Website:www.jriiejournal.com ISSN 2520-7504 (Online) Vol.8, Iss.3, 2024 (pp. 402 - 412)

Comparing Traditional Teaching Methods Versus Computer Simulations on students' performance in Learning Ohm's Law at Dodoma City Secondary Schools, Tanzania

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Abstract: *Physics educators have long grappled with the challenge of poor students' performance. The reason behind poor performance is due to the complexity of physics subject which makes most of students performing poorly especially in Tanzania. Different approaches have been used to improve performance this include computer simulation. Computer simulations have become increasingly essential in global education, particularly in the realm of science instruction. In this regard, this paper compares the effectiveness of using computer simulations in relation to traditional methods as a teaching method for improving students' performance in learning the concepts of Ohm's law. The research involved a total of 120 students from three selected secondary schools in Dodoma city council, with forty (40) students from each school. The study employed pre-testing and post-testing methods, administered before and after implementing computer simulation interventions. The results demonstrated a significant increase in students' performance scores following computer simulation-based instruction at p value of 0.000 which is less than threshold of 0.05. Furthermore, the dispersion of test scores revealed that computer simulation-based teaching led to lower score variations compared to traditional methods, with minimum scores showing improvement from 0% to 20%. Statistical analysis confirmed the significant differences between the two teaching methods, reinforcing the conclusion that computer simulations have the potential to significantly enhance students' performance and comprehension of Ohm's law. Study emphasized the importance of incorporating innovative teaching tools like computer simulations to improve the learning outcomes of physics students.*

Keywords: *Computer Simulation, Physics, Performance, Traditional teaching method, Ohm's Law.*

How to cite this work (APA):

Daniel, E., Juma, Z. R. & Kyobe, J. (2024). Comparing Traditional Teaching Methods Versus Computer Simulations on students' performance in Learning Ohm's Law at Dodoma City Secondary Schools, Tanzania. *Journal of Research Innovation and Implications in Education, 8*(3), 402 – 412. **https://doi.org/10.59765/yftrp4925.**

1. Introduction

Computer simulations have become increasingly essential in global education, particularly in the realm of science instruction (Nzabalirwa, 2022). Nzabalirwa's study revealed that employing technological aids such as computer simulations is notably more effective than traditional teaching methods, especially in science subjects. Previously, science subjects, including physics, relied solely on conventional pedagogical approaches characterized by teacher-centered instruction. However, the inherent practical and abstract aspects of subjects like physics necessitate the integration of computer simulations to enhance engagement and practical skill acquisition (Ouahi, Hassouni & Ibrahmi, 2021). Physics educators have long grappled with the challenge of poor student performance (MoEST, 2019, 2020). As a result, computer simulations have emerged as a valuable supplement to teaching, demonstrating their efficacy in improving student outcomes (Gadzikwa, 2018). Liu, Yan, and Chen's (2018) research further substantiates this claim by comparing student performance between traditional methods and technology-enhanced visual aids. Their findings indicate substantial performance improvement with visual aided technology, resulting in narrower score ranges and standard deviations. Computer simulations, by emulating real-world operations and phenomena, enrich science instruction through enhanced visualization and interactive virtual reality (Nzabalirwa, 2022)

In Tanzanian secondary schools, declining performance in science subjects, particularly physics, can be attributed to the prevalent abstract and theoretical teaching methods (Abiasen & Reyes, 2021). This disconnects from real-world applications often demotivates students. To rectify this, innovative teaching methods like computer-based simulations should become an integral part of educators' strategies (Simanjuntak, 2021). Nzabalirwa, (2022) assert that computer simulations expand both teachers' and learners' potential for knowledge acquisition and its practical application. Beichumila et al., (2022) argue that computer simulations eliminate practical limitations, enabling students to engage with complex concepts and interact with the real world. Mengistu and Kahsay, (2015) emphasize the value of virtual simulations in improving learners' understanding by providing a level of reality unattainable through traditional methods.

