Research Journal of Education, Teaching and Curriculum Studies
Vol. 2 No. 2 (2024): ISSN (Online): 2958-8626
DOI: https://doi.org/10.58721/rjetcs.v2i2.764

Influence of Simulations on Students' Achievement in Physics in Secondary Schools in Nandi East, Kenya

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Article History
Received: 2024-05-29
Revised: 2024-09-11
Accepted: 2024-09-13
Published: 2024-10-02

Keywords
Integration
Mobile Technologies
Simulations
Students' achievement

How to cite:
Kibiwott, D. K. & Njoroge, B. (2024). Influence of Simulations on Students' Achievement in Physics in Secondary Schools in Nandi East, Kenya. *Research Journal of Education, Teaching and Curriculum Studies,* 2(2), 70-79.

Abstract
Many secondary schools in Kenya are yet to incorporate Mobile Technologies into their educational practices, despite widespread ownership and use by both students and teachers. This study investigated the influence of simulations on students' achievement in physics in secondary schools in Nandi East, Kenya. The dismal performance in physics locally and nationally may be linked to slow technological integration, hence the need for the study. The target population consisted of Form Three physics students and 30 Heads of Department (HODs) from 31 secondary schools. A descriptive survey design was utilized. Random and purposive sampling was used to select participants, and data collection involved questionnaires and interviews. Using Taro Yamane's Formula, the sample size was determined to be 300 students, 30 HODs, and 30 schools. Data were analyzed using SPSS, providing descriptive statistics such as frequencies, percentages, pie charts, means, and standard deviations (SD). The reliability of the questionnaire items was confirmed with a Cronbach Alpha coefficient above 0.7. The findings emphasize the significant benefits of integrating simulations on students' academic achievement in secondary school physics learning. While the study offers important insights, its geographical limitation, technological access issues, and narrow scope constraints must be considered. These results have implications for various stakeholders including learners, parents, teachers, school administrators, curriculum developers, and policymakers. Learners will benefit from improved effectiveness, engagement, and personalized instruction, while policymakers will gain insights for future improvements. The study recommended learners be allowed to bring their own devices to school to ensure equality and equity in access to digital learning materials.

Introduction

The education landscape is rapidly evolving with the widespread adoption of mobile devices such as smartphones, laptops, and tablets, which have fundamentally reshaped how information is accessed, shared, and learned. These technological advancements offer unprecedented opportunities for innovative learning experiences, allowing students to access educational resources anytime and anywhere (Lornah, 2015). This ubiquitous connectivity has transformed our daily lives and revolutionised educational practices, enhancing how we acquire knowledge and skills. Smartphones, in particular, have become indispensable tools for students, providing versatile functionalities that support learning beyond traditional classroom settings (Chen & deNoyelles, 2013). Research indicates that integrating mobile technologies into education fosters greater student engagement, collaboration, and access to comprehensive information, thereby improving academic performance and learning outcomes (Gulek & Demirtas, 2005). Moreover, students report enhanced problem-solving skills, critical thinking abilities, and a more positive attitude towards learning when mobile technologies are effectively integrated into their educational experiences (Berge & Muilenburg, 2013).

In the realm of science education, the integration of technology has shown promising results in cultivating students' interest and motivation in science subjects (Hennessy, 2007). Physics education is crucial in developing students' analytical thinking and fostering an open-minded approach to complex problem-solving (Kenya Institute of Education (KIE), 2006). However, despite the potential benefits of mobile technologies, students' performance in physics at the national level remains a concern, as evidenced by consecutive reports from the Kenya National Examination Council (KNEC) indicating suboptimal results over the past five years (2018-2022).

Table 1: Performance of Physics in KCSE 2018-2022

Paper	**Maximum Score**	**2022**	**2021**	**2020**	**2019**	**2018**
P1	80	22.42	21.12	21.58	25.63	22.98
P2	80	21.69	17.59	25.93	20.43	22.13

Kenya National Examination Council 2022 Report

There is a growing emphasis on utilising interactive simulations and educational applications to address these challenges and capitalise on the potential of mobile technologies in enhancing science education. Simulations offer a dynamic and immersive learning environment that allows students to visualise abstract concepts, conduct virtual experiments, and engage in hands-on learning experiences (UNICEF, 2013). These interactive tools complement traditional teaching methods and cater to diverse learning styles, promoting a more profound understanding and retention of scientific principles among students.

