Effects of Virtual Simulation Package on Senior School Students' Performance in Modern Physics in Badagry, Lagos

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ABSTRACT

This research work is titled Effects of Virtual Simulation Package on the performance of Senior School Students in Modern Physics in Badagry, Lagos. This study explores the impacts of virtual simulations on learning Modern Physics. The quasi experimental pretest posttest non equivalent controlled group was used with 2 x 2 x 3 factorial design. The total number of SS III Physics students was 1824 but a purposive sampling was used to select 255 students (165 males and 90 females) in two co educational schools located at Badagry was taken. Three instruments which have been validated were used, these were the Modern Physics Performance Test (MPPT), Virtual Simulation Package on Modern Physics (VSP-MP) and a Lesson Note, where the I-CVI values were 0.9, 1.0, and 0.92 respectively. Kuder-Richardson Formula 21 (KR-21) were used to attain reliability of MPPT which received a coefficient of 0.72. These data were analysed through the descriptive statistics (mean and standard deviation via t-test and ANCOVA), at the level of significance of 0.05. The findings reveal that students who were instructed through VSP did exceptionally better when compared to those who were taught conventionally; there was not any significant difference in performance of the students on the basis of gender; but the performance differed significantly across the different levels of scores. The study also suggests to use virtual simulations to teach Physics, train teachers to use simulations and also conduct very large longitudinal research to increase generalisability.

Keywords: Virtual Simulation, Performance, Modern Physics, Gender, Score Level

INTRODUCTION

Physics is one of the core sciences and that no technological development, economic development, and national development can be achieved without the aid of physics. It forms the basis of any phenomena including subatomic and cosmic, and such makes innovations in matters concerning medicine, energy, transportation, communication and the defense of nations (Weidner & Brown, 2019). In secondary school, modern physics, which is based on post-Newtonian physics including quantum mechanics and relativity, plays a key role in training the students to meet the needs in the twenty-first century. However, the inability of a significant group of Nigerian students to cope with such abstract concepts is due to poor teaching techniques, lack of experience in practical work, and sufficient resources, which create variations in the performance of external examination results like West African Senior School Certificate Examination (Offordile, et al., 2021).

The modern physics presents some of the most important concepts shaping the modern technologies such as energy quantization, atom structure and the photoelectric effect. These subjects are already abstract and hence many learners have problems with them when they are presented using traditional pedagogical strategies. Research reports show that, although there are signs of improvement in the recent past; Nigeria students are still not doing well when it comes to concepts in modern physics because of lack of innovative teaching tools (Haleem et al., 2022). Empirical analysis also indicates that virtual simulation an interactive digital technology through which real-world scientific environments are simulated has emerged to enhance a better understanding of students with complex contents, improve the learning process in classrooms and student performance, positively affects physics (Hamed & Aljanazrah, 2020).

Virtual simulation offers a captivating environment where the students can visualize the use of physics concepts, experiment and interact with these concepts using a repeatable, safe and student-focused environment (Efi et al., 2024). Use of such technology in science teaching enhances cognitive skills and differentiated learning where a teacher could adopt a matched strategy based on the varying academic levels that learners have (Zubairu et al., 2024). As the students are divided into high, medium, and low score groups, teachers will be able to deliver individual instruction: the former would readily cope with complex simulations, and the latter two would learn significantly more by means of seeing, touching, and becoming practically involved to reduce the performance gaps (Alabi et al., 2023).

Gender has continued to be a salient predictor of the performance of students taking physics; the results have shown that there is advantage in performing physics in men as well as findings that have been reported to show little or no gender differences which shows the importance of inclusive teaching approaches (Merayo & Ayuso 2022; Abuh, 2021; Godspower-Echie & Sopuruchi,2017). One such positive tool with the potential to reduce the gap in gender-related educational outcomes is virtual simulations, which unconditionally level the ground in terms of interaction experience, exploration, and conceptual mastery (Kassa et al., 2024). Since the performance of senior secondary school students in modern physics in Badagry, Lagos is relatively low, the research undertaken in the present study thus sought to determine how a Virtual Simulation Package can influence their performance in this subject using gender and scores level as moderating variables.