Additionally, Saudelli, Kleiv, and Davies, (2021) highlighted the benefit of visual aided simulations in bridging gaps associated with abstract physics concepts and mathematical aspects. Therefore, this study seeks to compare the impact of traditional teaching methods versus computer simulations on students' performance in understanding physics concepts, particularly Ohm's law. The findings of this research hold significance for both educators and students. They can serve as a catalyst for science teachers to adopt more effective teaching methodologies. Moreover, school administrators may be encouraged to support teacher development through relevant training programs. Lastly, the study's outcomes provided valuable guidance for future researchers conducting similar investigations in related subjects. Computer simulation is more effective when used as a supplement face-face teaching and learning environment. From this ground, the researcher inspired to think on instructive transformation from traditional to modern teaching strategies as an instrument to recover the performance in physics subject. Therefore, the study compared traditional teaching methods with computer simulations on students' learning Ohm's law in Tanzanian secondary schools.

1.2. Statement of the Problem

Although physics has made a substantial impact on contemporary society, there has been a noticeable decrease in both enrolment and academic achievement in secondary schools over the course of several years (MoEST, 2019, 2020, 2021). Based on statistical data provided by the National Examination Council of Tanzania, it is evident that the performance in the physics subject, specifically in the domain of electricity, during the form four national examination results (CSEE) exhibited a downward trend over the years 2019, 2020, and 2021. The respective percentages for these years were recorded as 24.1%, 22.4%, and 34.49%. These figures indicate a performance level that falls below the anticipated average. The traditional instructional approaches mostly employed by physics educators have been widely recognized, among other reasons, as the primary factors associated with substandard academic performance in the field of physics (Ouahi et al., 2021).

Few research conducted in Tanzania delved in comparing the effect of computer simulations (CSs) in the instruction and acquisition of physics knowledge as a supplementary approach to standard teaching methods (Abiasen & Reyes, 2021). Therefore, present scenario prompted the researcher to contemplate pedagogical transformation, specifically the integration of contemporary instructional methodologies that involve the employment of computerized programs like CSs with the aim of improving the existing condition. Hence, the present study compared Traditional Teaching Methods Versus Computer Simulations on students' performance in Learning Ohm's Law, within the context of secondary education in Tanzania.

2. Literature Review

2.1 Related empirical literature review

Salame and Makki, (2021) sought to evaluate the impact of computer simulation on students' academic achievement in the field of physics, while also investigating potential disparities in performance based on gender and geographical location. The study aimed to investigate the effects of computer simulations on academic achievement among middle school students in the provincial directorate of education. The data were gathered by the administration of a performance test, consisting of both a pretest and a post-test. The pretest was administered to evaluate the existing knowledge of participants in both experimental groups about the subject matter of electricity. It comprised a set of five questions with a single choice response format and an additional three questions with closed-ended response options. A post-test was employed to assess the impact of utilizing the computer simulation on the learner's performance. The post-test comprised five closed-ended questions with a single-choice response format, as well as three additional closed-ended questions. Following the recommendations of two instructors and a seasoned pedagogical physics inspector in the field of secondary education, required adjustments were made to the performance test. Subsequently, a reliability examination of the test items was conducted with a sample of 34 students. The Cronbach's alpha coefficient was computed for the pretest (0.780) and post-test (0.708) in order to assess the internal consistency of the test items used in both groups prior to and following the study's implementation.

The statistical data obtained from a semi-experimental study using a pretest and posttest design, with an experimental group and a control group, indicated that students in the experimental group who received instruction through simulations achieved greater success compared to the group of students who were taught using the traditional approach (Salame & Makki, 2021). Moreover, it was observed that there was no discernible disparity in the outcomes between male and female participants in the experimental cohort. This finding implies that computer simulators (CSs) do not exhibit bias based on gender. Additionally, it was noted that students residing in rural areas achieved slightly lower scores compared to their urban counterparts, regardless of their exposure to CSs. Based on the findings of this study, it can be concluded that the selected simulation had a beneficial effect on the academic performance of the participants in the experimental group. This effect was observed through the enhancement of their cognitive processes, specifically in refining their understanding, which is crucial for the improvement of skill application. Consequently, the utilization of the simulation facilitated the participants in overcoming specific challenges encountered during the learning process.

