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Building Teachers' Capacity in Teaching Stem with Phet Simulations in Nigeria

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Abstract: *The study aimed to enhance the capacity of secondary school science teachers in Nigeria to teach STEM subjects using PhET Simulations, a set of interactive tools for teaching and learning science and mathematics. A descriptive survey research design was employed, targeting all secondary school science teachers in the Ido Local Government Area of Ibadan. The sample comprised 50 teachers, and data was collected using a 24-item questionnaire developed by the researchers, titled "STEM Teachers' & PhET Simulations (STEMT & PhETSIMS)." The reliability of the questionnaire was confirmed through the Cronbach alpha technique, yielding a coefficient of 0.85, indicating high internal consistency. Data analysis involved calculating the mean and standard deviation to assess teachers' preparedness in using PhET Simulations for STEM education. The findings revealed a significant need for training secondary school teachers in Nigeria to effectively integrate PhET Simulations into their teaching practices. Consequently, the study recommended that government bodies and relevant stakeholders provide continuous professional development opportunities focused on PhET Simulations for STEM educators. This approach is essential for improving STEM education quality in Nigeria, equipping teachers with modern tools and methodologies to engage students in science and mathematics learning.*

Keywords: *STEM Education, PhET Simulations, Teacher Capacity Building, Technology-Enhanced Learning.*

Introduction

Education in the twenty-first century demands skills in science, technology, engineering, and mathematics (STEM) to address complex challenges. Developing these capabilities in students must begin early, through effective teaching. Early exposure and relevant experiences can foster a sustained interest in STEM fields. Integrated approaches to teaching and teacher preparation are essential for cultivating a generation that is both interested and proficient in STEM. It is crucial to attract high achievers to STEM fields and strengthen the rigor of STEM education within both pre-service and in-service teacher training programs (Prinsley & Johnston, 2015).

As science education plays a pivotal role in shaping the future workforce and addressing societal challenges, teachers must diversify their teaching methods and embrace technology to engage today's tech-savvy generation (Aregbesola, Ojelade, Haastrup & Nyinebi, 2024). However, boosting the confidence of teachers towards technology advance societies is so crucial. Ojelade, Aregbesola and Haastrup (2022) asserted that there is a shift with the strategies, pedagogies, mode and methodologies in teaching and learning of science.

Building teachers' capacity to teach STEM (Science, Technology, Engineering, and Mathematics) with PhET simulations is a significant initiative in Africa. Therefore, the integration of technology-based instructional tools, such as interactive simulations, has become increasingly essential in modern STEM education. Particularly in the African context, leveraging these resources can significantly enhance the quality and accessibility of science, technology, engineering, and mathematics (STEM) learning. One promising approach is the utilization of the PhET Interactive Simulations, a widely acclaimed collection of free, research-based virtual laboratories and models. Empowering teachers to incorporate PhET simulations into their pedagogical practices is a critical step towards improving STEM education in Africa.

PhET Interactive Simulation in 2002 was founded by Nobel Laureate Carl Wieman, a project at the University of Colorado Boulder which creates free interactive math and science simulations. PhET simulations are based on extensive education research engaging students through an intuitive, game-like environment where students learn through exploration and discovery. Research has demonstrated the potential of PhET simulations to support inquiry-based instruction, foster conceptual understanding, and engage students in active learning. By supporting teachers' capacity to integrate these simulations, we can unlock the transformative power of technology-enhanced science education (Geelan & Fan, 2014; Podolefsky, 2012; Rutten et al., 2014). Teachers' ability to leverage PhET simulations in the classroom hinges on several key factors, including their technological proficiency, pedagogical knowledge, and access to appropriate professional development opportunities (Geelan & Fan, 2014).

