

**Effectiveness of Augmented and Virtual Reality Teaching Methods on Biology
Students' Achievement on Micro-organisms in
Ikot Ekpene Municipality, Akwa Ibom State- Nigeria**

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Abstract

This study was on effectiveness of augmented and virtual reality teaching methods on Biology students' academic achievement on micro-organisms in Ikot Ekpene municipality, Nigeria. Three research questions were raised to guide the study while three null hypotheses were formulated and tested at 0.05 level of significant using quasi-experimental design. The population of the study was 4,432 and the sample size was 176 SS1 Biology students. Students were assigned into two experimental and a control groups respectively using simple random technique. Researchers made test, Biology Achievement Test in micro- organism (BATIMO) with a reliability coefficient of 0.89 was used after validation using Kuder- Richardson formula-20. Data generated were analyzed using descriptive analysis and ANCOVA. The lesson packages prepared by the researchers were used in order to standardize the concept taught by the research assistants. The findings showed that students taught micro-organisms using augmented and virtual reality teaching methods achieved significantly better than those taught with direct instruction teaching method. The findings also showed no significant difference between the mean achievement scores of male and female Biology students taught the same concept. It was recommended among others, that Biology teachers should make use of augmented and virtual reality methods in the teaching of micro-organisms.

Keywords: Achievement, Augmented-reality, Teaching, Virtual-reality, Micro-organisms

Introduction

Biology is a natural science that deals with the living world. It is a science subject which aims at equipping students with appropriate scientific skills, attitudes, competences and ability to apply scientific knowledge to every challenges of life. Ezekiel *et al.* (2021) opined that Biology excites intellectual curiosity, increases awareness of fragile ecosystem and stimulates critical thinking. The curriculum of Biology as contained in the Federal Ministry of Education (FME 2013), include: understanding of the structure and functions of living organisms as well as appreciation of nature; acquisition of adequate laboratory and field skills in order to carry out and evaluate experiments and projects in Biology. The growth of modern science has placed an increasing demand for the teaching and learning of Biology as well as obtaining high in academic achievement.

Academic achievement is the degree or level of success gained at the conclusion of educational endeavours. It is the extent to which students have achieved educational goals. Buditjahjanto and Irfansyah (2023) described academic achievement as the scholastic standing of a student at a given moment, which states individual abilities. Students' academic achievement can be explained in the form of grades obtained from tests or examinations on subjects taken. Chitra, Mubin and Nadarajah (2024) observed that there has been an unending sequence of poor academic achievement of Biology students in micro-organisms. Dinah (2022) observed that students are increasingly finding it difficult to pass the subject at both the West African Examinations Certificate (WAEC) and the National Examinations Council (NECO). The academic failure is not only frustrating to the students and the parents, its effects are correspondingly grave on the society in terms of dearth of manpower in all spheres of the economy. These has generated a source of worry to many including parents. According to Udoh, Anidu, and Ekon (2024), the foregone issue has been blamed on several factors ranging from poor teaching environment, poor teaching methods, poor teaching strategies, poor choice of instructional materials, teachers' unprofessionalism, among others. Buditjahjanto and Irfansyah (2023) ascertain that numerous factors contribute or militate against improved academic achievement of students in schools and some of these factors include lack of appropriate or suitable teaching methods.

Teaching methods are approaches used by teachers to facilitate learning of a concept in the classroom. Udoh, *et al.* (2020); Ekon and Udoh (2021) stated that teaching methods are strategies, techniques, styles and principles use in carrying out teaching and learning process for easy assimilation by the learners or used by the teacher to enable easy learning. The type of teaching method adopted determines to a greater extent what the students assimilates. Yilshik at all, (2020) opined that if suitable and appropriate teaching methods are used for a particular concept, the knowledge acquired will be accelerated and can be applied in solving problems for human existence. Anidu and Udoh (2021) added that some teaching methods are teacher-centered and it is based on the assumption that students are passive subjects that store what they learnt as a result of repeated practice and reinforcement such as direct instruction teaching method.