Additionally, the study conducted by Salgong and Ngumi, (2016) investigated the process of student comprehension and acquisition of knowledge pertaining to Ohm's law within an educational setting. The research was carried out on a sample of 32 students enrolled in physical education programs who had previously studied physics during their high school education. Initially, the students were presented with an instructional demonstration of the learning approach, afterwards followed by an experimental methodology, and the last lecture was delivered employing the method of inquiry. Students were supplied with learning tools that utilized the Serway book, and they were instructed to gather the necessary physics material for microteaching exercises. The qualitative data underwent descriptive analysis. The findings from a study conducted on the utilization of physics textbooks in middle school revealed that a significant majority of students, specifically 94%, expressed a negative sentiment towards the textbooks. Textbooks sometimes consist of extensive written information and complicated details presented in a formal style, which can lead to confusion and difficulty for students in understanding the subject. The findings indicate that students encountered challenges in understanding written information. Primarily, Ohm's law can be seen as a concise expression of fundamental principles, encapsulating a mathematical equation that necessitates computation for the derivation of outcomes. Therefore, through the redesign of the pedagogical approach to teaching and studying Ohm's law, students can engage in a comprehensive educational experience that encompasses several aspects, including the circuitry, data patterns, data analysis, and eventually the conclusions derived from the study. Thus, by using CSs students will be enabled not only to understand Ohm's law but also fostering their ability to engage in critical thinking, strategic planning, and practical application of this knowledge in many real-world scenarios.

Furthermore, in their work, Liu,Yan and Chen, (2018) investigated the application of virtual analog simulation (VAS) in the context of physics education. The study was conducted using a research and development (R&D) approach, incorporating integrated experimental models. The participants in this study consisted of 60 ninth-grade students from a junior high school located in Kudus, Central Java. The study investigated the enhancement of students' understanding by analyzing the normalized gain derived from pretest and posttest scores. The findings of this study indicate that there exists a distinction in the learning outcomes between traditional learning methods, such as the utilization of power point software, and the implementation of VAS software. The use of virtual analog simulation (VAS) has been found to be more effective in facilitating students' understanding of the electrical dynamic concept, as indicated by an N-gain of 0.36 (equivalent to 36%) and categorization within the medium range. In contrast, traditional learning methods have a lower N-gain of 0.28 (equivalent to 28%).

2.2 Connectivism Theory of Learning

The research incorporated the connectivism theory of learning as theoretical framework of the study. This is a framework that amalgamates principles derived from chaos, network, complexity, and self-organization theories.

In this educational approach, learning unfolds within intricate and constantly shifting environments that transcend individual control (Kabigting, 2021). Networks play a pivotal role in this process, where connections among various entities culminate in the integration of knowledge. Connectivism acknowledges that decision-making hinges on swiftly evolving information, necessitating the capacity to discern crucial from peripheral data. It underscores the significance of the ability to acquire fresh knowledge over retaining existing information and underscores the importance of maintaining connections for perpetual learning. Proficiency in recognizing interconnections across diverse fields and the paramount value of current, precise information are considered fundamental skills within this framework. Beyond education, connectivism has broader implications, impacting information dissemination, media practices, and knowledge management. It challenges conventional educational methodologies and underscores the pivotal role of technology in the learning process. Tools such as simulations, online courses, webinars, social networks, and blogs are regarded as instrumental in facilitating learning within the contemporary digital landscape (Kron, Fetters & Marsellaet, 2017). In the study's context, connectivism served as a guiding principle for crafting a conceptual framework and input-output models, with simulation techniques employed to regulate and evaluate students' performance.

3. Methodology

3.1 Research Design

This study employed a quasi-experimental research design, which involved the use of quantitative research methods for data collection and analysis from the study participants. Within this design, the researcher opted for a one-group pre-test post-test design due to the challenge of selecting research subjects with non-homogeneous abilities. This study's design essentially revolves around comparing the outcomes achieved by the research participants before and after they received a specific treatment. In this particular design, there is a single group that undergoes a sequence of events, including a pre-test (O1), the treatment itself (X), and a post-test (O2). The treatment's impact is assessed by evaluating the differences between the scores obtained in the pre-test and post-test assessments, as illustrated in the research design diagram.