Statement Of Problem

As much as physics is the key to the national development and technological progress, academic performance of students at the discipline continues to decline simultaneously in terms of both internal and external evaluation (Ezugwu & Oguguo, 2022: WAEC, 2019). This gap has mostly been pegged on abstract concepts of modern physics, poor laboratory resources, safety issues, and the same old teacher-centered pedagogical methods that have not encouraged critical thinking and active participation in modern-day digital environment (Prasad, 2016). It is reported that most students would avoid questions related to modern physics on exams, and most of the students that do actually answer the questions usually perform lower as they are poorly exposed to practical experiments and proofs of concepts (WAEC, 2019). The key benefits of using virtual simulation technology include its interactive, low-cost, and risk-free nature that allows students to view and experiment with complex physics phenomena; though, not much of the reviewed research on integration of such technology into secondary school education (especially ones in Badagry of Lagos State) has been done. The topic of interest today therefore establishes the impact of a Virtual Simulation Package on the performance of senior secondary school students in modern physics with a particular interest being put on the impact of gender and the level of a score.

REVIEW OF LITERATURE

It is premised upon Constructivist Learning Theory that was firstly expounded by Jean Piaget, a theory that supposes that knowledge is not imposed on the learner but instead, it is created by the learner via experience, interaction, and reflection (McLeod, 2024). The dynamism of learning produced by prior knowledge and cognitive development are placed at the forefront by cognitive constructivism. In this context, acquisition and accommodation of new information by the learner is accomplished through integration with already developed conceptual structures. Virtual simulation-based teaching revolves around a set of constructivist principles; active learning, discovery learning, schema activation and scaffolding. Thanks to these principles, students will be able to make their own hypotheticals, to vary parameters and settings to run virtual experiments, and make conclusions on their own, which will promote in-depth conceptual thinking about abstract physics concepts such as finding the quantization of energy and the transitions between atoms (Kritish et al., 2024). Zone of Proximal Development (ZPD) and scaffolding are also applied to transfer the use of aids in learning to independence further through an instructional course in a virtual reality environment (Muhammad et al., 2024).

The expansion of constructivist principles to the digital level evidences the works of Sugata Mitra and the development of the so-called Self-Organised Learning Environments (SOLEs) on the example of his Hole in the Wall experiment and further formulations which have shown that, when endowed with technology in the form of computers, learners are able to master complicated concepts in a more collaborative and coordinated manner (McTamaney, 2024). The Experiential Learning Theory developed by Kolb supports the constructivist frame by

focusing on the results of active experiments and reflective observation, which can be well-presented under the influence of virtual simulations (Wijnen-Meijer et al., 2022). Social Constructivism as Vygotsky stated it is also realized through students working collaboratively together in multiple shared virtual environments to enhance communication and co-construction of knowledge (Saleem et al., 2021). Elements of virtual simulations help to relieve the cognitive load with immediate feedback and interactive visualization, allowing the learners to better struggle with abstract concepts (Brodie, 2024; Skulmowski & Xu, 2021). Critical thinking, problem-solving skills, and scientific inference are consequently improved after repeated occurrence of immersion in virtual experimentation (Rusconi, 2024; Sapriati et al., 2023). In an incontrovertible summary, constructivism serves as a sound educational foundation in using virtual simulation packages to drive performance in modern day teaching of physics.

Virtual labs are simulations of real laboratory environments, freely allowing students to operate variables, conduct experimentation, and explore intangible concepts like electromagnetism and quantum mechanics without expensive physical equipment (Fantinelli et al., 2024). They are usually categorized into immersive, semi-immersive, none-immersive, collaborative, or augmented-reality/virtual-reality (AR/VR) integrated, whereas each type offers a different degree of engagement (Barnard, 2023). Virtual Physical Laboratory and PhET Simulations are platforms that deliver content in both forms, theoretical and practical, which promotes an investigative learning process and hypothesis testing and involves instant visual feedback, which promotes independent research and problem-solving (Tsvetkova et al., 2024; Gao & Zhu, 2023).

Virtual simulation environments solve the problem of obsolete laboratory infrastructure, safety hazards, inaccessibility, especially in the setting of a country such as Nigeria (Olalekan, 2023). Besides the remote and synchronous learning process, these environments allow collaborative learning because they offer real-time simulations, the aspect of interactive whiteboards, quizzes, and breakout rooms (Chan, 2024). To connect the gap between conceptual teaching and practices, the simulation models used in educational institutions are either theory-based or experimentally-based or a combination of both to be referred to as a hybrid form (Zheng et al., 2024). The effectiveness of technology depends on instructional design, realism, and ability to increase engagement as well as foster the understanding of the intricate physics concepts (Anderson & Taner, 2022).