Direct instruction refers to the delivery of lectures to students where the teacher only instructs the students without any activity. Phipps (2020) stated that it is a class lecture, commonly associated with direct instruction by the teacher and it can be used in a variety of teaching situations. Direct instruction, for example, is when a teacher shows a film to students to impart knowledge. The instructor in this case is not actively giving any instruction. However, by focusing their students' attention on a specific topic, they are still providing direct instruction. Olorunmolu and Ahmadu (2019) pointed that direct instruction methods are teacher-centered with no activity for the learners making them passive and therefore obtaining knowledge from the teacher without building their engagement level with the subject matter and this approach is least practical, more theoretical and memorizing. It does not apply activity-

based learning to encourage students to learn real life problems based on applied knowledge especially in micro-organisms.

Micro-organisms are those organisms which cannot be seen with naked or unaided eyes. They can only be seen with the aid of a microscope. Chitra *et al* (2024) described micro-organisms as germs or microbes and can be found everywhere in nature (in the air, water, soil, surfaces of objects, on living, and within living organisms). Most micro-organisms are disease-causing agents known as pathogens while a lot are also beneficial to man in nature. Some examples of micro-organisms are; viruses, bacteria, protozoa, fungi, algae (Guzman-Cole & García-Ojeda, 2022). Many micro-organisms are beneficial in the following ways; they function as decomposers and primary producers, useful in sewage disposal, used in industry and medicine, used in the production of antibiotics like penicillin by *penicillium notatum* and streptomycin by *streptomyces griseus* and are used in industries for the production of butter, cheese, yoghurt, bread, wine and palm wine. Dinah (2022) added that proper teaching methods can further help in improving students' academic achievement. This reveals the fact that there are some underlining factors which may be responsible for this trend which could be averted through the use of innovative teaching methods such as virtual reality and augmented teaching methods.

Virtual reality is the creation of simulation of a real-world experience that a person can enter and leave at any time using technology. According to Liu *et al.* (2022), virtual reality (VR) is the use of computer technology to create a simulated environment. Unlike traditional user interfaces, VR places the user inside an experience. Instead of viewing a screen in front of them, users are immersed and able to interact with 3D worlds. Virtual reality helps students to understand invisible conceptual worlds of science through animation which can lead to more concrete understanding of scientific concepts. Virtual reality also encourages the development of the mental capability of the students, and it best suited where mastery is required of subjects that students perceive as difficult, abstract or interesting (Cowan *et al*, 2020). Virtual reality does not only allow learners to construct and manipulate screen "objects" for exploring underlying concepts, but they also provide learners with the observation and manipulation tools necessary for exploring and testing hypotheses in the simulated world. According to Udoh and Ekon (2018), virtual reality allows learners to visualize abstract concepts and link them to prior knowledge thereby fostering conceptual learning. Students interacting with virtual reality gain a better understanding of a real system and this interactivity provides opportunities for students to modify their mental models by comparing the outputs of the model with their expectations.

Augmented reality (AR) is another digital teaching method that refers to computer display of digital information onto the real world. Ziden and Ifedayo (2022) opined that augmented reality enhances the real-world experience by adding virtual information, images, or objects through the use of a device's camera, display and sensors. AR aims to blend the digital and physical worlds, creating a more interactive and immersive experience. The basic idea of augmented reality is to superimpose graphics, audio and other sense enhancements

over a real-world environment in real-time. Barteit *et al.*, (2021) added that augmented reality (AR) is an interactive experience that combines the real world and computer-generated 3D content. The primary value of augmented reality is the manner in which components of the digital world blend into a person's perception of the real world, not as a simple display of data, but through the integration of immersive sensations, which are perceived as natural parts of an environment. Augmented reality also has a lot of potential in the gathering and sharing of tacit knowledge. Ziden and Ifedayo (2022) also added that teaching methods such as augmented and virtual reality can benefit both gender (male and female) students.