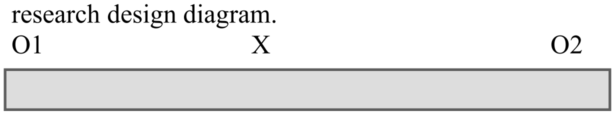

Figure 1: Pre-test and post-test research design

3.2 Population and Sampling Procedures

In this study, the researcher motivated to choose form two students due to the abstractness of form two physics topics particularly Ohm's law concept. The concept has been taught under practical approach using computer simulations as well as traditional methods in order to make comparison of the two approaches. The sample size consisted of 120 random selected students from three selected secondary schools found in Dodoma City Council. The purposive sampling was used to select schools basing on closeness to each other and have adequate ICT facilities to make the research rather cost-effective, meanwhile random sampling was employed to get the sample size of the respondents (students).

3.3 Data Gathering Procedure and Lessons Development

The researcher, in collaboration with physics teachers prepared a test as a data collection tool used as both pre-test and post-test for each teaching technique to check if there is any difference in students' performance or not in learning Ohm's law. Also, the Physics Educational Technology (PhET) interactive software was used to aid teaching and learning Ohms' law. Firstly, students were taught Ohm's law by using traditional teaching methods which were used by teachers and then pre-test administered. Secondly students were taught by using computer simulations whereby PhET simulations were installed in computer laboratory and post-test administered. These instructional approaches were employed to teach the same subject matter of which two (2) periods each having a duration of 120 minutes were firstly delivered to each selected school.

3.4 Validity

The study's validity pertains to the accuracy of the data collection instrument used, which included pre and post-tests (Mullany & Stockwell, 2021). Respondents were encouraged to freely participate, also research involved individuals with substantial knowledge to ensure the collection of pertinent data. The study provided a comprehensive description of each procedure and meticulously analyzed the data to meet the criteria for trustworthiness (Beichumila & Bahati, 2022).

3.5 Reliability

Reliable analysis demands consistent and stable research methods and measurements to ensure predictable, replicable, and accurate results. To gauge the internal consistency of both dependent and independent variables, Cronbach's alpha (α) was employed. An α-reliability coefficient greater than 0.7 is typically deemed an acceptable level of internal consistency in research, factoring in research design, data collection methods, interaction, calculation, and processing choices (Fallon, 2016). In this study, internal consistency was assessed for the test questions (D1, D2, D3, and D4 for pretest, and E1, E2, E3, and E4 for posttest) employed to compare student learning before and after the use of computer simulations (CS's). All test questions exhibited a Cronbach's alpha reliability value exceeding 0.7, confirming their internal consistency and the reliability of the results.

3.6 Data Analysis Plans

The collected data were analyzed through statistical package for social sciences (SPSS) v 20 and Microsoft excel for both descriptive and inferential statistics. Descriptive statistical analysis included the dispersion and distribution of test scores. Also Paired samples t-test was used for inferential analysis to test the significance of the variation before and after the test at value (p) < sig. (0.05) to accept the alternative hypothesis.

3.7 Ethical Consideration

During and after data collection all ethical issues concerning access to data and guidelines were strictly administered. This included permission to test the respondents from school and respondents themselves and anonymity where no respondent's identity was exposed.

4. Results and Discussion

4.1 Comparing Traditional Methods with Computer Simulations in Learning

Before and after the instructional intervention, a total of 120 students underwent testing using assessments of varying difficulty levels. These assessments encompassed comprehension (referred to as D1/E1, consisting of multiple-choice questions), recall (D2/E2, which involved sentence completion exercises), mathematical problem-solving (D3/E3, where students applied mathematical concepts), and numerical problem-solving (D4/E4, where students applied their knowledge both before and after the intervention). This section of the study also evaluated the distribution, central tendency, and mean values of the test scores. Additionally, a paired t-test was employed to confirm the statistical significance of the observed outcomes.

