The impact of Gender and Virtual Reality Technology in Teaching Biology on Academic Performance of Senior Secondary Schools Biology students in Akwa Ibom State

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Abstract

This study seeks to investigate the impact of gender and Virtual Reality Technology in Teaching Biology on Academic Performance of Senior Secondary Schools Biology students in Akwa Ibom State. Pretest -posttest non-randomized control group design was adopted for the study. This research was conducted in Akwa Ibom State. The population of this study consisted of 1768 students offering biology as a subject in eight secondary schools in Akwa Ibom State, Nigeria. The stratified random sampling technique was used to determine the sample size which consist of 406 senior secondary school male and female students offering Biology which were divided into control and experimental groups. The research instruments were (1) Biology Performance Test (BPT) and (2) Students' Questionnaire to measure teacher's attitude (SQTA). Descriptive Statistic of Mean and Standard Deviation were used to present data for answering research questions. ANCOVA was used to analyze data generated from the field work. From the study it concluded that Application of Virtual Reality Technology in biology is more effective than the use of conventional teaching method because VRT increases knowledge of the topic, promote active experiences rather than just giving passive information as it is done in conventional learning. One of the recommendations from the study states that VRT should be incorporated into the curriculum in special education to provides customized learning experiences for students with disabilities or special needs.

Keyword: Virtual Reality Technology, Academic Performance and Akwa Ibom State.

Introduction

Technology rules the world and education is no exception. Nowadays, technology is everywhere in education; from blended learning to computerized testing, digital and online technologies are reshaping the classroom experience for students. This is revolutionizing the classroom in a new and exciting way, and there's no turning back. Many in the educational technology field see new technologies as powerful tools to help schools meet the needs of ever-more-diverse student populations. The idea is that digital devices, software, and

learning platforms offer a once-unimaginable array of options for tailoring education to each individual student's academic strengths and weaknesses, interests and motivations, personal preferences, and optimal pace of learning. Educators and students alike have found that integrating technology in classroom experiences is not only more engaging but also more impactful. This has increased the growth of educational software and applications to be more "adaptive," and relying on technology and algorithms to determine not only what a student knows, but what his or her learning process is, also his or her emotional state. According to National Educational Technology Standard (NETS, 2022) learning environments must incorporate strategies and tools that prepare students for their futures.

Umur and Xing, (2017) stated that the introduction of VR has made it possible for students to experience their education in more immersive and engaging ways. VR can transport students from their desks and allows them to embark on virtual field trips, exploring various geographical locations and historical sites without leaving the classroom. By using VR headsets and applications, educators can bring immersive experiences to their students, fostering a deeper understanding and appreciation of diverse cultures and places. These virtual travels can also help students grasp complex geographic concepts and develop a broader worldview.

VR technology can allow biology students experience a laboratory experiment without being present in a physical laboratory, they can mix volatile chemicals and see the reaction without being physically harmed and allow them to not only see but interact with virtual worlds. As a result, the teacher's role is shifted from delivering content to facilitating learning. The benefits of this concept include the unlimited capacity of a virtual classroom, the ability to share numerous experiences in 'real life' kind of simulation and facilitating access to school for learners living in remote communities. One of the most significant benefits of incorporating VR in the classroom is its ability to simplify abstract concepts and complex subjects. For example, VR applications can break down intricate scientific phenomena, such as molecular interactions or cellular processes into visually engaging and easily understood experiences. This kind of immersive learning can help students retain information more effectively and enhance their understanding of a subject matter that may otherwise be difficult to grasp through traditional teaching methods.

Academic performance is defined as students' ability to carry out academic tasks, and it measures their achievement across different academic subjects using objective measures such as final course grades and grading point average. The study conducted by Wang, (2017) revealed that VR had a marginally positive impact on student's scores and a strong impact on students' learning engagement. Improving students' academic performance is essential for achieving educational goals. Some practical steps a teacher can take to enhance students' grades are: Helping them adopt a positive mental attitude by encouraging self-motivation instead of feeling defeated by lower-than-expected grades, they could turn negativity into motivation and then believe that they can improve and take control of the situation. They could replace thoughts like "I'm a failure" with "I can and will do better." They could set high expectations and cultivate an enable environment by setting challenging yet achievable expectations for students.