Integrating simulations into physics education holds promise for improving student comprehension and applying theoretical concepts. By providing realistic scenarios and interactive feedback, simulations enable students to explore scientific phenomena in a controlled yet engaging manner, bridging the gap between theoretical knowledge and practical skills (Wu, 2022). Moreover, simulations can facilitate collaborative learning experiences, where students work together to solve complex problems and gain insights into real-world applications of physics principles.

In light of these considerations, this study aims to explore the effectiveness of simulations and mobile technologies in enhancing learning experiences in physics education. By investigating how simulations can be integrated into existing curriculum frameworks to improve student engagement, motivation, and academic performance, this research seeks to provide empirical evidence to inform educational practices and policy decisions. Ultimately, the findings of this study aim to contribute to the ongoing discourse on leveraging technology to transform science education and address the persistent challenges in improving student outcomes in physics at both local and national levels.

Physics is frequently perceived as complex due to its intricate concepts, theories, laws, and models (Mualem & Elyon, 2007). Both nationally and specifically in Nandi East Sub-County, student performance in physics remains unsatisfactory. One potential solution to enhance students' understanding and performance in physics is the incorporation of simulations into the curriculum. Despite their potential to significantly improve educational outcomes, there is a noticeable lack of empirical research examining the impact of simulations on physics education in secondary schools within Nandi East, Kenya. Furthermore, the adoption of simulations in teaching is progressing slowly. Additionally, the number of students opting to study physics is relatively low despite the subject's crucial role in Science, Technology, Engineering and Mathematics (STEM) education. This study aims to evaluate the effect of simulations on the academic achievement of secondary school students in physics in Nandi East, Kenya.

Simulations involve interactive visualisations that enhance students' understanding and achievement by simulating real-world scenarios or processes. Research has shown significant benefits of simulations in Physics education. Almasri (2022) found that simulations enhance students' conceptual understanding and problem-solving skills. Their meta-analysis revealed that students who used simulations performed better in assessments than those who did not. De Jong and Joolingen (2018) noted that simulations support inquiry-based learning, allowing students to experiment with variables and see immediate results, which deepens their understanding of Physics concepts. Sahin and Yilmaz (2020), highlighted that mobile technologies enable students to access simulations anytime and anywhere, fostering continuous learning and making simulations more integrated into students' daily lives. Huang et al. (2019) noted that Mobile Technologies-based simulations provide more immersive and intuitive learning experiences, enhancing student engagement and understanding.

Students who used simulations showed improved comprehension and retention of Physics concepts Sunday et al. (2024). Chumba et al. (2020)., demonstrated that simulations could bridge the gap between theoretical knowledge and practical application, particularly in resource-constrained environments where physical laboratories are limited. Simulations and animations significantly enhanced students' achievement and engagement in Physics by demystifying abstract concepts, making them more accessible to students, which could improve students' critical thinking and problem-solving abilities (Achor, 2020). Incorporating mobile technologies, which have simulations and animations, has enabled the development of more interactive and personalised learning experiences. Kairo et al. (2022) explored the impact of simulations on secondary school students and opined that learners achieved higher test scores and showed more enthusiasm for the subject. Malack (2020) highlighted that simulations fostered a deeper understanding of complex Physics topics, leading to improved academic achievement. Their study emphasised the importance of incorporating simulations into the curriculum to enhance learning outcomes. In these simulations and animations, MT has been particularly effective in reaching students in remote areas, providing them with quality educational resources and interactive learning tools. The study aimed to assess the influence of simulations and animations through mobile technologies on students' physics achievement in secondary schools in Nandi East Sub County in Nandi County, Kenya.

Methodology

The study employed a descriptive survey design to investigate the influence of simulations on students' achievement in Physics. This design aimed to collect data describing the current state of variables without manipulation. Data collection involved using a self-report questionnaire administered to Physics students and structured interviews for HODs, assessing the frequency and extent of simulation use in learning. Responses from the questionnaire were gathered using Likert-scale questions. Surveys were conducted to explore students' attitudes, skills, knowledge, and perceptions regarding the integration of simulations in Physics education.