4.1 Dispersion of Test Scores

In this section of the research, the differences in students' test performance are illustrated and elaborated in Table 1. The scores from the initial assessment, conducted using conventional teaching techniques, are categorized as D1, D2, D3, and D4. Conversely, the scores from the subsequent evaluation following computer simulation instruction are denoted as E1, E2, E3, and E4. It is crucial to emphasize that identical sets of questions were employed for both the initial and subsequent assessments.

Table 1 Dispersion of test scores

Pre-test				**Post test**		
	N	**Std. Deviation**	**Range**		**Std. Deviation**	**Range**
D1	120	31.965	100	E1	22.053	80
D2	120	28.476	100	E2	24.764	92
D3	120	27.438	93	E3	20.040	88
D4	120	32.666	100	E4	27.064	90
Average Before	120	19.835	93	Average After	15.809	77

In the initial pre-test, it's clear that there was a notable level of variation in scores across various difficulty levels. For instance, in level D1 (Understanding), we observed a standard deviation of 31.965, indicating a wide range of scores spanning 100 points. This highlights the significant differences in students' initial understanding of Ohm's law concepts. Likewise, in level D4 (Logic), a high standard deviation of 32.666 and a range of 100 points were evident, indicating a diverse range of performance in logic-based questions. However, when we examine the post-test results after the introduction of computer simulations, a trend toward more consistent student performance emerges. In level E1 (Understanding), the standard deviation decreased to 22.053, and the range narrowed to 80 points, suggesting a reduction in score variability and a more focused distribution of scores. This pattern is consistently observed across other difficulty levels as well. For instance, in level E3 (Mathematical Computation), the standard deviation decreased to 20.040, with a range of 88 points, indicating improved score consistency following the intervention.

When examining the overall averages before and after the intervention, it becomes evident that the average standard deviation decreased from 19.835 in the pre-test to 15.809 in the post-test. This decline indicates that the introduction of computer simulations contributed to more consistent learning outcomes across varying difficulty levels. This is reflected in the narrower range of scores observed in the post-test data, which extended up to 77 points. In summary, the data reveals that the pre-test scores displayed varying levels of dispersion across different difficulty levels, with some levels exhibiting high variability. However, the adoption of computer simulations in the post-test resulted in a reduction in score dispersion, signifying that this instructional approach fostered more uniform learning outcomes and a tighter distribution of scores across different difficulty levels. The contrast between the pre-test and post-test scores highlights the limitations of traditional teaching methods, despite instructors' diligent efforts, as students frequently achieved low scores. These findings align with those of Liu et al. (2018), who compared traditional and technology-assisted teaching methods, and Kron et al. (2017), who noted enhanced student performance following the incorporation of technology-enhanced teaching methods. The outcomes of this study, which demonstrate a narrow range and standard deviation in test scores following the implementation of visual-aided technology, suggest that computer science can be integrated into Tanzanian classrooms to improve student performance.

4.2 Central Tendency of the Scores

Table 2 exhibits the measures of central tendency, including the mean, median, and mode, for the scores of students instructed in physics using traditional methods (D1, D2, D3, D4) and those educated with computer simulations (E1, E2, E3, E4). These central tendency measures offer an understanding of the typical or central test scores within each of the two instructional groups.

Table 2 Central tendency of the scores

Pre-test				Post test		
	N	Mean	Median		Mean	Median
D1	120	63.67	70.00	E1	80.49	80.00
D2	120	49.12	33.00	E2	64.85	67.00
D3	120	71.12	78.00	E3	77.60	82.00
D4	120	64.58	50.00	E4	76.31	100.00
Average Before	120	62.05	67.00	Average After	74.68	77.50

In the initial pre-test, students displayed a range of performance levels across different difficulty levels. In the understanding level (D1), the mean score was 63.67, indicating a relatively strong understanding of fundamental concepts. Conversely, in the memory level (D2), the mean score was lower at 49.12, suggesting challenges in recall and practical application. Meanwhile, the mathematical computation level (D3) showed a higher mean score of 71.12, pointing to better proficiency in applying mathematical concepts, while the logic level (D4) had a mean score of 64.58, signifying a reasonable grasp of logical aspects. Following the introduction of computer simulations in the post-test, there was a noticeable enhancement in student performance across all levels. In the understanding level (E1), the mean score significantly increased to 80.49, indicating a substantial improvement in comprehension. In the memory level (E2), the mean score rose to 64.85, reflecting progress in recall and application. Similarly, the mathematical computation level (E3) saw an improvement with a mean score of 77.60, demonstrating increased proficiency in applying mathematical concepts. In the logic level (E4), students exhibited growth with a mean score of 76.31, although with a median of 100.00, signifying a somewhat skewed distribution of scores.