To ensure the scientific literacy; critical thinking; and facilitating technological growth, the Nigerian senior secondary school physics curriculum is structured into six thematic areas of conservation principles, energy quantization and associated with it concepts (Bada & Akinbobola, 2022). It combines exorcism of ICT-based approaches like virtual presentations, animations, and multimedia resources to present abstract concepts easier and interesting. In these digital tools, virtual experimentations can be conducted, analytical thought can be developed, and traditional teaching methods can be supported (Oladejo et al., 2023). The problem is that delivery of effective educational services depends on the good relationships between the schools and the industry partners and on the continuity of professional development initiatives that stimulate teaching innovation (Musser, 2020). In this context, the current research examines the process of virtual simulation packages inclusion in the teaching and learning of physics as it relates to the Nigeria senior secondary curriculum.

The curriculum design of Nigeria follows the contemporary trends of physics wherein the topics of contemporary relevance include relativity, quantum mechanics, and quantization of energy: the strands that cannot be ignored in the interpretation of atomic, sub-atomic, and cosmic processes (NERDC, 2024; Driessen, 2024). Key principles, such as wave-particle duality, uncertainty principle, and quantum entanglement, attempt to replace the classical paradigm and give the underlying idea to the development of problems in the production of nuclear energy, medical imaging, semiconductor technology, and alternative sources of power (Mohamed et al., 2024; Dutta, 2022). More specifically, the phenomenon of energy quantization explains the abilities of electrons to absorb and release quantized packets of energy, which forms the basis of atomic spectra, the photoelectric effect, as well as the generation of x-rays (Zhu et al., 2021). Areas of application of the given principle are nanotechnology, solar photovoltaics, quantum computing, and improved diagnostic techniques, which allows reasserting the strategic significance of the relevant principle of sustainable development and modern technological advancement (Fernandez et al., 2024). In this regard, the process of integrating modern physics into an ICT enhanced curriculum has a dual effect of strengthening theoretical knowledge and arousing the ability to solve real life problems and technological advancements.

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The empirical evidence of the past shows that virtual simulations have a positive effect on the academic performance of physics students because they fit the curriculum approach of being focused on deep conceptual practice and scientific thinking. Diab et al. (2024) stated that students completing tasks in interactive digital environments started to perform better due to their increased engagement, a decreased number of misconceptions, and their ability to deal with problems. According to Ma et al. (2023), simulation-based instruction also resulted in excellent academic achievement compared with traditional solutions because it provided active learning experiences and allowed the development of higher-order thinking.

As a cog in the wheel of organizational learning, Mukhlidi et al. (2024) initiated the iterative research and development initiative by implementing a quasi-experimental study in designing and developing an interactive web-based simulation in the Applied Physics domain, as part of the ADDIE framework. The sample of the study consisted of 69 undergraduate students who were purposively sampled, due to the investigative design of such a study. The instrument proved to be very valid (86.33%) and quite practical (84.94%) and the experimental group recorded an average measure of learning gain of 0.32 hence it can be said to be operationally effective.

A study by Buday et al. (2023) involved a post-experiment and pre-experiment conclusion into the effect of PhET simulations on the performance of Grade 10 students (N=61) by utilizing the paired t-tests and Psychomotor Qualities-II Instrument (PMQ-II). The results indicated that learners that could use the simulations scored higher on Ohm Law and showed an increase in their intrinsic and grade motivation. At the same time, Banda and Nzabahimana (2022) employed the ANCOVA methods and demonstrated an improvement in conceptual understanding and motivational outcomes after the integration of PhET simulations in lessons with oscillations and waves when testing the sample of 280 undergraduate students in a quasi-experimental analysis.

Najib et al. (2022) evaluated the effectiveness of structured PhET modules of 60 secondary students by designing pre- and post-tests and ANCOVA tests. The experimental group received significant improvements on their academic performance, thus, confirming the worth of systematic simulation teaching. Liu et al. (2022) have confirmed similar findings in the study of 362 learners who were exposed to the use of immersive virtual reality (IVR) systems. The cognitive load of IVR was observed to decrease whereas understanding of the complicated physics material was found to be benefited through the pedagogical imposition. All these results point out to the potential of simulation technologies to develop practical, conceptual, and analytical skills by offering more enriched learning environments.