However, there is a clear gender gap in academic performance between male and female students, with boys lagging behind girls in terms of subject grades, secondary school graduation, and tertiary level enrollment and completion (Jackman & Morrain-Webb, 2019). According to them, girls outperform boys in most subjects at every level of education. They argue that female students have higher grade point averages, and a higher rate of acceptance into college. In their study, female students perform better than male in reading and comprehension but that the opposite is true for math and science. They also narrated how achievement gaps for social class and ethnicity often outweigh those for gender, and it is the interplay of these factors that together impact on the performance of girls as well as boys. The study suggests that young people's attainment is linked to their ideas about what it means to be male or female and that those who defy traditional gender stereotypes appear to do better in the classroom.

Statement of Problem

Studies have shown high entries and poor results of students in internal and external Biology examination and some of these problems identified as cause of students poor performance include: poor teaching strategies, abstract, vast and eclectic nature of Biology, teachers-centred instruction, lack of well-equipped laboratories, and non-utilization of appropriate technology that can transport students into reality and give them exciting engaging experience where they can become part of the topic. Studies has also shown that VR promotes active learning through immersive experiences in virtual environments, helping students mold their problem-solving skills while improving comprehensive skills. It is in view of these issues that there is therefore a need to explore the world of Virtual Reality. However, the researcher has this question in mind, Could the use of Virtual Reality enhance academic performance of SS2 Biology students?

Objectives of the Study

This study seeks to investigate the effect of the application of Virtual Reality Technology in teaching Biology on academic performance in Biology of Senior Secondary Schools students in Akwa Ibom State; specifically, the study seeks to:

1. Determine if there is a difference in academic performance of SS2 Biology students taught with Virtual Reality Technology and those taught with a conventional method.
2. Find out if there is a difference in the performance of Biology students taught with the application of Virtual Reality Technology based on gender.

Research Question

1. What difference exists in the academic performance of SS2 Biology students taught with Virtual Reality Technology and those taught with the conventional method?
2. What difference exists in the performance of Biology students taught with the application of Virtual Reality Technology based on gender?

Research Hypothesis

1. There is no significant difference in the academic performance of SS2 Biology students taught with Virtual Reality Technology and those taught with the conventional method.
2. There is no significant difference in the academic performance of Biology students taught with the application of Virtual Reality Technology based on gender.

Concept Virtual Reality Technology in Education

The term education generally refers to the process of facilitating learning, acquiring knowledge, skills, or positive values. The main goal of education is to prepare students for life, work, and citizenship by training their knowledge and skills deemed necessary in the society. The education sector, from K-12 through higher education, has a long history of adopting emerging technologies to supplement traditional pedagogical methods. From smart boards to laptops and even the internet itself, there have been many examples of technologies that have profoundly altered the way educators and students teach and learn. Technology today is evolving at a rapid pace, enabling faster change and progress, causing an acceleration of the rate of change. However, it is not only technology trends and emerging technologies that are evolving, but a lot more has also changed, making IT professionals realize that their role will not stay the same in the contactless world tomorrow.