Target Population and Sample Size

The sample size was computed using Taro Yamane's Formula;

$$n = \frac{N}{1 + N(e)^2}$$

Where:
n = The desired sample size

e = Probability of Error (the desired precision, 0.032 for 96.8% Confidence Level for schools and Heads of Department (HODs) and 95.00% confidence level for students).

N= The estimate of the population size.

The distribution of the respondents

Schools; $n = \frac{31}{1+31(0.032)^2}$ n=**30**

HODs; $n = \frac{31}{1+31(0.032)^2}$ n=**30**

Physic students $n = \frac{1200}{1+1200(0.05)^2}$ n=**300**

Table 2: Sample Size

Respondents	**Target Population**	**Sample Size**
Heads of Department (HODs)	31	30
Physics Students	1200	300

Source: Researcher (2023)

Reliability

The Cronbach Alpha Test gauged the reliability of questionnaire items for students. It is most effective for multi-item scales, offering a unique and quantifiable internal consistency estimation (Opiyo et al., 2017). The reliability coefficient (α) for Simulations was, α=0.717 and since the reliability coefficients exceeded 0.70, it can be concluded that the research instruments demonstrate reliability.

Data Analysis Procedure

Quantitative data collected using a questionnaire from physics students was coded and data inputted into a computer with Statistical Package of Social Sciences (SPSS) programs that were employed to generate descriptive analysis that included frequencies, pie charts, means and SD, as well as percentages. The replies captured by the questionnaire were coded into even themes to facilitate analysis. The results were discussed, and where summary, recommendations and conclusions were drawn. Inferential statistics such as Pearson correlation coefficients plus multiple Regression models were extensively applied.

Multiple Regression analysis was utilised to explore the correlation between the dependent and independent variables

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$$Y = \beta_0 + \beta_1 X_1 + \propto$$

where: Y= Dependent Variable (Students' achievement in physics), β_0 =Regression intercept, β_1=slopes of the regression equation, and X_1= Simulations and $\propto$= Error term

Ethical Considerations

Ethical considerations encompass moral principles. While research-based knowledge is crucial, human dignity should never be compromised (Ambang, 2021). It was the researcher's duty to uphold the respondents' integrity by ensuring strict privacy standards. Creswell and Creswell (2017) stress the importance of clearly communicating research aims to provide participants with an understanding of the study's purpose and benefits. Full consent was obtained from all relevant parties, especially minors, who were protected through a Minors' Consent Form signed by a responsible adult. Research instruments were securely stored, and proper citation and recognition of sources were maintained. The gathered information will not be used for harm or financial gain.

Results and Discussion

Response Rate

Questionnaires were given to 300 physics students, and the return rate was 100%.

Demographic Information of Students

Figure 1: Gender of Students

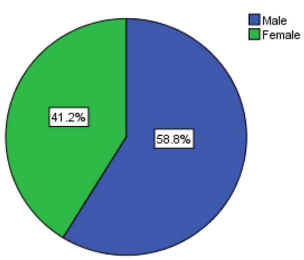

Figure 1 illustrates the gender distribution of students. The survey assessed the gender of respondents; 58.8% (176) of the students were males, while 41.2% (124) were females, showing a high proclivity of male learners towards Physics.

Figure 2: Access to Unlimited Wi-Fi Services by Students

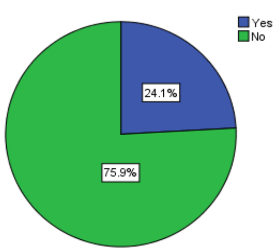

Figure 2 displays the percentage of students with access to unlimited Wi-Fi services. On access to unlimited Wi-Fi services. Of the respondents, 24.1% affirmed having such access, while 75.9% indicated they did not. The majority of students lacked access to unlimited Wi-Fi services.

Figure 3: Mobile Devices Students Access

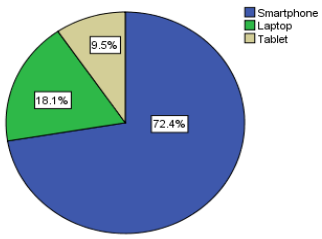

Figure 3 illustrates the extent of access that students have to mobile devices. Figure 3 summarises mobile devices accessed by the respondents. 72.4% reported accessing Smartphones, 18.1% accessed Laptops, and 9.5% accessed Tablets. The study's results indicated that most students used Smartphones, in contrast to Laptops and Tablets, and according to Pechenkina (2017), nowadays, virtually every single learner possesses or accesses at least one multifunctional device which contains a variety of applications. These portable devices are available to students, though there is no equity in their distribution among learners.