Empirical findings on the effect of gender in the achievement of physics showed a mixed result due to the complex interaction of the socio-cultural, psychological and instructional factors. According to a study conducted by Kusimba et al. (2024) female students performed better in physics than their male counterparts in a public secondary school in Kenya and it was reported that this superior performance can be attributed to heightened academic discipline regardless of their same gender aspirations regarding career goals, and therefore gender equity policies needed to be established. On the other hand, Abubakar (2024) failed to show a significant gender gap among the achievement of 92 SSII biology students having been instructed using Virtual Learning Strategy (VLS) but VLS made a host of difference in its performance compared to the traditional method.

By analyzing the results of a study done on the improvement of 91 SSII physics learners using instructional discussion strategies, Bebenimibo et al., (2022) shows that the strategies cancel gender bias in academic performance and hence should be used to facilitate equal learning in the future. Focusing on score data in four science topics, specifically biology, physics, chemistry and mathematics, Adam et al.(2022) demonstrated that male students are performing better than female counterparts in biology and physics, but there is no noticeable discrepancy in their performance in chemistry and mathematics, which makes it necessary to raise attention to the activities aimed at improving female performance. In quasi-experimental design with 195 respondents, Yakubu (2021) indicates that gender is a powerful determinant of performance as males registered greater results in science and technology. These results reinforce the comprehensive work on efficiency of ICT-driven and learner-centered approaches by extending the importance of gender in determining academic performance in science-focused learning.

It has been empirically determined that the level scores of students also have a significant correlation with the performance of students in physics and other sciences, and that diverse instructions have a positive effect on

performances of the overall student body. Alabi et al. (2023) indicate that the use of computer simulations enhances performance in physics in all levels of scores whereby female students are always ahead of males. According to Ibitomi et al., (2022) low, as well as high achieving students, are helped through computer simulation-based instruction and as a result of the instruction there are significant achievement gains achieved. Bada (2022) proves that the brain-based teaching strategies can succeed in improving performances of students in physics, particularly, in heat energy concepts. According to Toma et al., (2023) eliminating the lowest test score helps increase academic performance and lessen the stress of learners with low scores, and this is a crucial point regarding the beneficial assessment practice to learners with the lowest scores. Obielodan et al. (2022) have demonstrated a substantial improvement in learning outcome between the audio-visual teaching aids and social learning studies regardless of the score level of students in the previous study. Taken together, these results stress the nature of instructional practices that embrace a wide range of academic capabilities to promote fair and better academic achievements in science learning environments.

Objectives of the Study

This study specifically examined the:

1. difference in the performance of secondary school physics students taught using virtual simulation package and those taught using conventional teaching method;

2. difference in the performance of male and female students taught using virtual simulation package;

3. difference in the performance of high, medium and low score physics students when taught using virtual simulation package;

4. interaction effect of virtual simulation package, gender, and score levels on academic performance of senior school physics students; and

Research Questions

The following research questions were raised and answered in this study.

1. What is the difference in the performance of secondary school physics students taught using the virtual simulation package and those taught using the conventional teaching method?;

2. what is the difference in the performance of male and female students taught using the virtual simulation package?;

3. what is the difference in the performance of high, medium and low score physics students when taught using virtual simulation package?;

4. will there be any interaction effect of virtual simulation package, gender, and score levels on academic performance of senior school physics students?; and

Research Hypotheses

The following hypotheses were formulated and tested at 0.05 level of significance.

H_{01}: there is no significant difference in the performance of secondary school physics students taught using the virtual simulation package and those taught using the conventional teaching method;

H_{02}: there is no significant difference in the performance of male and female students taught using virtual simulation package;

H_{03}: there is no significant difference in the performance of high, medium and low score physics students when taught using virtual simulation package;

H_{04}: there is no significant interaction effect of virtual simulation package, gender, and score levels on academic performance of senior school physics students; and