Gender is a psychological experience of being a male or female. It has to do with personality and central components of self-concept. Udoh *et al.* (2024) stated that gender is the range of physical, biological, mental and behavioural characteristics pertaining to and differentiating between the feminine and masculine (female and male) population. Ziden and Ifedayo (2022) opined that gender refers to a socio-cultural construct that connotes the differentiated roles and responsibilities of men and women in a particular society. This implies that gender determines the role, which one plays in relation to general political, cultural, social and economic system of the society. Anidu and Udoh (2021) added that gender refers to all the characteristics of male and female, which a particular society has determined and assigned each sex. Gender has also formed a notable subject of discourse in students' academic achievement in different disciplines like science. Some research works have shown contradicting evidences in students' academic achievement in science due to gender. For instance, Ndirika and Udoh (2019) found out that there is no significant influence in the academic achievement of male and female Biology students but Udoh *et al.* (2024) reported that there are significant gender differences in students' academic achievement and retention in sciences. Since the issue of gender in science and achievement of students has not yet been resolved particularly in relation to Biology; hence, the need for further study on the influence of gender on students' achievement in micro-organism with the use of augmented and virtual reality teaching methods in senior secondary schools.

Research Questions

The following research questions were raised to guide this study.

1. What is the difference in the mean achievement scores of Biology students taught micro-organisms using augmented, virtual reality and direct instruction teaching methods?
2. What is the difference in the mean achievement scores of male and female Biology students taught micro-organisms using augmented teaching method?
3. What is the difference in the mean achievement scores of male and female Biology students taught micro-organisms using virtual reality teaching method?

Research Hypotheses

The following null hypotheses were formulated and tested at 0.05 level of significance to guide the study.

1. There is no significant difference in the mean achievement scores of Biology students taught micro-organisms using augmented, virtual reality and direct instruction teaching methods
2. There is no significant difference in the mean achievement scores of male and female Biology students taught micro-organisms using augmented teaching method
3. There is no significant difference in the mean achievement scores of male and female Biology students taught micro-organisms using virtual reality teaching method

Methodology

The study adopted non-randomized pretest-posttest control group of the quasi-experimental design with three (3) groups, two (2) experimental groups and a control group. Experimental group one (1) was taught micro-organisms using augmented teaching method, experimental group two (2) was taught using virtual reality teaching method and group three (3) was the control group taught with direct instruction teaching method. The design was considered appropriate since the students were taught in their intact classroom setting. The population of the study was four thousand, four hundred and thirty-two (4,432) and the sample was one hundred and seventy-six (176) Senior Secondary One (SS1) Biology students (male and female) for 2023/2024 session from three (3) secondary schools in Ikot Ekpene municipality of Akwa Ibom State. The instrument was BATIMO with a reliability coefficient of 0.89. On the basis of the high index, the instrument was considered reliable and suitable in conducting the research

The Biology teachers were used as research assistants. The research assistants were trained for two (2) days and they were given detailed instructions with lesson packages on the concept of micro-organism. The researchers randomly assigned three (3) classes, two (2) experimental groups and a control group respectively. The teaching of the concept was done by the research assistants in each school from a well-articulated lesson package developed by the researchers for two (2) weeks. The lesson packages prepared by the researchers were used in order to standardize the concept taught by the research assistants. After the teaching, post-test was administered to the three (3) groups. All activities in the three (3) groups were strictly supervised by the researchers. The data collected were analyzed using descriptive statistics (mean and standard deviation), and Analysis of Covariance (ANCOVA) based on its ability to control for the effect of pre-test. All the hypotheses were tested at .05 level of significance.

Results

Research Question 1: What is the difference in the mean achievement scores of Biology students taught micro-organisms using augmented, virtual reality and direct instruction teaching methods? The results of these analyses are presented in Table 1

Table 1: Mean and Standard Deviation of Pre-test and Post-test Scores of Students taught Micro-organisms Grouped by Teaching Methods.