Technology is evolving and as it emerges, it is necessary for the users to stay up to date in order to be able to apply it or use it maximally. And this means keeping your eyes on the future to know which skills you will need to learn. As said earlier, technology has emerged from the normal computer to the Generative AI, a cutting-edge technology, has revolutionized various industries by enabling machines to create content that resembles human-generated work. It encompasses a wide range of applications, from text generation to image synthesis and even music composition to computing power which has already established its place in the digital era, with almost every device and appliance being computerized. And it is here for even more as data science experts have predicted that the computing infrastructure, we are building right now will only evolve for the better in the coming years with data science to robotics and IT management. To Artificial intelligence which has played an essential role in making our world smarter and smoother. It is not just simulating humans but going the extra mile to make our lives hassle-free and simpler. To Datafication which is simply transforming everything in our lives into devices or software powered by data. So, in short, Datafication is the modification of human chores and tasks into data-driven technology. From our smartphones, industrial machines, and office applications to AI-powered appliances and everything else. To Extended reality which comprises all the technologies that simulate reality, from Virtual Reality, Augmented Reality to Mixed Reality and everything else in-between. It is a significant technology trend right now as all of us are craving to break away from the so-called real boundaries of the world. By creating a reality without any tangible presence, this technology is massively popular amongst gamers, medical specialists, and in the field of education.

Virtual Reality (VR) has moved from being the purview of gaming to professional development and education. It plays a vital role in teaching process, providing an interesting

and engaging way of acquiring information. Virtual Reality Technology is based on head-mounted devices and can be subdivided into the following two types: Head-mounted device immersion system and environment immersion system. Head-Mounted device immersion system that completely relies on a head-mounted virtual environment display device, which displays different pictures and sounds to achieve an immersive experience effect for learners. However, such a head-mounted device is easy to produce visual vertigo and is not suitable for long-time wearing. The immersion system in accordance with the environment projects multi-angle heads of objects on the four walls of a room, and users can achieve a fully immersive 3D three-Dimensional Virtual Reality experience by wearing polarized glasses. Virtual reality technology also based on head-mounted devices makes learners' hands and other body parts relatively free and can be fully combined with creation, movement, model understanding and other knowledge content for Design. The Virtual Reality immersion system with the environment can make the external space environment become an important part of the virtual learning system.

Limniou, Roberts and Papadopoulos, (2008), designed a Virtual Reality system adapted to the environment to help learners understand the chemical reactions at the molecular level of acid rain, providing a fully Immersive experience environment for learners to learn intelligent skills. It was found that students who studied in a 3D learning environment performed significantly better in answering relevant chemistry questions than those who studied in a 2D environment, and the learners evaluated the 3D environment more positively. Compared with traditional classrooms, learners believe that using a 3D learning environment can help them better understand the occurrence of chemical reaction. Virtual Reality applications in the education domain have many benefits. Virtual Reality fully immerses students and completely focuses their senses on the teaching topic. When experiencing topics as if they are reality, students' brains create clear, detailed mental maps, helping to improve knowledge retention by up to 75%. Experiential learning with Virtual Reality benefits a range of student outcomes. Thus, with engaging, individualized experiences like walking with prehistoric dinosaurs or holding a beating human heart teachers can improve student understanding, attainment and even increase test scores by up to 20%. Virtual Reality improves teamwork and social skills through creating exciting, collaborative learning environments. Students can safely communicate and investigate learning topics virtually, in pairs, groups in the educational metaverse all of which benefits interaction and collaboration in the classroom. Teachers can genuinely put their students into other people's shoes with Virtual Reality. By helping students to see life from different points of view, such as exploring diverse cultures or experiencing what life is like for refugees, educators can improve emotional awareness and build empathy. Virtual Reality benefits special education by creating new opportunities and opening accessibility. Considering immersive sensory rooms to important life skills, teachers can create personalized learning environments that align to students' specific learning contexts and meet their individual needs.

Virtual Reality and Academic Performance:

The study conducted by Wang, (2017) revealed that VR had a marginally positive impact on student scores and a strong impact on students' learning engagement. It indicates

that VR provides a small improvement in academic performance and a large improvement in student engagement. Virtual Reality (VR) technology has been applied to different educational subjects and there is some empirical evidence indicating its potential benefits for students' learning. Many studies have revealed that adopting VR in science lessons in the classroom can improve students' academic achievement and engagement through immersive experiences. This is because VR captivates students by transporting them into interactive 3D environments. These engaging experiences motivate learners to explore and participate actively in their studies. VR also provides a safe space for students to practice real-world scenarios.

