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IMPACT OF DIGITAL SIMULATION, VISUAL LABS AND ONLINE RESOURCES IN SCIENCE CURRICULUM DELIVERY IN SECONDARY SCHOOLS IN DELTA STATE

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ABSTRACT

The research examined the influence of digital simulation, visual laboratories, and internet-based materials on the delivery of science curriculum in secondary schools within the Delta North Local Government Area of Delta State. Employing a pretest, posttest control group quasi-experimental design, the study focused on a population of 29,031 second-year science students enrolled in public Senior Secondary Schools. A sample of 289 science students was selected from six senior secondary schools in Delta State. The assessment tool utilized for the research was the Science Achievement Test (SAT), which underwent validation by three experts and demonstrated a reliability index of 0.77 through the Kuder-Richardson 21 method. The SAT was administered as a pretest before implementing the instructional interventions and as a posttest after their application. Data collected from both the pretest and posttest were examined using statistical methods including t-tests, Analysis of Covariance (ANCOVA), and Scheffe's post-hoc test. The findings indicated significant disparities in mean achievement scores between students instructed with and without digital simulation, visual laboratories, and online resources. Specifically, students taught with digital simulation, visual laboratories, and online resources showed higher achievement scores compared to those without such resources. Moreover, there was a significant discrepancy in mean achievement scores among students exposed to digital simulation, visual laboratories, and online resources, with digital simulation yielding the highest scores followed by visual laboratories and online resources, respectively. Consequently, the study concluded that integrating digital simulation, visual laboratories, and online resources into science education positively impacts teaching and learning outcomes in secondary schools in Delta State. It was recommended, among other suggestions, that science educators incorporate digital simulations into their teaching practices to facilitate interactive learning experiences for students.

Keywords: Curriculum, Science, Digital Simulation, Visual Labs, Online Resources,

Introduction

The significance of science and technology in the advancement of any nation's development cannot be overstated, as countries are vigorously pursuing scientific and technological growth in an era where the world is increasingly reliant on these fields for the functioning of society. This is because proficiency in science and technology plays a crucial role in societal progress. The rapid evolution of scientific and technological applications, along with their widespread utilization across various domains of human activity globally, underscores their indispensability. Any society or nation that lacks investment in science and technology risks isolation from the interconnected global community (Sambo, Kukwi, Eggari & Mahmuda, 2014). According to Oyovwi (2020), science educates future generation in the acquisition of necessary knowledge, skills and attitude for coping with the ever demanding world of science and technology

Recognizing the pivotal role of science and technology in national development, there has been a concerted effort to prioritize the provision of quality education in Science, Technology, and Mathematics (STM) in Nigeria. Consequently, the Federal Government of Nigeria, through its National Policy on Education (2013), outlined the objectives of science education in Nigeria, which include the cultivation of scientists for national progress and fostering an understanding of the intricate workings of the physical world and life processes.

Science remains the cornerstone of human advancement and societal development. Conant (1951) characterized science as a globally accepted set of concepts and frameworks derived from experimentation, observation, and subsequent iterative processes of inquiry. Science serves as the linchpin for both individual and national progress. The Chambers Dictionary of Science and Technology defines science as a methodical accumulation of established knowledge, encompassing the means by which this knowledge is expanded and the standards by which its veracity is assessed. In essence, science can be defined as a structured examination and systematic compilation of facts, principles, techniques, and methodologies. The importance of science in a national development cannot be overemphasized hence science educators have continuously sought ways to make the teaching and learning of science more effective in the secondary schools since a poor foundation at the secondary school level will jeopardize any effort to enhance achievement in science and production of scientists and technologists needed for advancement (Oyovwi, 2021 & Oyovwi, 2019)

Science curriculum can be viewed as all the experiences in science provided by the school for the achievement of goals of science education (Oyovwi, 2012). In Nigerian secondary schools, the science curriculum encompasses subjects such as Biology, Chemistry, Physics, Mathematics, and agricultural Science. As outlined by Mohammed and Bello (2010), science exhibits four primary attributes:

- Science is a global pursuit.
- Science is a human endeavor.
- Science functions as a societal establishment.
- Science is an aspect of cultural engagement.

Science plays a crucial role in society due to its relevance to everyday life and its connection to various professions. Recognizing the multifaceted importance of science, the Nigerian government, through the Federal Ministry of Education, advocates for the inclusion of science subjects in secondary school curricula. According to the National Policy on Education (FRN, 2013), there is an emphasis on the effective teaching and learning of science at the secondary school level. The manner in which science curriculum is conveyed to students significantly influences their grasp of scientific concepts.