Extant literature has highlighted the importance of cultivating teacher self-efficacy in the use of instructional technologies (Chukwuemeka & Iscioglu, 2016; Tschannen-Moran et al., 2018). When teachers possess a strong sense of confidence in their ability to implement technology-aided lessons, they are more likely to adopt and sustain the use of tools like PhET simulations (Ziya'ulhaq, 2021). STEM fields are among the most critical to drive the socio-economic development of a country and prepare citizens to tackle the challenges of the 21st century. Developing countries in Africa, such as Nigeria, with a large youth population, have significant potential to benefit from advancements in STEM. However, despite the recognized importance of STEM education, many African schools face significant challenges in effectively delivering STEM curricula.

These challenges include limited access to educational resources, such as well-equipped laboratories, modern technology, and up-to-date teaching materials, inadequate infrastructure and funding can create barriers to hands-on learning experiences, limiting students' ability to develop practical skills. In the current global landscape, a significant number of African higher education students aspire to STEM careers, yet the region faces challenges in providing quality STEM education. This is because many African countries face a shortage of qualified STEM teachers, as well as limited opportunities for in-service training and support which have resulted in a lack of pedagogical expertise and confidence in delivering engaging and relevant STEM lessons. Conventional teaching methods, such as rote memorization and lecture-based instruction, remain prevalent in many African schools and may fail to capture students' interest and foster the critical thinking and problem-solving skills essential for STEM learning. Therefore making it a challenge to them to embrace modern, student-centered teaching strategies such as PhET in many educational settings.

Effective STEM teaching requires providing training and ongoing professional development for educators on how to use innovative technology like PhET simulation and how to find PhET simulations that aligns to curriculum learning objectives which are relevant to hands-on activities they could carry out. PhET simulations are design to be highly interactive, allowing students to manipulate variables, observe real-time changes, and actively participate in the learning process. This hands-on approach facilitates a deeper understanding of complex concepts and promotes student engagement, making STEM subjects more accessible and exciting. Therefore, this study examined building teachers' capacity to teach STEM with PhET Simulations in Africa.

Purpose of the Study

The purpose of this study is to examine building teachers' capacity in teaching STEM with PhET Simulations in Nigeria. Specifically, two objectives were raised to guide he study:

1. To determine the extent to which teachers are prepared to teach STEM subjects with PhET Simulation in secondary schools.
2. To find out problems associated to the use of PhET simulations with the STEM curriculum-learning objectives in secondary schools by teachers

Research Questions

1. To what extent do teachers prepared to teach STEM subjects with PhET Simulation in schools?
2. How do PhET simulations aligned with STEM learning objectives present challenges for secondary school teachers?

Literature Review

STEM (Science, Technology, Engineering, and Mathematics) education plays a crucial role in fostering innovation, critical thinking, and addressing socio-economic challenges in Africa. As the continent strives toward sustainable development, STEM skills are essential for driving progress across sectors such as healthcare, agriculture, energy, and technology. STEM education nurtures problem-solving abilities, analytical skills, and creativity, enabling individuals to develop innovative solutions to complex challenges (Bransford & Donovan, 2004). By equipping students with these vital competencies, Africa can cultivate a vibrant ecosystem of entrepreneurship and technological advancements, thereby propelling economic growth and social transformation. Many African countries face pressing issues such as food insecurity, healthcare accessibility, and environmental sustainability. STEM education empowers individuals to tackle these challenges through scientific research, technological innovations, and data-driven decision-making.

Effective STEM education can lead to breakthroughs in sustainable agriculture, renewable energy, and disease prevention, ultimately improving the quality of life for communities across the continent (Bruno & Dell'Aversana, 2018). As the global economy continues to evolve, STEM skills are becoming increasingly valuable across various industries. By investing in STEM education, African nations can equip their workforce with the knowledge and expertise needed to thrive in emerging fields like artificial intelligence, biotechnology, and renewable energy. This alignment with market demands will enhance economic competitiveness and attract foreign investment, fostering sustainable development.