Teaching Methods	Pre-test		Post-test		Mean Difference	
	N	$\bar{X}$	SD	$\bar{X}$	SD	
Augmented	59	13.36	3.66	33.37	4.08	20.01
Virtual reality	56	11.52	2.45	31.73	4.02	20.21
Direct instruction	61	11.13	1.52	22.30	4.59	11.17

Results in Table 1 shows that the mean difference scores of students taught the concept of taught micro-organisms using augmented, virtual reality and direct instruction teaching methods are 20.01, 20.21 and 11.17 respectively. Comparing the mean difference scores of the three groups, it indicates that virtual reality with mean difference score of 20.21 was the highest in enhancing students' achievement, followed by augmented with mean difference score of 20.01. The use of direct instruction teaching method was the least with mean difference score of 11.17 in enhancing students' achievement in micro-organisms.

Null Hypothesis 1: There is no significant difference in the mean achievement scores of Biology students taught micro-organisms using augmented, virtual reality and direct instruction teaching methods. The results of these analyses are presented in Table 2.

Table 2: Summary of Analysis of Covariance (ANCOVA) of Students' Post-test Scores Classified by Teaching Methods with Pre-test Scores as Covariate

Source	Sum of Squares	df	Mean Square	F-value	P-value	Decision
Corrected Model	4406.500 ^a	6	734.417	41.24	.00	S
Intercept	6028.732	1	6028.732	338.54	.00	S
Pre-test (Covariate)	25.631	1	25.631	1.43	.23	NS
Methods (Main Effect)	3773.944	2	1886.972	105.96	.00	S
Gender (Main Effect)	59.640	1	59.640	3.34	.06	NS
Methods * Gender	21.351	2	10.676	.60	.55	NS
Error	3009.478	169	17.808			
Total	155548.000	176				
Corrected Total	7415.977	175				

^{NS} = Not significant at .05 level of significance; ^{*} = Significant at .05 level of significance

Results in Table 2 shows that the analysis of covariate (pre-test scores) of the three groups of students taught micro-organisms using augmented, virtual reality and direct instruction teaching methods is not significant since the calculated F-value (1.43) having a calculated p-value (.23) is greater than the significant level (.05), indicating that the mean of the three groups were statistically equivalent. The Table also shows that the calculated F-value (105.96) having a calculated p-value (.00) of the main effect of teaching methods is less than the significant level (.05), therefore, the null hypothesis one is rejected. This implies that there

exists a significant difference among the achievement mean scores of Biology students taught micro-organisms using augmented, virtual reality and direct instruction teaching methods. In order to determine the direction of significance, the scores were subjected to post hoc analysis as shown in Table 3.

Table 3: LSD (Least Square Difference) Post hoc Analysis of Students' Post-test Grouped by Teaching Methods with Pre-test as Covariate

(I) Methods	(J) Methods	Mean Difference (I-J)	Std. Error	Sig. ^b
Augmented	Virtual reality	1.612	.845	.06 ^{NS}
	Direct instruction	10.891 [*]	.824	.00 [*]
Virtual reality	Augmented	-1.612	.845	.06 ^{NS}
	Direct instruction	9.279 [*]	.805	.00 [*]
Direct instruction	Augmented	-10.891 [*]	.824	.00 [*]
	Virtual reality	-9.279 [*]	.805	.00 [*]

^{NS} = Not significant at .05 level of significance; ^{*} = Significant at .05 level of significance

Table 3 shows the post hoc analysis scores of students taught micro-organisms using augmented, virtual reality and direct instruction teaching methods. Students taught using augmented and virtual reality teaching methods had a significantly higher achievement when compared with those taught using didactic teaching method. A non-significant difference existed between the achievement scores of students taught using augmented and virtual reality teaching methods.

Research Question 2: What is the difference in the mean achievement scores of male and female Biology students taught micro-organisms using augmented teaching method? The results of these analyses are presented in Table 4.

Table 4: Mean and Standard Deviation of Male and Female Biology Students' Pre-test and Post- test Scores Micro-organisms Grouped by Teaching Method.

