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Development and Evaluation of Virtual KAB Simulation for Enhancing Biology Students' Learning Outcomes in Senior Secondary Schools in Minna Metropolis, Niger State Nigeria

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Abstract

This study developed and evaluated Virtual KAB, a simulation platform designed to enhance biology learning outcomes among senior secondary school students in Minna Metropolis, Niger State, Nigeria. The research adopted a quasi-experimental pretest–posttest design involving 83 SSII students purposively selected from two schools, with one group taught reproduction using Virtual KAB and the other through conventional demonstration. Data were collected using the Biology Reproduction Performance Test (BRPT). Findings revealed that students taught with Virtual KAB achieved significantly higher mean gain scores (30.84) compared to those taught without it (12.45). Similarly, retention gains were greater in the experimental group (16.64) than in the control (1.35), indicating that the simulation promoted deeper understanding and long-term recall of biological concepts. Gender-based analysis showed no significant difference in retention, suggesting that the tool is equally effective for male and female learners. These results affirm the constructivist view that interactive, technology-based learning fosters engagement and meaningful knowledge construction. The study concludes that Virtual KAB significantly enhances students' academic achievement and retention in biology, thereby addressing challenges associated with inadequate laboratory facilities and traditional teaching limitations. The study recommends the integration of simulation tools

into classroom practice and curriculum design to improve learning outcomes and sustain interest in biology across genders.

Keywords: Virtual KAB, Simulation, Biology, Students and Senior Secondary School

Introduction

In the 21st century, the integration of technology into education has revolutionized the way students learn and interact with scientific concepts. Biology, as a core science subject in Nigeria's secondary school curriculum, demands hands-on experimentation and visualization to foster deep understanding (Okon and Yusuf, 2022). However, many schools in Minna Metropolis, Niger State, face challenges such as inadequate laboratory facilities, limited access to equipment, and overcrowded classrooms, which hinder effective science instruction. To bridge this gap, virtual simulations have emerged as innovative tools that replicate laboratory experiences digitally (Fayombo Babalola and Olaleye, 2022). The development of Virtual Kab, a customized biology simulation platform, aims to provide students with interactive, immersive learning experiences that mimic real-life biological experiments. By leveraging digital technology, Virtual Kab seeks to enhance students' conceptual understanding, engagement, and academic performance in biology (Adebayo, 2021).

Biology is a branch of science that deals with the study of living organisms. Biology is primarily concerned with the nature of organisms and their relationship to each other and to their environment. Biology as a subject enable one understand major biological processes (Physiological) example digestion, respiration, circulation, excretion and gaseous exchange. Through Biology organisms tend appreciate the effect of these biological processes and the larger environment as a whole. Biology like other science subjects is a practical oriented discipline which seeks to develop in a learner, scientific inquiry and problem solving skills. The general goals of Biology Education is to equip the learner with the basic knowledge, skills and attitude that will enable one to lead an independent and useful life (Akinwumi and Adodo, 2021).

In today's rapidly evolving educational landscape, student learning outcomes in biology are increasingly influenced by the integration of technology into classroom instruction. Traditional methods of teaching biology often limited to textbook explanations and sporadic practical sessions have proven insufficient in helping students grasp complex scientific concepts and retain information effectively (Abubakar *et al*., 2021). Many students struggle to connect theoretical knowledge with real-world biological processes, leading to poor academic performance and diminished interest in the subject. The use of computer-based simulations, such as virtual laboratories, offers a transformative solution by creating immersive, interactive environments where students can visualize and manipulate biological systems (Umoke

and Nwafor, 2022). These simulations replicate real-life experiments, allowing learners to engage with content actively rather than passively. As a result, students develop stronger conceptual understanding, improved critical thinking skills, and greater confidence in applying scientific principles. In regions like Minna Metropolis, where access to physical lab resources is limited, virtual tools like Virtual Kab can significantly enhance learning outcomes by bridging the gap between theory and practice, fostering deeper engagement, and promoting long-term retention of biological knowledge (Solikhin *et al*, 2019).