RESEARCH METHOD

In the current research, the quasi-experimental, pretest-posttest, non-randomised, and non-equivalent control group design (2 X 2 X 3 factorial) was used to determine the treatment type, gender, and level of the score. The research sample was comprised of 1,824 SS3 physics students in Badagry. Purposive sampling was used to select two public schools (with sufficient infrastructure and their readiness to cooperate with the researcher) and a total of 255 (165 males, 90 females) students formed the final sample. Some of the instruments were the Modern Physics Performance Test (MPPT) and an authorized Virtual Simulation Package (VSP-MP). The VSP-MP was confirmed by five professionals who obtained strong content-based validity rates (0.90-1.00) and reliability testing results given in values of KR-21 was 0.72. The research was conducted in lines with ethical guidelines such as informed consent, confidentiality practices and training the participants in terms of safety. Two weeks of type of treatment came between the pre- and post-testing. To perform statistical analysis, SPSS version 25. 0 was used with the significance level of 0.05 and descriptive statistics (mean, standard deviation) were used to answer research questions and inferential statistics (t-test, ANCOVA) to test hypotheses.

DATA ANALYSIS AND RESULTS

Research Question One: What is the difference in the performance of secondary school physics students taught using the virtual simulation package and those taught using the conventional teaching method?

Table 1 displays the mean performance scores of secondary school physics students in both the pretest and posttest, comparing those instructed with the virtual simulation package (Experimental group) to those taught via the usual technique (Control group). The Experimental group exhibited a pretest mean score of 8.17 (SD = 4.64) and a posttest mean score of 14.31 (SD = 3.22), resulting in a mean gain score of 6.14. Conversely, the control group, instructed via the traditional teaching method, recorded a pretest mean score of 7.37 (SD = 4.84) and a posttest mean score of 11.19 (SD = 3.67), yielding a mean gain score of 3.82. Additionally, the mean score differential between the two groups was 2.32, signifying superior performance enhancement among students educated with the virtual simulation package relative to those instructed through conventional methods. This indicates that the virtual simulation software was more effective in improving students' performance in Physics.

Table 1 Mean and Standard Deviation of Pretest and Posttest Scores of Student Taught Physics Using the Virtual Simulation Package and Conventional Teaching Method

		Pre-test		**Post-test**			
Group	***N***	**Mean**	***SD***	**Mean**	***SD***	**Mean Gain**	**Mean Score Difference**
Experimental	121	8.17	4.64	14.31	3.22	6.14	
							2.32
Control	134	7.37	4.84	11.19	3.67	3.82	

Research Hypothesis One (H_{01}): There is no significant difference in the performance of secondary school physics students taught using the virtual simulation package and those taught using the conventional teaching method.

Table 2 presents a t-test performed to assess the performance disparity between secondary school Physics students in the experimental and control groups. The analysis indicates a statistically significant difference between the experimental group, students instructed with the virtual simulation package (M=14.31, SD=3.22), and the control group, those taught via the conventional method (M=11.19, SD=3.67), at t(253) = 7.16 and p=.00; <.05 alpha level. Consequently, the null hypothesis was dismissed. This indicated a statistically significant

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difference in the performance of secondary school physics students instructed with the virtual simulation software compared to those taught via the usual technique, favouring the former group.

Table 2 t-test Analysis of Difference in Performance of Secondary School Physics Students in Experimental and Control Groups

Groups	***N***	**Mean**	***SD***	***t*-value**	***df***	***Sig.* (2-tailed)**	**Remark**
Experimental	121	14.31	3.22				
				7.16	253	**.**00	Significant
Control	134	11.19	3.67				

Research Question Three: What is the difference in the performance of male and female students taught using the virtual simulation package?

Table 3 indicates the mean performance scores of male and female students instructed with the virtual simulation application. The posttest mean score for male students' performance using the virtual simulation software was 14.39, whereas the posttest mean score for female students' performance using the same package was 14.16. The average difference is 0.23 in favour of the male students.

Research Hypothesis Three (H_{03}): There is no substantial disparity in the performance of male and female pupils instructed utilising a virtual simulation tool.

Table 3 presents a t-test performed to assess the disparity in performance between male and female students instructed using a virtual simulation tool. The data indicates no statistically significant difference between male students (M=14.39, SD=3.30) and female students (M=14.16, SD=3.13) instructed with a virtual simulation software, t(253) = .39, p = .70; > .05 alpha level. Consequently, the null hypothesis is not rejected. This indicated that there was no statistically significant difference in the performance of male and female pupils instructed utilising a virtual simulation tool.