Teaching Method	Gender	N	Pre-test		Post-test		Mean Difference
			$\bar{X}$	SD	$\bar{X}$	SD	
Augmented	Male	26	13.15	3.41	33.23	5.18	20.08
	Female	33	13.52	3.89	33.48	3.04	19.96

Results in Table 4 shows that the mean difference in the achievement score of male students taught micro-organisms using augmented teaching method is 20.08 and their female counterparts is 19.96. It can be inferred from the results that male students achieved a little better than their female counterparts when taught micro-organisms using augmented teaching method.

Null Hypothesis 2: There is no significant difference in the mean achievement scores of male and female Biology students taught micro-organisms using augmented teaching method. The results of these analyses are presented in Table 5.

Table 5: Summary of Analysis of Covariance (ANCOVA) of Students' Post-test Scores Grouped by Teaching Method with Pre-test Scores as Covariate

Methods	Source	Sum of Squares	Df	Mean Square	F-value	P-value	Decision
	Corrected Model	89.328 ^a	2	44.664	2.84	.06	NS
	Intercept	3378.926	1	3378.926	214.90	.00	S
	Pre-test	88.390	1	88.390	5.62	.02	S
Augmented Reality	Gender (Main Effect)	.253	1	.253	.016	.89	NS
	Error	880.468	56	15.723			
	Total	66681.000	59				
	Corrected Total	969.797	58				

Results in Table 5 shows that the analysis of covariate (pre-test scores) of male and female students taught micro-organisms using augmented teaching method is significant since the calculated F-value (5.62) having a calculated p-value (.02) is less than the significant level (.05), indicating that the mean of the two groups were not statistically equivalent. The Table also shows that the calculated F-value (.016) having a calculated p-value (.89) of the main effect (gender) is greater than the significant level (.05), therefore, the null hypothesis two is accepted. This implies that there exists no significant difference between the mean achievement scores of male and female Biology students taught micro-organisms using augmented teaching method.

Research Question 3: What is the difference in the mean achievement scores of male and female Biology students taught micro-organisms using virtual reality teaching method? The results of these analyses are presented in Table 6.

Table 6: Mean and Standard Deviation of Male and Female Biology Students' Pre-test and Post- test Scores Taught Micro-organisms Grouped by Teaching Method.

Teaching Method	Gender	N	Pre-test		Post-test		Mean Difference
			$\bar{X}$	SD	$\bar{X}$	SD	
Virtual reality	Male	20	10.45	2.13	30.45	4.39	20.00
	Female	36	12.11	2.44	32.44	3.67	20.33

Results in Table 6 show the mean difference in the achievement score of male students taught micro-organisms using virtual reality teaching method as 20.00 and their female counterparts

as 20.33. It can be inferred from the results that female students achieved a little better than their male counterparts when taught micro-organisms using virtual reality teaching method.

Null Hypothesis 3: There is no significant difference in the mean achievement scores of male and female Biology students taught micro-organisms using virtual reality teaching method. The results of these analyses are presented in Table 7.

Table 7: Summary of Analysis of Covariance (ANCOVA) of Students' Post-test cores Grouped by Teaching Method with Pre-test Scores as Covariate

Methods	Source	Sum of Squares	Df	Mean Square	F-value	P-value	Decision
Virtual Reality	Corrected Model	52.339 ^b	2	26.169	1.65	.20	NS
	Intercept	2305.978	1	2305.978	145.73	.00	S
	Pre-test	1.196	1	1.196	.07	.78	NS
	Gender (Main Effect)	50.637	1	50.637	3.20	.07	NS
	Error	838.643	53	15.823			
	Total	57279.000	56				
	Corrected Total	890.982	55				

Results in Table 7 shows that the analysis of covariate (pre-test scores) of male and female students taught micro-organisms using virtual reality teaching method is significant since the calculated F-value (.07) having a calculated p-value (.78) is more than the significant level (.05), indicating that the mean of the three groups were statistically equivalent. The table also shows that the calculated F-value (.3.20) having a calculated p-value (.07) of the main effect (gender) is greater than the significant level (.05), therefore, the null hypothesis three is accepted. This implies that there exists no significant difference between the mean achievement scores of male and female Biology students taught micro-organisms using virtual reality teaching method.