VR offers a consistent environment for repeated training. Students and teachers can access the same virtual scenarios, ensuring standardized learning experiences which play a pivotal role in shaping high-stakes standardized tests and boosting high academic performance. VR simulations allow gamification, performance metrics, and collaborative features (using avatars) embedded in the software, enabling continuous peer interaction, active learning, enjoyment, and performance feedback which are all elements that enhance proficiency-based training and encourage self-motivation/personalized learning needed for an excellent academic performance.

Gender and academic performance of students:

Gender differences in academic performance have engaged the attention of scholars for some time now, yet no consistence result has emerged. Recent studies in the developed world have shown a reversal in academic performance between males and females, with females outperforming males in almost all disciplines at various levels of the educational ladder (Tshabalala and Ncube, 2016); Awoniyi and Balogun, (2000) reported that gender had no significant influence on academic performance of students. Sax, (2007) opined that boys preferred trucks and little girls preferred dolls, which has shown in their classroom; girls and boys see the world differently that is one reason they fight because their brains are wired differently Sax, (2007). This does not necessarily mean that schools should have Gender-specific classes but should develop instructional packages or materials that are capable of engaging both sexes. Some studies have shown that effectiveness of utilization of VR has not been identical for gender differences.

Research has identified several conceptual areas that suggest reasons for differential effects of virtual environments across genders. These include visual and spatial functioning, human navigation and way finding theory, and socially- and culturally influenced perceptions of and experiences with computer technology. These factors come together in self-efficacy theory, as each influences the formation of an individual's technological self-efficacy, which determines an individual's performance and perception of that performance in a technology learning environment such as VRT. Other studies of virtual environments have reported gender differences in favour of males on a variety of performance measures. Chiang, (2023) found out that Gender significantly influences students' immersion in environmental education and that gender significantly influences students' empathy generated by environmental education. Also, that Gender significantly influences students' actual behaviours generated by environmental education. While Awoniyi and Balogun, (2000) reported that gender had no significant influence on academic

achievement of students, Muhammad and Muhammad, (2004) reported that gender has influence on the academic achievement of students thus this issue is still far from being conclusive.

Methodology

Pretest -posttest non-randomized control group design was adopted for the study. This research was conducted in Akwa Ibom State. The population of this study consisted of 1768 students offering biology as a subject in eight secondary schools in Akwa Ibom State, Nigeria. The stratified random sampling technique was used to determine the sample size which consist of 406 senior secondary school male and female students offering Biology which were divided into control and experimental groups. The research instruments were 1 Biology Performance Test (BPT) and (2) Students' Questionnaire to measure teacher's attitude (SQTA). Descriptive Statistic of Mean and Standard Deviation were used to present data for answering research questions. ANCOVA was used to analyzed data generated from the Hypothesis.

Result

Research Question 1

What difference exists in the academic performance of SS2 Biology students taught with Virtual Reality Technology and those taught with the conventional method?

Research question was answered using the results in Table 1

Table 1:

Mean and Standard Deviation Scores of Students' Pretest and Posttest Performance Classified by Instructional Method

Instructional method		Pretest		posttest		
	N	$\overline{X}$	SD	$\overline{X}$	SD	Gain in Mean
VRT	56	15.10	2.08	27.01	3.02	11.91
Conventional	60	12. 00	2.00	22.89	3.09	10.89

In Table 1, the gain in mean (posttest-pretest mean difference) for the experimental group is 11.91 and that of the control group is 10.89. This result indicates that the students taught with VRT performed better than those taught using conventional method. In order to ascertain if the difference is significant, the posttest scores were subjected to the Analysis of Covariance (ANCOVA) using pretest as covariate.

Research Question 2

What difference exists in the performance of Biology students taught with the application of Virtual Reality Technology based on gender?

