's population consists of 424 SS 2 physics students, with an average age of 16 to 17 years, divided into 258 males and 166 females. They were assigned to eleven Dutsin-Ma Education Zone public co-educational senior secondary schools. The study employs simple random sampling to select 117 SS2 students from two co-educational schools in the population. The schools were randomly assigned as the experimental group and the control group. The experimental group, also known as the treatment group, includes 65 SS2 students, while the control group includes 52 students. There were 61 males and 56 females in the two schools studied. A Physics Conceptual Understanding Test (PCUT) with a reliability coefficient of 0.781 was used to collect data. Two experts from the Federal University of Dutsin-Ma's Education and Educational Foundation departments validated the instrument. The data was analyzed using descriptive statistics in the form of standard deviations, means, and t-tests of independence at a significance level of 0.05.

3. Result and Discussion

Table 1: Experimental and Control Groups' PCUS Post-Test Mean Scores

Groups	N	Mean score	Standard dev.	Degree of freedom	t-value	P-value	Remark
Experimental	65	11.17	4.656	115	5.139	.000	Significant
Control	52	7.73	1.402	-	-	-	-

According to Table 1, students who were taught physics concepts using virtual reality received a mean score of 11.17, which was higher than the mean score of 7.73 for students who were taught the same concepts using the traditional method. In the inferential analysis, a p-value of 0.000 and a t-value of 5.139 were found. Given that an alpha value of 0.005 is greater than a p-value of 0.000, there is a significant difference in mean scores of students' conceptual understanding of physics between those taught using a virtual reality-based strategy and the students in the conventional teacher-based style of teaching. This means that experimental students significantly outperformed control students in terms of conceptual understanding of physics concepts.

Table 2: Post-test Mean Scores of Male and Female Students in the Treatment Group

Groups	N	Mean	SD	Df	t-value	P-value	Remark
Male	43	17.86	3.399	63	1.118	.268	Not sig.
Female	22	18.86	3.468	-	-	-	-

Table 2 shows that female students who were taught physics concepts using a virtual reality strategy scored higher than male students, who scored 17.86. In contrast, the inferential statistic revealed a t-value of 1.118 and a p-value of 0.268. There is no discernible difference in the mean scores of students' conceptual comprehension of physics based on gender because the calculated p-value of 0.268 is higher than the alpha value of 0.05. This means that when physics concepts were taught using virtual reality training, male and female students performed equally well in terms of conceptual understanding.

4. Discussion of Findings

Students who learned physics using virtual reality had higher mean conceptual understanding scores than students who learned using a traditional teacher-centered method, according to this study. This means

that teaching physics with a virtual reality-based instructional method improves students' conceptual understanding. The findings supported those of Crouch (2014), who looked into the impact of virtual reality-based training on students' conceptual understanding and interest in physics. The findings revealed a statistically significant improvement in Newton's Law understanding ($p = .0205$). The findings of this study corroborated those of Ogunleye (2002), which investigated the impact of game-based learning on mathematical conceptual understanding. The data analysis revealed that the outcomes were significantly different. The result also agreed with that of Liu *et al*. (2020), on their study of the impacts of an immersive virtual reality-based classroom on scientific students' learning outcomes. According to their findings, the experimental group outperformed the control group in terms of academic success and engagement scores (cognitive, behavioral, emotional, and social).

Furthermore, no significant differences exist in the conceptual comprehension scores based on the gender of students exposed to the virtual reality-based teaching technique, according to the findings. This means that students taught using virtual reality had similar outcomes, with no statistically significant differences in their mean conceptual understanding scores. However, this finding contradicted Allcoat and Von Mühlenen (2018), who revealed that male and female students with similar IQs and academic performance achieved different results on science tasks, with males outperforming females. The finding also agreed with that of Smith and Hamilton (2015) in their study of the consequences of using virtual reality simulation as a teaching method to help nursing students prepare their skills. Their result revealed no gender difference when taught using virtual reality.

5. Conclusion and Recommendations

The researchers concluded that virtual reality instruction has the potential to improve senior high school students' conceptual understanding of physics concepts based on the findings of this study. Furthermore, because there was no significant gender difference in their conceptual understanding of physics concepts, virtual reality instruction can benefit both male and female physics students. The study's findings revealed that virtual reality-based instructional strategies were successful in engendering conceptual understanding in both male and female students, leading to the following recommendations: Senior secondary school teachers should expose physics students to virtual reality instruction to promote their conceptual understanding of physics concepts.

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Authorship Contribution

The first author, Ahmed Salihu, drafted the background of the study and reviewed the relevant literature. Abdulmalik Sabitu, the second and corresponding author, manage the methodology, data collection, and analysis.

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Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Declarations

There are no specific declarations to be made regarding this article.

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