Discussion of Findings

The findings on the difference among the mean achievement scores of Biology students taught micro-organisms using augmented, virtual reality and direct instruction teaching methods indicated a significant difference. Students taught using augmented and virtual reality teaching methods had a significantly higher achievement when compared with those taught using direct instruction teaching method. A non-significant difference existed among the achievement mean scores of Biology students taught using augmented and virtual reality teaching methods.

The significantly higher achievement of students taught using augmented and virtual reality teaching methods when compared with those taught using direct instruction teaching method could be attributed to the fact that they equip students with appropriate scientific skills,

attitudes, competences and ability which could not be possible with the use of direct instruction teaching method. This is why Udoh and Ekon (2018) asserted that augmented and virtual reality which are computer technology allows learners to visualize abstract concepts and link them to prior knowledge thereby fostering conceptual learning. The finding of this study is in line with that of Ekon and Udoh (2021) who found that students taught Biology concept using innovative teaching methods had a significantly achievement than those taught the same concept with conventional teaching method.

The findings also collaborate with Buditjahjanto and Irfansyah (2023) who found that there is a significant difference in the achievement of science students when taught with innovative teaching methods. However, the findings disagree with Udoh, Umoh, and Udo (2020) who found no significant difference on students' achievement when taught with print media and library research teaching methods.

A non-significant difference that existed between the achievement scores of students taught using augmented and virtual reality teaching methods could be attributed to the fact that the use of computer technology promotes conceptual change, motivation and excitement for enriching the learning of plant classification resulting in enhancement of students' achievement. This is why Udoh *et al.* (2020) stated that innovative teaching methods generate motivation hence, facilitate easy assimilation by the learners. The finding of the study is in line with Udoh and Ekon (2018) who showed that there was no significant difference between the achievement scores of students in senior secondary schools. However, the findings of the study disagree with the findings of. Anidu and Udoh (2021); Dinah (2022) also found that that there was significant difference between the achievement scores of students in senior secondary schools with perception of difficult topics.

The findings on the difference between the mean academic achievement scores of male and female Biology students taught micro-organisms using augmented and virtual reality methods indicated a non-significant difference. The observation from the result confirms that both male and female students achieve equally. This shows that both male and female students explored their environment leading to higher academic achievement of both male and female students in the concept. This is why Ekanem (2021) asserted that teachers should be able to select appropriate teaching methods that would actively engage students in the learning process to enhance academic achievement. The findings of the study corroborate with Anidu and Udoh (2021); Buditjahjanto and Irfansyah (2023) who observed that there is no significant gender difference in academic achievement of science students. This implies that when male and female students are exposed to the same learning environment with appropriate instructional resources irrespective of gender, they will assimilate faster and achieve equally since knowledge has to do with intellectual ability. However, the findings disagree with Ekanem (2021) and Edet (2024) who showed that male students achieved better than female in biology when using simulation technique while female achieved better significantly than male when using computer text-assisted programmed instruction.

Conclusion

Based on the findings from the study, it is concluded that the use of augmented and virtual reality teaching methods in teaching resulted to a significant higher academic achievement on Biology students when compared with those taught using didactic teaching method. This implies the need to move from conventional teaching method to student- centered and practical oriented for teaching of Biology concepts. This is because student- centered instructional methods provide complementary learning activities that can serve as alternative to conventional teaching method like didactic teaching method.

Recommendations

1. Science teachers, especially the Biology teachers should adopt expeditionary and 5E as innovative teaching methods in teaching various concepts. This will make their teaching more effective and meaningful to the students.
2. Parents and Biology teachers should encourage both male and female students towards excellence in Biology since they can benefit equally from science instructions because they all participated in the learning process

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