Overall, the average scores before and after the intervention increased from 62.05 to 74.68, suggesting that the integration of computer simulations into the teaching of Ohm's law positively impacted students' comprehension and application of the subject. However, variations in score distributions, as evidenced by differences between mean and median scores in certain levels, may warrant further investigation to understand the factors contributing to these disparities and refine the teaching approach. These findings align with the research conducted by Saudelli et al. (2021), which explored the influence of PhET (Physics Education Technology) simulations on the academic performance of undergraduate physics students. After the implementation of computer simulations in the instructional process, students achieved significantly higher average scores compared to traditional teaching methods. Furthermore, studies indicate that the use of visualization techniques can be advantageous in addressing the challenges associated with abstract and complex physics concepts. Additionally, the incorporation of mathematical elements within these simulations can help students bridge the gap between their mathematical skills and their comprehension of physics concepts. These findings suggest that the potential for achieving more consistent and improved academic performance through computer simulations extends not only to Form 2 students but also to students in subsequent grade levels.

4.3 Distribution of the scores

The distribution characteristics of test scores in both the pre-test and post-test assessments offer valuable insights into the patterns of student performance across different difficulty levels. Table 3 presents distribution of the scores

Table 3 Distribution of the scores

Pre-test				**Post test**		
	N	**Skewness**	**Kurtosis**		**Skewness**	**Kurtosis**
D1	120	-.418	-1.098	E1	-1.069	.481
D2	120	.247	-.596	E2	-.088	-.828
D3	120	-2.140	2.971	E3	-2.308	4.605
D4	120	-.381	-.715	E4	-.404	-1.497
Average Before	120	-.939	.656	Average After	-1.127	1.457

In the pre-test, level D1 (Understanding) displayed a slightly negatively skewed distribution with a relatively flat shape, while level D2 (Memory) exhibited a slightly right-skewed distribution with less peakedness. Conversely, level D3 (Mathematical Computation) showcased a strongly negatively skewed and leptokurtic distribution, indicating heavier tails and a sharper peak. Level D4 (Logic) displayed a somewhat negatively skewed and less peaked distribution. With the introduction of computer simulations in the post-test, there were noticeable similarities in distribution characteristics. Levels E1 (Understanding) and E2 (Memory) maintained negatively skewed distributions with slightly reduced peakedness. Level E3 (Mathematical Computation) continued to exhibit a strongly negatively skewed and leptokurtic distribution, suggesting that the teaching intervention did not significantly alter its shape. Level E4 (Logic) also maintained a slightly negatively skewed and less peaked distribution.

The average skewness across all levels remained negative both before and after the intervention, indicating a propensity toward negatively skewed distributions. However, the average kurtosis increased after the intervention, indicating a slight increase in peakedness in the post-test data. Overall, these distribution characteristics highlight the influence of computer simulations on the shape of score distributions, resulting in more consistent negatively skewed distributions with varying degrees of peakedness across different difficulty levels. Prior to the intervention, the pre-test scores exhibited diverse distribution shapes, including negative skewness and varying degrees of peakedness (kurtosis), with some levels displaying strongly negatively skewed and leptokurtic distributions, suggesting challenges in score distribution and performance variations.

Following the intervention, the post-test scores demonstrated more consistent characteristics. While they retained negative skewness in most cases, indicating a tendency toward lower scores, the kurtosis values generally decreased, suggesting that the post-test distributions were less peaked and closer to a normal distribution. This indicates a reduction in extreme scores and a more even spread of scores, which is considered a more desirable distribution for assessments. The varying levels of difficulty and complexity among certain questions may have led to differences in students' academic achievements.