Table 3 t-test Analysis of Difference in Performance of Male and Female Students Taught Using the Virtual Simulation Package

Gender	***N***	**Mean**	***SD***	***t*-value**	***df***	***Sig.* (2-tailed)**	**Remark**
Male	76	14.39	3.30				
				0.39	253	**.**70	Not Significant
Female	45	14.16	3.13				

Research Question Five: What is the difference in the performance of high, medium and low score physics students when taught using virtual simulation package?

Table 4 presents the mean performance of high, medium, and low-scoring Physics students in pretest and posttest assessments following instruction with a virtual simulation package. The high-achieving Physics students (N = 68) exhibited a pretest mean score of 11.44 and a posttest mean score of 16.56. The average improvement of high-achieving Physics students is 5.12 following instruction with a virtual simulation software. The average score of Physics students (N = 40) was 4.70 on the pretest and 12.55 on the posttest. The average gain score of medium-scoring Physics students is 7.85, but low-scoring Physics students (N = 13) had a pretest mean score of 1.69 and a posttest mean score of 7.92. Students with low scores in Physics had a mean increase score of 6.23. Students with low scores in Physics exhibited the highest mean gain score (7.85), followed by those with high scores (5.12), while students with medium scores recorded the lowest mean gain score (4.70).

Table 4 Pretest and Posttest Mean Performance of High, Medium and Low Score Physics Students when Taught Using Virtual Simulation Package

Score Levels	*N*	Pretest Mean	*SD*	Posttest Mean	*SD*	Mean Gain
High	68.00	11.44	3.31	16.56	1.17	13.25
Medium	40.00	4.70	1.50	12.55	1.63	11.05
Low	13.00	1.69	1.03	7.92	2.10	8.86

Research Hypothesis Five: There is no significant difference in the performance of high, medium and low score physics students when taught using virtual simulation package.

Table 5 presents the Analysis of Covariance (ANCOVA) about the mean performance of high, medium, and low-scoring Physics students instructed with a virtual simulation application. The analysis indicates that the result ($F(2,117) = 56.62$, $p < .05$) was significant, as the p-value of 0.00 is below the .05 alpha threshold. The results indicate a statistically significant difference in the performances of high, middle, and low-scoring physics students when instructed utilising a virtual simulation tool. Consequently, the null hypothesis was dismissed. This indicates a substantial disparity in the performance of high, middle, and low-scoring Physics students when instructed with a virtual simulation tool.

Table 5 Analysis of Covariance (ANCOVA) on the Mean Performance of High, Medium and Low Score Physics Students when Taught Using Virtual Simulation Package

Source	Type III Sum of Squares	*df*	Mean Square	*F*	*Sig.*	Remark
Corrected Model	1097.685[a]	3	365.895	285.397	.000	
Intercept	1917.920	1	1917.920	1495.970	.000	
Pretest	99.587	1	99.587	77.677	.000	
Score level	145.169	2	72.585	56.616	.000	Significant
Error	150.001	117	1.28			
Total	26011.000	121				
Corrected Total	1247.686	120				

a. R Squared = .800 (Adjusted R Squared = .797)

Table 6 shows a post hoc analysis on the mean difference in performance among students with high, medium and low score Physics students when taught using virtual simulation package.

Table 6 revealed that the mean difference between students with low and moderate (M=4.63), low and high (M=8.64), high and medium (M=4.01) score Physics students when taught using virtual simulation package is statistically significant ($p = 0.00$).

Table 6 Bonferroni Post Hoc Analysis on the Mean Difference in Performance Among Students with High, Medium and Low Score Physics Students when Taught Using Virtual Simulation Package

					95% Confidence Interval	
(I) CAL	(J) CAL	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound

Low	Medium	-4.6269*	.46431	.000	-5.7545	-3.4993
	High	-8.6357*	.44024	.000	-9.7049	-7.5666
Medium	Low	4.6269*	.46431	.000	3.4993	5.7545
	High	-4.0088*	.28980	.000	-4.7126	-3.3050
High	Low	8.6357*	.44024	.000	7.5666	9.7049
	Medium	4.0088*	.28980	.000	3.3050	4.7126

Research Question Eight: Will there be any interaction effect of virtual simulation package, gender, and score levels on academic performance of senior school physics students?