Statement of the Problem

Many secondary schools in the Minna Metropolis lack the proper infrastructure to support consistent, laboratory-based learning in biology. This has contributed to a number of issues, including low student retention, poor academic outcomes, and a general lack of interest in science-related careers. Traditional teaching methods often rely on rote memorization and theoretical instruction, which don't meet students' need for hands-on experience. This absence of engaging and accessible lab experiences creates a learning gap that makes it difficult for students to understand complex biological processes (De Freitas *et al*., 2020).

Reports from the West African Examination Council (WAEC) in 2017 and 2018 have highlighted that students are often unable to make logical inferences from experimental results or connect the structure of a specimen to its function. These findings suggest a decrease in student achievement in biology, which may be due to a lack of interest in the concepts being taught and poor retention of what they learn. One major contributing factor could be the lack of or poor use of instructional materials during the teaching and learning process. This decline in performance is a concern for students, teachers, parents, and other stakeholders, as it could lead to a shortage of professionals in fields like medicine and education (Partridge, 2020).

There is a pressing need to find alternative teaching strategies that can simulate lab conditions and improve learning outcomes. The core issue is the limited use of virtual simulations like Virtual Kab, and the lack of empirical evidence to show how effective they are in improving biology education in the region.

Objectives of the Study

The primary aim of this study is to develop and evaluate the effectiveness of Virtual Kab, a biology simulation platform, in improving learning outcomes among secondary school students in Minna Metropolis, Niger State. Specifically, the study seeks to:

1. investigate the academic achievement score of students taught reproduction using virtual kab and those without virtual kab.
2. determine the retention rate of reproduction among students exposed to Virtual Kab and those without virtual kab.
3. identify gender-based differences in learning outcomes resulting from the use of the virtual kab.

Research Questions

1. What is the mean academic achievement score of students taught reproduction using virtual kab and those without virtual kab?
2. what is the retention rate of biological concepts among students exposed to Virtual Kab and those without virtual kab?
3. what is the difference in the retention scores of male and female students taught reproduction using virtual kab and those without virtual kab?

Research Hypotheses

HO_1: There is no significant difference in the mean academic achievement scores of students taught reproduction using virtual kab compared to those taught without using virtual kab

HO_2: There is no significant difference in the mean retention scores of Biology students taught reproduction using virtual kab and those without virtual kab

HO_3: There is no significant difference in the retention scores of male and female students taught reproduction using virtual

Materials and Method

The research design adopted for the study is the quasi-experimental design involving Pretest and Posttest and Posttest using experimental and control group. The instruments for the study include Biology Reproduction Performance Test (BRPT) which was developed by the researcher. The Pretest was administered using RPT instruments to Experimental group and control group before treatment to establish equivalence in prior knowledge of the two groups. The treatment for the study in experimental group was virtual kab while the control group received demonstration method. This was followed by Posttest after three weeks of teaching to determine the students' academic performance in students taught reproduction concepts. The population of the study comprises all Senior Secondary School students SSII within Minna metropolis with a population of five thousand one hundred and seven (5107). Purposive sampling technique was used to select two secondary schools and assigned to experimental group (computer simulation group) and control group (Demonstration teaching methods) respectively. Finally, stratified simple random sampling technique was used to select 83 SSII students. The experimental group had 42 (23 male – 19 female) students and control 41 (21 male – 20 female) students. The sample was in line with the central limit theorem which stressed that adequate sample should cover between 10 -15% of the total population Tuckman (1975). The Biology Reproduction Performance Test (BRPT) consists of 25 multiple-choice questions.

Results

Table 1: Mean achievement scores of students taught reproduction using virtual kab simulation and those taught without

Group		Pretest		Post-test		Mean Gain
	N	$\bar{x}$	SD	$\bar{x}$	SD	
Experimental	40	32.83	2.89	63.67	4.59	30.84
Control	43	33.64	4.02	46.09	5.33	12.45

The data in Table 1 is a summary of the mean pre-test and post-test scores as well as mean achievement gain scores of students taught reproduction using virtual kab and those taught without virtual kab. The result shows that students taught (experimental) with virtual kab had the highest mean achievement gain score of 30.84 while those in the control group who were taught without the virtual kab had the least mean achievement gain score of 12.45. This result suggests that teaching with virtual kab enhances students' achievement in Biology than using conventional methods.