The term "curriculum" typically denotes the array of knowledge and skills students are expected to acquire through structured interactions and planned or unplanned experiences. It serves as the mechanism through which educational objectives are achieved. In the context of education, curriculum encompasses the sequence of activities and experiences designed to foster the development of skills essential for adult life. Curriculum delivery, therefore, encompasses the strategies employed to enable students to attain their learning objectives, involving teaching, learning support, guidance, interaction, mentorship, and participatory and collaborative learning.

The delivery of science curriculum in Nigerian secondary schools ideally involves a blend of theoretical instruction, laboratory practical sessions, and fieldwork (Imran et al., 2021). Students are encouraged to engage in hands-on activities such as experiments, observations, and data analysis to cultivate critical thinking and scientific proficiency. Practical sessions play a pivotal role in science education, allowing students to hone practical skills, conduct experiments, and directly observe scientific phenomena. In Nigeria, science educators employ various teaching methods including lectures, laboratory sessions, group discussions, demonstrations, audiovisual aids, and field trips (Ahmed et al., 2019). Furthermore, a variety of educational resources such as digital simulations, visual laboratories, and online materials are integrated into the teaching process to enhance student engagement and comprehension.

Digital simulation involves the use of computer algorithms and mathematical equations to replicate real-world systems or processes (Merrill, 2022). It enables users to observe, analyze, and predict outcomes without the need for physical experimentation. Digital simulations facilitate dynamic and immersive learning experiences, enabling students to interact with virtual models and comprehend complex concepts in real-time. Visual laboratories, on the other hand, offer interactive, visual representations of scientific concepts and experiments (Weible et al., 2019). These platforms allow learners to manipulate variables, observe outcomes, and draw conclusions through virtual simulations, enhancing understanding and engagement. Visual labs feature 3D models, animations, data visualization, and interactive quizzes to facilitate learning. By utilizing tools such as microscopes and imaging software, visual labs enable students to explore scientific phenomena in a safe and accessible manner, bridging theoretical knowledge with practical applications. The integration of digital simulations, visual labs, and online resources in science curriculum delivery requires adequate instructors' proficiency and employment of ICT skills, which remains a significant determinant of successful implementation of emerging technologies and innovations (Nkedishu, Nwaorgu & Egwunyenga, 2022)

Online resources are digital platforms and materials accessible via the internet that support learning and provide educational content (Gray et al., 2020). These resources come in various formats, such as articles, e-books, videos, tutorials, interactive simulations, and virtual laboratories. They are increasingly utilized in education due to their flexibility in terms of accessibility, timing, and location. Students can access subject-specific information, practice exercises, and supplementary materials at their own pace. Teachers can create blended learning environments by integrating traditional instruction with digital content, enhancing the overall learning experience. The internet offers a plethora of online resources that complement traditional biology textbooks and lectures. Educators can utilize these resources to engage students through quizzes, simulations, videos, and interactive exercises (Chu et al., 2018). Online platforms provide additional contexts for understanding biological concepts through videos, podcasts, and documentaries. They also facilitate collaboration among students through forums, discussion boards, and virtual study groups. The shift from conventional teaching methods to digital learning platforms has significantly impacted student engagement in science education, supporting findings by researchers who documented increased student sensitivity and responsiveness to technology-enhanced learning environments in higher education (Nkedishu & Okonta, 2023). The above authors stated further that integration of digital simulations and virtual laboratories in secondary school science curriculum aligns with established research demonstrating that students' technological adaptability directly influences learning outcomes when transitioning from traditional to digital educational frameworks.

Incorporating digital simulation, visual labs, and online resources into science education can enhance the learning experience by providing a deeper understanding of complex concepts, opportunities for interactive experimentation, and exposure to real-world applications. Empirical studies have shown positive impacts of these tools on science teaching. However, there is a lack of comparative studies on their effectiveness in Delta State, creating a gap in knowledge that this study aims to address. The study investigates the impact of digital simulation, visual labs, and online resources on science teaching in secondary schools in Delta State to determine the most effective approach for science instruction.

Statement of the Problem

The field of education has witnessed rapid technological advancements, including the introduction of digital simulation, visual labs, and online resources, which have transformed science teaching in secondary schools in Delta State. While traditional teaching methods have been used for decades, integrating these technological tools presents new opportunities to enhance the learning experience. However, the effectiveness of digital simulation, visual labs, and online resources in enhancing science education in Delta State remains uncertain. This study seeks to address this gap by examining whether the adoption of these tools will enhance students' achievement in science.