Figure 4: Mobile Technologies and Performance in Physics

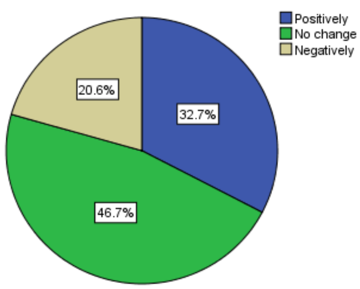

Figure 4 analyses the impact of mobile technologies on students' performance in Physics. The impact of MT on physics performance was sought. 32.7% of the learners indicated positively that MT affects physics performance, 46.7% indicated MT has no effect, and 20.6% suggested MT negatively affects physics performance.

Descriptive Statistics

Likert data gathering instrument was employed to collate primary data regarding the types of mobile technologies integrated into teaching and learning physics in Nandi East, Kenya secondary schools. The views of respondents were measured using a five-point Likert scale, where one corresponds to "Never," 2 to "Rarely," 3 to "Occasionally," 4 to "Often," and 5 to "Very Often." with cut point limit of 1.0 - 1.80, 1.81 - 2.60, 2.61 - 3.40, 3.41 - 4.20 and 4.21 - 5.0, respectively.

Influence of Simulations on Students' Achievement in Physics

The researcher explored the influence of simulations on students' achievement in Physics. The essence was to assess the effect of these interactive visualisations on students' physics achievement.

Table 3: Influence of Simulations on Students' Achievement in Physics

Statement	N	Mean	SD
I use simulations to visualize and understand complex Physics concepts.	300	2.92	0.91
I engage with animated Physics tutorials to reinforce my classroom learning.	300	2.94	1.02
I study Physics problems and solutions using interactive simulation apps.	300	2.12	0.95
I use online simulations to conduct virtual Physics experiments.	300	2.14	0.96
I create animated presentations to explain Physics topics to my peers.	300	2.16	0.94
I access and utilize educational Physics animations from various online platforms.	300	3.20	0.98
I participate in online forums and discussions involving Physics simulations.	300	2.14	0.91
I share and collaborate on Physics simulations with my classmates through digital platforms.	300	2.07	0.90

The study aimed to determine whether students use simulations to visualise and understand complex Physics concepts, along with other digital tools and platforms designed to enhance their learning experience. The findings provide valuable insights into how students engage with these technologies, highlighting their prevalence and effectiveness. The research revealed some students engage in visualising and understanding complex Physics concepts through simulations, as indicated by a recorded mean of 2.92 with an SD of 0.91 and a range of values from 1 to 5. This suggests that while not all students utilise these tools, a significant portion finds them beneficial in making abstract concepts more concrete and understandable. Engaging with animated Physics tutorials to reinforce classroom learning among students had a mean of 2.94 and an SD of 1.02. The findings suggest that students recognise the value of these tutorials in enhancing their understanding and retention.

The use of interactive simulation apps recorded a mean of 2.12 and an SD of 0.95, indicating a notable number of students employ these apps to tackle Physics problems. These apps often allow for hands-on manipulation of variables and immediate feedback. The use of online simulations to conduct virtual Physics experiments had a mean of 2.14 and an SD of 0.96. Virtual experiments offer a safe, cost-effective, and accessible way for students to explore experimental Physics, simulating lab environments and experiments that might otherwise be impractical due to resource constraints, broadening the scope of experimental learning. Creating animated presentations to explain Physics topics to peers recorded a mean of 2.16 and an SD of 0.94, indicating that some students actively create educational content, facilitating peer learning and enhancing communication skills. The ability to access and utilise educational Physics animations from various online platforms posted a mean of 3.20 and an SD of 0.98, indicating that many students frequently use these resources. Online educational animations provide diverse explanations and perspectives on Physics, making learning more flexible and personalised.