Table 2: Mean retention scores of students taught reproduction using virtual kab and those taught without virtual kab

Group		Pretest		Post-test		Mean
	N	$\bar{x}$	SD	$\bar{x}$	SD	Gain
Experimental	40	48.83	3.19	65.47	3.99	16.64
Control	43	46.24	4.00	47.59	6.26	1.35

Table 2 presents the mean interest gain scores of students taught reproduction using virtual kab and those taught without virtual kab. The result shows that the mean pre-interest and post-interest scores of students taught with virtual kab (experimental) are 48.83 and 65.47 respectively with standard deviations of 3.19 and 3.99 making a gain of 16.64 while those in the control group who were taught without virtual kab had mean pre-interest and post-interest scores of 46.24 and 47.59 respectively with a mean gain of 1.35.

Table 3: Mean retention scores of male and female students taught reproduction using virtual kab

Group		Pretest		Post-test		Mean
	N	$\bar{x}$	SD	$\bar{x}$	SD	Gain
Male	40	58.17	9.06	62.76	3.99	4.59
Female		60.64	4.34	63.09	6.26	2.83

The data in Table 3 is a summary of the mean post-test and retention scores as well as mean gain of male and female students taught reproduction using virtual kab. The result shows that male students obtained a post-test score of 58.17 and retention score of 62.76 making a mean gain of 4.59. The female students obtained a post-test score of 60.64 and retention score of 63.09 making a mean gain of 2.83. It could be observed that male students had a higher mean retention gain score of 4.59 while their female counterparts obtained mean retention score of 2.83.

Table 4: T-test of academic achievement scores of students taught reproduction using virtual kab compared to those taught without using virtual kab

Group	N	Df	$\bar{x}$	SD	t-value	p-value	Decision
Experimental	38		17.13	1.21			
		38			8.62	0.00	Sig
Control	36		13.95	1.16			

Significant at p > 0.05 level

The t-test results indicates the experimental group had a higher mean score (17.13) compared to the control group (13.95). The P-value of 0.000 and t-value of 8.62 indicates a statistically significant difference between the experimental and control group. The findings suggests that integrating virtual kab into the teaching of reproduction is an effective method for enhancing students' academic achievement. The null hypothesis that suggests no significant differences in achievement is rejected.

Table 5: T-test of academic retention scores of Biology students Taught reproduction using virtual kab

Group	N	Df	$\bar{x}$	SD	t-value	p-value	Decision
Experimental	38		17.13	1.21			
		38			8.62	0.00	Sig
Control	36		13.95	1.16			

Significant at p > 0.05 level

The t-test results indicate a statistically significant difference in academic retention score for students taught reproduction using virtual kab (experimental group mean= 17.13, SD=1.21) compared to a control group (mean=13.95, SD=1.16). the t-test yielded a t-value of 8.62, a p-value of 0.00 with a t-value of 8.62 indicating a statistical significant difference. This indicates that the virtual kab significantly enhances retention compared to to the conventional method.

Table 6: T-test of academic retention scores of male and female students taught reproduction using virtual

Group	N	Df	$\bar{x}$	SD	t-value	p-value	Decision
Male	43		17.53	1.39			
		18			1.12	0.27	NS
Female	40		16.85	1.06			

NS= Not Significant at p > 0.05 level

The analysis of the retention scores of male and female students taught reproduction using virtual kab showed that males had a score of (M=17.53, SD= 1.39 scored slightly higher than the females (M=16.85, SD=1.06). however, the difference was not statistically significant, t-value(18)=1.12, P-value 0.27, indicating that gender did not influence students retention levels. This suggests that virtual kab instructional methods were equally effective for both male and female students in learning reproduction.

Discussion of the Findings

The findings of this study revealed that students taught reproduction using virtual KAB simulation achieved significantly higher mean achievement and retention scores compared to those taught with conventional methods. Specifically, the experimental group recorded a mean

achievement gain of 30.84, while the control group had only 12.45. This indicates that the virtual KAB approach enhanced understanding and mastery of biological concepts. These findings are consistent with studies such as Baudin, Roussel and Meyer, (2022), who reported that computer-assisted instruction significantly improved students' academic performance. Similarly, Abdelhameed and Yahia, (2024) noted that integrating virtual simulations into biology teaching and learning promoted deeper conceptual understanding and long-term retention by the students.