Purpose of the Study

The study examined the impact of digital simulation, visual laboratories, and online resources on the delivery of science curriculum in secondary schools within Delta State. Specifically, the research aimed to compare:

- The disparity in mean achievement scores between students instructed in science with and without digital simulation.
- The variation in mean achievement scores between students instructed in science with and without visual laboratories.
- The contrast in mean achievement scores between students instructed in science with and without online resources.
- The difference in mean achievement scores among students instructed in science with digital simulation, visual laboratories, and online resources.
- Research Questions:
- This study was guided by four research questions:
- What is the distinction in mean achievement scores between students instructed in science with and without digital simulation?
- What is the contrast in mean achievement scores between students instructed in science with and without visual laboratories?
- What is the difference in mean achievement scores between students instructed in science with and without online resources?
- What is the variation in mean achievement scores among students instructed in science with digital simulation, visual laboratories, and online resources?

Hypotheses

HO1:Null Hypotheses:

- HO1: There exists no substantial disparity in the mean achievement scores of students instructed in science with and without digital simulation.
- HO2: There exists no notable contrast in the mean achievement scores of students instructed in science with and without visual laboratories.
- HO3: There exists no significant distinction in the mean achievement scores of students instructed in science with and without online resources.
- HO4: There exists no noteworthy variation in the mean achievement scores among students instructed in science with digital simulation, visual laboratories, and online resources.

Research Method and Procedure

The research employed a pretest, posttest control group quasi-experimental design, wherein the independent variables were manipulated to ascertain their impact on the dependent variables. In this study, the independent variables encompassed digital simulation, visual laboratories, and online resources, while the dependent variable was students' achievement in biology. A quasi-experimental design was chosen due to the impracticality of randomizing subjects, as intact classes were utilized to ensure stability and prevent disruption of classroom activities.

The study population consisted of 29,031 SSII science students attending public Senior Secondary Schools in the Delta North Local Government Area of Delta. A sample size of 289 science students was selected from six senior secondary schools through simple random sampling techniques. The assessment instrument utilized was the Science Achievement Test (SAT), comprising 50 multiple-choice objective items. The SAT underwent validation by three experts, an experienced science teacher, and two lecturers.

Its reliability index was established at 0.77 using the Kuder-Richardson 21 method. The SAT was administered as both a pretest and posttest to students before and after the treatment phase. The treatment involved instructing students in selected science topics using digital simulation, visual laboratories, and online resources over a period of six weeks. Data from the pretest and posttest were collected, collated, and analyzed using t-tests and Analysis of Covariance (ANCOVA).

Results

Research Question One: What is the difference between the mean achievement scores of students taught science with and without digital simulation?
Table 2

Mean and Standard Deviation of Achievement Scores of Students Taught Science With and Without Digital Simulation

Group	N	$\bar{x}$	SD	Mean Difference
Students taught with digital simulation	**67**	**60.78**	**14.68**	**21.26**
Students taught without digital simulation	**63**	**39.52**	**8.80**	

Table 2 illustrates a mean and standard deviation score of 60.78 and 14.68, respectively, for students instructed in science with digital simulation, whereas their counterparts taught without digital simulation obtained a mean and standard deviation score of 39.52 and 8.80. The mean difference between the achievement scores of these two groups of students is 21.26, favoring those taught with digital simulation. Consequently, there is a discrepancy of 21.26 between the mean achievement scores of students instructed in science with and without digital simulations.

- **HO_1:**There is no significant difference between the mean achievement scores of students taught science with and without digital simulation.

Table 3

T-test Comparison of Mean Achievement Scores of Students Taught Science With and Without Digital Simulation

Group	N	$\bar{x}$	SD	Df	t-cal.	Sig. (2-tailed)	Decision
Students taught with digital simulation	**67**	**60.78**	**14.68**	**128**	**9.934**	**0.000**	**HO_1 is rejected**
Students taught without digital simulation	**63**	**39.52**	**8.80**				

P<0.05

Table 3 reveals a notable contrast in the mean achievement scores between students instructed in science with digital simulation and those without, with a t-value of 9.934 and a significance level of P(0.000) < 0.05. Consequently, HO1 is refuted. Hence, there exists a significant disparity in the mean achievement scores of students taught science with and without digital simulation, favoring those instructed with digital simulation.