Participation in online forums and discussions involving Physics simulations and animations registered a mean of 2.14 with an SD of 0.91. These forums are valuable collaborative learning and problem-solving platforms, allowing students to engage with peers and experts, share insights, and seek help on challenging topics. Sharing and collaborating on Physics animations and simulations with classmates through digital platforms registered a mean of 2.07 and an SD of 0.90. The lower mean suggests that while there is some level of collaboration, it is not as widespread. In summary, the study highlights a varied landscape of digital tool usage among students for learning complex Physics concepts. While simulations, animations, and interactive apps are utilised to different extents, there is a need to encourage broader and more consistent use of these technologies to further students' achievement in physics. The study explored how simulations and digital tools impact students' understanding of complex physics concepts. Findings showed that many students use simulations and animated tutorials to grasp abstract ideas, which improves their comprehension and problem-solving skills. Interactive simulation apps were praised for enhancing hands-on learning, while virtual labs provided a cost-effective alternative to physical experiments. The study also noted the positive role of student-created educational content and online forums in reinforcing learning. Overall, the research highlights the effectiveness of these digital tools in enhancing students' engagement and achievement in physics.

Findings from Structured Interviews with Heads of Department

The research conducted interviews with Heads of Departments (HODs) to investigate the impact of mobile technologies (MT) and MT-powered simulations on students' academic achievement in physics. The findings highlight a significant consensus among the HODs regarding the benefits of these technologies. A notable seventy-six point seven per cent of the HODs agreed that MT-enabled simulations positively impact students' academic achievement in physics. This suggests a strong belief in the educational value of simulations. The majority of HODs, an overwhelming ninety-three point three per cent, viewed the overall impact of mobile learning on physics students' academic achievement positively.

This broad approval underscores the potential of MT to enhance educational outcomes by providing immediate access to resources, facilitating interactive learning, and offering personalised educational experiences. Regarding their role in promoting online learning through MT, sixty point zero per cent of the HODs saw themselves as active participants. This indicates a willingness among the majority to engage with and support the integration of MT in their teaching practices. The findings reveal that most HODs acknowledge the positive effects, particularly MT-enabled simulations, on students' academic performance in physics. Despite some reservations about potential negative impacts, the general sentiment is favourable, emphasising the importance of incorporating MT to enhance learning and improve academic outcomes in physics.

Study Implications

The study's findings imply that integrating simulations in physics education can significantly enhance student achievement. However, the benefits are contingent on equitable technological access, suggesting a need for policymakers to invest in technological infrastructure and teacher training. Additionally, the positive impact of simulations indicates that incorporating similar digital tools across other subjects could further improve educational outcomes. The study emphasises the potential for simulations delivered via mobile technologies to transform traditional teaching methods, making learning more interactive and engaging, thus encouraging wider adoption of digital resources in education.

Conclusion

The study explored how students use digital tools and simulations to improve their understanding of complex Physics concepts. Some students used simulations to visualise these abstract concepts and engaged with animated tutorials to reinforce classroom learning. Many students used interactive simulation apps to study Physics problems and conducted virtual experiments online, which provided a safe and cost-effective alternative to traditional labs. Although some students created animated presentations to explain Physics topics to their peers, a more significant number accessed and utilised educational animations from various online platforms, offering flexible and personalised learning opportunities. However, participation in online forums involving Physics simulations was limited, and most students did not frequently share or collaborate on animations and simulations with classmates through digital platforms. The study found that while a portion of students effectively utilised simulations to visualise and reinforce Physics concepts, and interactive simulation apps were available for studying and conducting virtual experiments, the creation and sharing of educational content were less common among peers. This indicates a need to encourage broader and more consistent use of these digital tools and collaborative platforms to enhance students' achievement in physics further. Emphasising the importance of these tools could lead to improved understanding and performance in the subject, ultimately fostering a more interactive and engaging learning environment.

Most HODs recognize the positive impact of MT-enabled simulations on students' academic achievement in physics. They view mobile learning and ICT-powered lessons as beneficial and are willing to integrate these technologies actively. Overall, the findings emphasise the importance of incorporating mobile technologies to enhance learning outcomes in physics.

While the findings indicate simulations can positively impact students' achievement in physics, some limitations must be acknowledged. Firstly, the study's geographical focus on Nandi East, Kenya, may limit the generalizability of the results to other regions. Technological access was uneven among students, with many lacking the necessary devices and Wi-Fi, potentially skewing the outcomes. The scope was also narrow, focusing solely on physics simulations without considering other educational methods. Furthermore, though statistically valid, the sample size of 300 students could benefit from being more extensive and more diverse to enhance generalizability.

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