Research Hypothesis Eight: There is no significant interaction effect of virtual simulation package on gender, and score levels on academic performance of senior school physics students.

Table 7 indicates that F(2, 114)=0.29, with a computed value of 0.75 (p>0.05), above the 0.05 significance threshold. This signifies that the interaction effect between score levels and gender is not statistically significant when utilising a virtual simulation package for instruction. Consequently, the null hypothesis is not rejected, indicating that there was no significant interaction effect of the virtual simulation package on gender and score levels on the academic performance of senior school physics students.

Table 7 Interaction Effect of Interaction Effect of Virtual Simulation Package on Gender and Score Levels on Academic Performance of Senior School Physics Students

Source	**Type III Sum of Squares**	***df***	**Mean Square**	***F***	***Sig.***	**Remark**
Corrected Model	1098.750[a]	6	183.125	140.170	.000	
Intercept	1877.967	1	1877.967	1437.455	.000	
Pretest	99.213	1	99.213	75.941	.000	
Gender	.059	1	.059	.045	.832	
Score Levels	130.100	2	65.050	49.791	.000	
Gender * Score Levels	.755	2	.377	.289	.750	Not significant
Error	148.936	114	1.306			
Total	26011.000	121				
Corrected Total	1247.686	120				

a. R Squared = .881 (Adjusted R Squared = .874)

SUMMARY OF FINDINGS

The following is the summary of the findings:

1. there was a statistically significant difference in the performance of secondary school physics students taught using the virtual simulation package and those taught using the conventional teaching method in favour of students taught using the virtual simulation package {$t_{(253)}$ = 7.16 and p=.00; <.05}.

2. there was no statistically significant difference in the performance of male and female students taught using virtual simulation package.

3. there was a significant difference in the performance of high, medium and low score Physics students when taught using virtual simulation package {$F_{(2,117)} = 56.62$, $p < .05$} in favour of the experimental group.

4. there was no significant interaction effect of virtual simulation package on gender and score levels on academic performance of senior school physics students

CONCLUSION

This research study investigated the effects of virtual simulation package on students' performance in modern physics with varying score levels, as well as their interaction with gender. The findings contributed valuable insights into effective instructional strategies, specifically in the context of virtual simulation.

Firstly, this study concludes that virtual simulation-based instruction significantly enhances secondary school students' academic performance in physics compared to conventional teaching methods, as evidenced by a notable mean gain score and supported by consistent empirical findings. Virtual simulation instruction leads to improved retention of physics concepts among secondary school students, demonstrating a clear advantage over traditional teaching methods.

Gender comparison within the research revealed that there is no statistically significant difference in the performance of male and female students taught using virtual simulation packages in physics, indicating that the strategy is gender-neutral and promotes equal academic opportunities for both genders. The study concludes that there is no statistically significant difference in the retention of male and female students taught using virtual simulation packages in physics, demonstrating that the strategy supports equal learning retention across gender lines.

This study revealed that the use of virtual simulation packages significantly improves students' academic performance in physics, particularly across different score levels. Medium-performing students benefitted the most, followed by low and high scorers. The virtual simulation strategy enhances conceptual understanding and offers an equitable platform for learners of varying abilities to engage with physics content effectively. This study concludes that virtual simulation packages significantly influence the retention of physics concepts among students of varying academic ability levels, with high scorers benefiting the most, followed by low and then medium scorers. The strategy not only enhances overall retention but also demonstrates differentiated effectiveness depending on student proficiency.

RECOMMENDATIONS

In line with the findings of the research, the following recommendations were made:

1. students should be encouraged to actively engage with virtual simulation tools as part of their regular study routines, as these platforms promote deeper understanding, improved retention, and equitable learning regardless of prior ICT competency or academic level.

2. teachers should receive continuous professional development on how to effectively integrate virtual simulation tools into physics instruction to enhance student engagement, conceptual understanding, and long-term retention.

3. school administrators should prioritize the provision of infrastructure, such as computer laboratories and reliable internet access, to support the successful deployment of virtual simulation tools across science classrooms.

4. examination bodies should begin to incorporate questions and assessments that reflect technology-enhanced instructional methods, including simulations, to align testing with modern teaching practices and real-world applications.

5. ICT and educational software developers should design interactive and user-friendly virtual simulation platforms that are adaptive to students with varying academic abilities and ICT competencies to promote inclusive learning.

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