Research Question Two: What is the difference between the mean achievement scores of students taught science with and without visual labs?

Table 4

Mean and Standard Deviation of Achievement Scores of Students Taught Science With and Without Visual Labs

Group	N	$\bar{x}$	SD	Mean Difference
Students taught with visual labs	**78**	**58.10**	**12.31**	**18.58**
Students taught without visual labs	**63**	**39.52**	**8.80**	

Table 4 displays a mean and standard deviation score of 58.10 and 12.31, respectively, for students instructed in science with virtual laboratories. In contrast, students taught biology without virtual labs obtained a mean and standard deviation score of 39.52 and 8.80. The mean difference between the achievement scores of these two groups of students is 18.58, favoring those taught with virtual labs. Hence, there is an 18.58-point difference between the mean achievement scores of students instructed in science with and without virtual labs.

- HO2:There is no significant difference between the mean achievement scores of students taught science with and without visual labs.

Table 5

t-test Comparison of Mean Achievement Scores of Students Taught Science With and Without Visual Labs

Group	N	$\bar{x}$	SD	df	t-cal.	Sig. (2-tailed)	Decision
Students taught with visual labs	**78**	**58.10**	**12.31**	**139**	**10.076**	**0.000**	**HO_2 is rejected**
Students taught without visual labs	**63**	**39.52**	**8.80**				

P<0.05

Table 5 illustrates a notable contrast in the mean achievement scores between students instructed in science with visual laboratories and those without, with a t-value of 10.076 and a significance level of P(0.000) < 0.05. Consequently, HO2 is invalidated. Hence, there exists a significant disparity in the mean achievement scores of students taught science with and without visual labs, favoring those instructed with visual labs.

Research Question Three: What is the difference between the mean achievement scores of students taught science with and without online resources?

Table 6

Mean and Standard Deviation of Achievement Scores of Students Taught Science With and Without Online Resources

Group	N	$\bar{x}$	SD	Mean Difference
Students taught with online resources	**81**	**50.81**	**14.05**	**11.29**
Students taught without online resources	**63**	**39.52**	**8.80**	

Table 6 presents a mean and standard deviation score of 50.81 and 14.05, respectively, for students instructed in science with online resources. Conversely, students taught biology without online resources achieved a mean and standard deviation score of 39.52 and 8.80. The mean difference between the achievement scores of these two groups of students is 11.29, favoring those taught with online resources. Hence, there is an 11.29-point difference between the mean achievement scores of students instructed in science with and without online resources.

HO_3: There is no significant difference between the mean achievement scores of students taught science with and without online resources.

Table 7

t-test Comparison of Mean Achievement Scores of Students Taught Science With and Without Online Resources

Group	N	$\bar{x}$	SD	Df	t-cal.	Sig. (2-tailed)	Decision
Students taught with online resources	**81**	**50.81**	**14.05**	**142**	**5.582**	**0.000**	**HO_3 is rejected**
Students taught without online resources	**63**	**39.52**	**8.80**				

P<0.05

Table 7 illustrates a notable contrast in the mean achievement scores between students instructed in science with online resources and those without, with a t-value of 5.582 and a significance level of P(0.000) < 0.05. Consequently, HO3 is invalidated. Hence, there exists a significant disparity in the mean achievement scores of students taught science with and without online resources, favoring those instructed with online resources.

HO4: There is no significant difference in the mean achievement scores among students taught science with digital simulation, visual labs and online resources.

Table 8

ANCOVA Comparison of Mean Achievement Scores of Students Taught Science With Digital Simulation, Visual Labs and Online Resources

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	**14994.587[a]**	**3**	**4998.196**	**36.116**	**.000**
Intercept	**52503.269**	**1**	**52503.269**	**379.378**	**.000**
Pretest	**10961.755**	**1**	**10961.755**	**79.207**	**.000**
Technology	**4051.134**	**2**	**2025.567**	**14.636**	**.000**
Error	**30723.289**	**222**	**138.393**		
Total	**761640.000**	**226**			
Corrected Total	**45717.876**	**225**			

Table 8 demonstrates a noteworthy disparity in the mean achievement scores among students instructed in science with digital simulation, visual laboratories, and online resources, with an F-value of 14.636 and a significance level of P(0.000) < 0.05. Consequently, HO4 is refuted. Hence, there exists a significant difference in the mean achievement scores among students taught science with digital simulation, visual laboratories, and online resources. The direction of this difference was determined using a Scheffe's post-hoc test, as depicted in Table 9.