This implies the need to tailor the instructional approach to effectively address the distinct requirements of students in various regions (Jane & Florence, 2022). The observed increase in average scores between the pre-test and post-test indicates a positive enhancement in students' performance following the implementation of the computer simulation intervention. This outcome suggests that using computer-based simulations as a teaching strategy yielded beneficial effects on students' knowledge acquisition and understanding of the subject matter. However, further data analysis is required to determine the extent of improvement and assess the statistical significance of the observed gains. These results are consistent with Jane and Florence, (2022), who found that the computer-based simulation teaching approach effectively enhanced students' self-concept in chemistry. Similarly, Simanjuntak et al., (2021) supports the use of innovative teaching methods, such as computer-based simulations, to improve learning outcomes. He also recommended that educators and policymakers consider integrating such approaches into the regular curriculum to enhance the overall quality of science education.

By examining variations in mean scores across different questions, educators can identify specific areas where students may be struggling or in need of additional support. This insight can help refine the teaching approach and target particular topics or concepts that require more attention. Teachers can address these areas through focused interventions and personalized instruction, ensuring effective fulfillment of students' learning needs. Furthermore, the study's findings are consistent with those of Kabigting, (2021), who found that teaching respondents agreed that both teaching methods were effective, promoted student participation, and influenced students' cognitive skills and content knowledge. Nonetheless, factors such as school infrastructure, teacher training, and available resources may vary across different regions or schools in Tanzania. Therefore, policymakers and educators should carefully assess the suitability and feasibility of implementing computer simulations in teaching in various settings.

4.4 Paired samples t-test

The presented data showcases the results of a paired samples t-test, which is a statistical analysis method used to compare the means of related groups. In this case, it compares the pre-test (Before) and post-test (After) scores within different difficulty levels (D1, D2, D3, D4) and their corresponding easier levels (E1, E2, E3, E4). For each pair of tests, the results include information about mean differences, standard deviations of differences, t-values, degrees of freedom (Df), and p-values. These statistics are used to assess the statistical significance of the observed differences, as detailed in Table 4.

Table 4 Paired t-test for Comparison

	Difficulty	Mean	Std. Deviation	t	Df	Sig. (2-tailed)
Pair 1	D1 - E1	-16.825	20.509	-8.987	119	0.000
Pair 2	D2 - E2	-15.733	21.032	-8.194	119	0.000
Pair 3	D3 - E3	-6.483	14.235	-4.989	119	0.000
Pair 4	D4 - E4	-11.725	20.067	-6.401	119	0.000
Pair 5	Before - after	-12.633	10.250	-13.502	119	0.000

In Pair 1 (D1 - E1), a substantial improvement is evident, with a mean score difference of -16.825 observed between Level D1 (pre-test) and Level E1 (post-test). The t-value of -8.987 and a p-value of 0.000, which is below the 0.05 threshold, highlight a highly significant difference, emphasizing the positive impact of computer simulations on the understanding of Ohm's law. Pair 2 (D2 - E2) demonstrates a similar trend, showing a significant mean score difference of -15.733, indicating considerable improvement after the intervention. The t-value of -8.194 and a p-value of 0.000, less than 0.05, underscore the statistical significance of this enhancement.

In Pair 3 (D3 - E3), there is also a notable improvement, with a mean score difference of -6.483. The t-value of -4.989 and a p-value of 0.000, falling below 0.05, confirm the statistical significance, suggesting that computer simulations positively impacted mathematical computation skills related to Ohm's law. Pair 4 (D4 - E4) reveals significant progress, with a mean score difference of -11.725 between Level D4 (pre-test) and Level E4 (post-test). The t-value of -6.401 and a p-value of 0.000, less than 0.05, establish the statistical significance of this improvement, indicating that computer simulations enhanced logical reasoning in the context of Ohm's law.