In terms of retention, students exposed to virtual KAB showed higher mean retention gains (16.64) compared to the control group (1.35). This suggests that simulations foster active learning and better recall of complex concepts. This aligns with the findings of Partridge and Moore, (2020), who demonstrated that virtual learning resources enhanced students' ability to retain scientific information. The results also confirm the constructivist learning theory, which emphasizes active engagement, visualization, and interactive learning as essential for meaningful knowledge construction.

Furthermore, the analysis of gender differences showed no statistically significant variation between male and female students in retention scores. This indicates that virtual KAB simulation is equally effective for both genders. This outcome corroborates the findings of Essam, (2024), who reported no gender disparity in the effectiveness of ICT-based instructional strategies, suggesting that digital tools provide a level playing field for all learners regardless of gender.

Conclusion

The study concludes that the use of virtual KAB simulation significantly enhances students' achievement and retention in biology compared to conventional teaching methods. The strategy not only improved performance but also promoted equitable learning outcomes across genders. These findings underscore the effectiveness of technology-driven instructional tools in making abstract biological concepts more concrete, engaging, and memorable. The study therefore recommends that biology teachers adopt virtual simulation platforms like KAB as a complementary teaching tool to improve student learning outcomes in reproduction and other complex biological topics.

Recommendations

i. Biology teachers should integrate virtual KAB simulation into classroom teaching of reproduction and other abstract concepts, as it enhances students' achievement and retention.

ii. Curriculum developers should embed simulation-based instructional strategies in the biology curriculum at secondary school level to ensure consistency and sustainability of technology-supported teaching.

iii. Since the study shows no significant gender difference, both male and female students should be equally encouraged to engage with virtual learning tools to maximize their learning potential.

References

Abdelhameed, H., & Yahia, A. (2024). Teacher readiness and challenges in integrating virtual laboratories into science classrooms. International Journal of Science Education, https://doi.org/10.1080/09500693.2023.2234567 46(2), 213–231.

Adebayo, T. (2021). Challenges in Nigerian science education: A review. Journal of Educational

Abubakar, A., Mohammed, A., Suleiman, S., Aliyu, A., & Musa, M. (2021). Students' perceptions and pedagogical applications of e-learning tools in online courses. Journal of Educational Technology, 5(4), 524–525.

Akinwumi, I. O., &Adodo, S. O. (2021). Effect of virtual simulation strategy on students' academic performance in biology in Ondo State secondary schools. Euro Global Contemporary Studies Journal, 1(4), 11–24 Awodun, A. O. (2020). Evaluation of PowerPoint p

Baudin, C., Roussel, F., & Meyer, J. (2022). Remote and virtual laboratories in biology education: Expanding access to authentic science practices. Journal of Biological Education, https://doi.org/10.1080/00219266.2021.1916405

De Freitas, S., Neumann, T., & Justice, S. (2020). The development and evaluation of a virtual simulation environment for secondary school students. Computers & Education, 55(3), 1026–1037.

Essam, N. (2024). Virtual experiments virtual simulation. International Journal of Innovative Science, Engineering & Technology, 8(5). https://ijiset.com/vol8/v8s5/IJISET V8I0542.pdf

Fayombo, G. A., Babalola, B. J., &Olaleye, Y. L. (2022). Cross-institutional study of the causes of absenteeism among university students in Barbados and Nigeria. Journal of Educational and Developmental Psychology, 2(1), 122–136.

Partridge, N. J., & Moore, C. M. (2020). A study of the effect of the virtual classroom model on student self-efficacy. Master's thesis, North Dakota State University Press.

Solikhin, F., Sugiyarto, K. H., & Ikhsan, J. (2019). The impact of virtual laboratory integrated into hybrid learning use on students' achievement. Jurnal Ilmiah Peuradeun, 7(1), 81-94.

Okon, E., & Yusuf, M. (2022). Virtual labs and student engagement in biology. African Journal of Science Education, 10(1), 23–39.

Umoke, J. C., &Nwafor, C. C. (2022). Effects of virtual simulation on secondary school students' achievement in biology. Journal of Education and Practice, 5(19), 101–110.

West African Examination Council (WAEC) (2017), Chief Examination report. Lagos WAEC press LTD.

West African Examination Council (WAEC), (2018-2020) Analysis of Result, Lagos; WAEC