Table 9

Post-hoc Test on Differences in Mean Achievement Scores of Students Taught Science With Digital Simulation, Visual Labs and Online Resources

(I) Instructional strategies	(J) Instructional strategies	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
digital simulation	**visual labs**	**2.007**	**1.961**	**.307**	**-1.857**	**5.872**
	online resources	**9.749***	**1.943**	**.000**	**5.920**	**13.578**
visual labs	**digital simulation**	**-2.007**	**1.961**	**.307**	**-5.872**	**1.857**
	online resources	**7.742***	**1.867**	**.000**	**4.063**	**11.421**
online resources	**digital simulation**	**-9.749***	**1.943**	**.000**	**-13.578**	**-5.920**
	visual labs	**-7.742***	**1.867**	**.000**	**-11.421**	**-4.063**

Table 9 unveiled the following findings: a notable contrast in the mean achievement scores of students instructed in science with digital simulation and visual laboratories, favoring digital simulation; a significant disparity in the mean achievement scores of students taught science with digital simulation and online resources, favoring digital simulation; and a significant difference in the mean achievement scores of students taught science with visual laboratories and online resources, favoring visual laboratories. This suggests that the utilization of digital simulation proves to be more efficacious in enhancing students' achievement scores in science, followed by visual laboratories and online resources, respectively.

Discussion

The study findings indicate a significant disparity in the mean achievement scores between students instructed in science with and without digital simulation, favoring those taught with digital simulation. This suggests that students taught science with digital simulation outperformed their counterparts taught without it. This observation could be attributed to enhanced visualization and active learning facilitated by digital simulation. Digital simulations provide students with visual representations of complex biological processes, aiding in comprehension and retention of information. Furthermore, they promote active engagement with the material, fostering critical thinking and problem-solving skills, which leads to improved performance. This finding aligns with previous research by Wang and Yang (2016), who reported improved student achievement in biology with the use of digital technologies compared to traditional methods.

Similarly, the study reveals a significant difference in the mean achievement scores between students taught science with and without visual labs, with higher scores favoring those taught with visual labs. This indicates that students instructed using visual labs performed better than those taught without them. Visual labs offer hands-on experiences and visual demonstrations, which help students' better understand and retain complex biological concepts. This active learning approach engages students and stimulates their curiosity, facilitating a deeper understanding of theoretical knowledge through practical applications. This finding is supported by Chu et al. (2018), who found that visual labs improved students' learning experiences.

Furthermore, the study shows a significant difference in the mean achievement scores between students taught science with and without online resources, with higher scores favoring those taught with online resources. This implies that students instructed using online resources achieved higher mean scores than those taught without them. Online resources provide access to a wide range of information, including interactive videos, virtual labs, and educational websites, which enhance students' understanding of complex science concepts. Additionally, the interactive elements in online resources promote active learning and collaboration among students, further enriching the learning experience. This finding is consistent with Jensen et al. (2015), who found that interactive simulations and online tutorials facilitated concept comprehension and critical thinking skills.

Moreover, the study reveals a significant difference in the mean achievement scores among students taught biology with digital simulation, visual labs, and online resources, favoring digital simulation, followed by visual labs and online resources, respectively. This indicates that digital simulation had the greatest impact on students' achievement in science, followed by visual labs and online resources. Digital simulations offer a more interactive and immersive learning experience, allowing students to manipulate variables and observe real-time effects, which enhances engagement and motivation. Visual labs, on the other hand, provide hands-on experiences and reinforce concepts through practical applications. Lastly, online resources supplement classroom teaching by providing additional materials and interactive elements that facilitate learning.

Conclusively, the use of digital simulation, visual labs, and online resources positively impacts students' achievement in science. However, digital simulation proves to be the most effective method, followed by visual labs and online resources. Therefore, science teachers should integrate these technologies into their lessons to provide interactive experiences and enhance student learning.

Based on the study findings, the following recommendations are proposed:

- Science teachers should incorporate digital simulations into their lessons to provide interactive learning experiences.
- Implementing virtual lab exercises can offer hands-on experiences and reinforce concepts learned in the classroom.
- Integrating online platforms, websites, and resources can supplement classroom teaching and provide additional materials for students.
- Science teachers should receive training and professional development opportunities to effectively utilize digital simulation, visual labs, and online resources in the classroom. Proper training ensures the successful integration of technology into teaching practices.

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