Pair 5 (Before - After) compares the overall pre-test and post-test scores across all levels. It demonstrates a highly significant improvement in student performance, with a mean score difference of -12.633. The t-value of -13.502

and a p-value of 0.000, below 0.05, underscore the overall effectiveness of computer simulations in enhancing students' understanding of Ohm's law concepts. The substantial mean score differences observed in all pairs indicate that computer simulations are a highly effective educational tool for improving student learning outcomes. The significant improvements across different difficulty levels suggest that this teaching approach can cater to a diverse range of students with varying levels of prior knowledge and aptitude in the subject matter. Moreover, the consistently low p-values (all less than 0.05) in each pair highlight the robustness of the results, suggesting that the positive impact of computer simulations on student performance spans across the entire spectrum of difficulty levels.

Additionally, the mean differences in Pair 5 (Before - After) demonstrate an overall enhancement in student performance across all levels. This broader perspective implies that implementing computer simulations doesn't target specific areas of knowledge but has a holistic effect on the overall understanding and application of Ohm's law. This outcome is particularly promising for educators aiming to enhance the overall competency and preparedness of students in the subject. Furthermore, the consistency in the reduction of kurtosis values in post-test distributions suggests that computer simulations contribute to more normal-like score distributions. This means that the intervention tends to mitigate the presence of extreme scores, making assessment results more reliable and less susceptible to outliers.

The results indicate improvements in post-test outcomes for questions of varying weight and complexity following instruction with computer simulations. Consequently, teaching through computer simulations had a positive impact on learning and significantly differed from traditional methods (Kanyaru & Maina, 2019). These findings align with the arguments presented by various scholars regarding the favorable effects of computer simulations on learning.

In the Tanzanian context, student performance varies across schools and regions due to disparities in comprehension levels resulting from decades of traditional teaching methods. The integration of the curriculum with computerized and virtual reality technology in science subjects is crucial to enhance student performance, particularly in science subjects that traditionally exhibit lower performance (MoEST, 2019, 2020). Education stakeholders should prioritize the implementation of computer simulations to achieve substantial improvements in real-time lessons.

5. Conclusion and Recommendations

5.1 Conclusion

This paper has confirmed that the utilization of computer simulations in teaching aids students in transforming abstract content into tangible knowledge and enables them to establish connections between knowledge and real-life scenarios. The findings of the current study align with the hypothesis, revealing a significant difference in performance between students instructed using computer simulations and those taught through conventional teaching methods. Consequently, the integration of computer simulations in this study has yielded substantial positive effects on students, enhancing their performance in physics assessments. It is evident that the incorporation of computer simulations empowers students to relate concepts to real-life situations and leads to performance improvements. Furthermore, this research has demonstrated that computer simulations have a favorable impact on students' mastery of Ohm's law concepts by fostering motivation and increasing interactivity in the learning process. The utilization of computer simulations thus emerges as an alternative teaching method capable of elevating students' performance and serving as a crucial component of effective pedagogy.

5.2 Recommendations

This study recommends:

1. Teachers should incorporate computer simulations into teaching as a powerful tool to bridge the gap between abstract content and real-life applications, enhancing students' understanding of complex concepts.
2. Teachers should recognize the substantial difference in performance between students taught using computer simulations and those taught through traditional methods. Acknowledge the effectiveness of computer simulations as an educational approach.
3. NGOs, government and all education actors should encourage the widespread use of computer simulations in physics education, as it has been shown to substantially improve students' performance in physics tests and assessments.
4. Education actors should promote motivation and interaction by recognizing the motivational and interactive benefits of using computer simulations to teach complex concepts such as Ohm's law. These benefits can significantly enhance student engagement and interest in the subject.

5.3 Limitation of the study

Study comparing traditional teaching methods with computer simulations in the context of teaching Ohm's law in Tanzanian secondary schools has encountered several limitations. These include a relatively small and non-representative sample of schools, potential bias in school selection, questions regarding the consistency of measurement tools, failure to account for external factors influencing student performance, a focus on short-term outcomes, limited information on teacher training, and the absence of detailed ethical considerations. Furthermore, resource disparities among schools were not thoroughly addressed. Despite these limitations, the study provides valuable insights into the potential benefits of using computer simulations in teaching, but caution is needed when applying its findings to broader educational contexts. Future research should consider these limitations and explore the long-term effects of technology-enhanced learning methods in various settings.

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