Table 2:

Mean and Standard Deviation Scores of Students' Pretest and Posttest Performance Classified based on Gender

Gender	N	Pretest $\bar{X}$	SD	Posttest $\bar{X}$	SD	Mean Gain
Male	24	10.32	2.16	16.71	2.91	6.39
Female	32	9.98	3.08	19.58	3.25	9.6

The result in Table two shows that the mean gain (Posttest-Pretest mean difference) for male students was 6.39 and that of their female counterparts was 9.6. This means that female students performed better than their male counterparts. In order to ascertain if the difference is significant, the posttest scores were subjected to the Analysis of Covariant (ANCOVA) using pretest as covariate.

Research Hypothesis 1

There is no significant difference in the academic performance of SS2 Biology students taught with Virtual Reality Technology and those taught with the conventional method.

Table 3:

ANCOVA analysis of the students' Mean achievement scores in Biology for Virtual Reality Technology group and conventional Method group

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	64691.317[a]	2	32345.658	1196.584	.000
Intercept	9065.943	1	9065.943	335.382	.000
PreTest	2.140	1	2.140	.079	.779
Method	64689.864	1	64689.864	23.114	.001
Error	6703.852	110	27.032		
Total	1232631.250	113			
Corrected Total	71395.169	112			

a. R Squared = .906 (Adjusted R Squared = .905)

Table 3 shows that there is a significant difference in the mean achievement scores of students taught algebra using Virtual Reality Technology and those taught using the conventional method $F(1, 112) = 23.114$, $p < 0.05$. This means that there is a significant difference in the mean achievement scores of students in experimental and control group. Therefore, the hypothesis that there is no significant difference in the academic performance of SS2 Biology students taught with Virtual Reality Technology and those taught with the conventional method is rejected. This implies that there existed a significant difference in the academic performance of SS2 biology Students taught with the application of Virtual Reality Technology. This study agrees with the findings of Enda Macgovern, Gerardo Moreira, and Cuauhtemoc Luna-Nevarez, (2019) who found out that VR application contributed to

student centered, experiential learning opportunities. They agreed that VR can be used for interactive study sessions, to shift the student's inclination towards much better form of learning.

Research Hypothesis 2

There is no significant difference in the academic performance of Biology students taught with the application of Virtual Reality Technology based on gender.

Table 4.

ANCOVA analysis of the male and female students' academic performance in Biology for Virtual Reality Technology

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	205.281[a]	7	29.326	1.198	.310
Intercept	82833.900	1	82833.900	3385.092	.000
PRETEST	205.228	6	34.205	1.398	.222
GENDER	.001	1	.001	.111	.995
Error	2593.842	53	24.470		
Total	812062.500	56			
Corrected Total	2799.123	55			

Table 4 shows that the Analysis of Covariance (ANCOVA) of academic performance of female and male students taught Biology using Virtual Reality Technology. The result showed that F-Cal value of .111 was found to be not significant in .995 which is greater than 0.005 ($P<0.005$) at 0.005 level of significant set for the study. The null hypothesis was therefore retained indicating that there is no significant difference in the academic performance of Biology students taught with the application of Virtual Reality Technology based on gender. This result is in agreement with the findings of Razavi, (2021) on the topic "Gender differences in the effect of virtual social networks use on students' academic performance" which found out that there was a significant difference in GPA female students who use VSNs.

Conclusion

Application of Virtual Reality Technology in biology is more effective than the use of conventional teaching method because VRT increases knowledge of the topic, promote active experiences rather than just giving passive information as it is done in conventional learning. VRT help students understand abstract, complex biology concepts, promote interactivity through discussion groups and boosts students' creativity. Gender does not significantly affect students performance in a VRT learning environment but in this study female students outperformed their male counterpart.

Recommendation

1. Virtual field trips that allow students to explore different locations and cultures should be set in place using VRT to open the students up to endless opportunities in learning.
2. VRT contents should be designed in a way that suits all genders.
3. Virtual Reality training should be made available and more accessible to both students and teachers.

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