PhET simulations, which offer interactive and engaging virtual environments for students to explore scientific concepts, visualize abstract phenomena, and conduct experiments in a risk-free and cost-effective manner, play a pivotal role in enhancing STEM education (Claiborn & Gemberg, 2014). Many STEM concepts, such as atomic structures, electromagnetic fields, and chemical reactions, can be challenging to comprehend through traditional teaching methods. PhET simulations provide vivid visualizations and animations, enabling students to grasp abstract ideas more effectively and develop a stronger conceptual understanding. By allowing students to explore, experiment, and formulate hypotheses within simulated environments, PhET simulations foster inquiry-based learning. PhET simulations are particularly valuable in quickly establishing conceptual understanding, promoting learning, and compensating for the lack of actual laboratory equipment in classrooms (Banda & Nzabahimana, 2021). This approach encourages critical thinking, problem-solving, and scientific reasoning skills, equipping students with essential skills for STEM disciplines and future careers.

To fully leverage the potential of PhET simulations in African classrooms, it is crucial to build teachers' capacity and provide them with the necessary training and support. Organizing professional development workshops focused on effectively integrating PhET simulations into STEM curricula is essential. These workshops should cover topics such as simulation pedagogy, lesson planning, and assessment strategies, empowering teachers to utilize these tools effectively in their classrooms. Raufman and Rauve (2020) emphasized that teachers in developing countries should be guided on how to write lesson plans that seamlessly incorporate PhET simulations, aligning them with specific learning objectives and national curriculum standards. By integrating simulations into their teaching practices, educators can create more dynamic and engaging learning experiences for their students.

Establishing communities of practice and knowledge-sharing platforms can facilitate collaboration among STEM teachers across different regions and schools. These platforms allow teachers to exchange best practices, share lesson plans, and provide peer support, fostering continuous professional growth and innovation in STEM teaching.

Implementing PhET simulations in African schools requires a comprehensive approach that addresses various challenges and considerations. Ensuring access to reliable internet connectivity and appropriate hardware infrastructure is crucial for the successful implementation of PhET simulations. Strategies such as investing in internet infrastructure, providing computer labs or mobile devices, and exploring offline solutions should be explored to overcome these challenges.

To enhance the relevance and impact of PhET simulations, it is essential to contextualize them to local environments and real-world examples that resonate with African students. This can be achieved by incorporating culturally relevant scenarios, local case studies, and contextual applications within the simulations or accompanying lesson plans. Implementing PhET simulations should be accompanied by ongoing support and evaluation mechanisms. Providing technical support, facilitating peer-learning networks, and regularly assessing the impact on student learning and engagement can help identify areas for improvement and ensure the effective integration of these simulations into STEM education.

Integrating PhET simulations into STEM education in African schools has the potential to significantly impact student engagement, achievement, and career aspirations. By leveraging the interactive and visual nature of PhET simulations, students can develop a deeper interest and understanding of STEM subjects. This increased engagement and comprehension can lead to improved academic performance and a stronger foundation for pursuing STEM-related fields. Exposure to cutting-edge simulations and inquiry-based learning experiences can inspire students to pursue STEM careers and contribute to advancing scientific research and innovation. This can foster a thriving ecosystem of STEM professionals and researchers in Africa, driving progress across various sectors.

As the adoption of PhET simulations gains momentum, efforts should be made to scale and sustain these initiatives across African nations. Collaboration among governments, educational institutions, and international organizations can facilitate the sharing of resources, best practices, and funding opportunities, ensuring the long-term sustainability and impact of these efforts. By investing in STEM education through the integration of PhET simulations, African nations can unlock the potential of their youth, cultivate a skilled workforce, and contribute to solving global challenges through scientific and technological advancements. The extent to which teachers are prepared to teach STEM subjects using PhET simulations in secondary schools can vary significantly based on several factors. Teachers need specific training to integrate PhET simulations into their curriculum. This includes understanding the simulations themselves and pedagogical strategies for using them to enhance learning.

Professional development programs can help teachers become familiar with the range of simulations available and how to align them with their curriculum. Professional development programs are essential for helping teachers integrate technology into their curriculum effectively. These programs provide educators with the necessary skills and knowledge to utilize various educational simulations and tools. Access to reliable technological resources, such as computers and internet connections, is crucial for the successful implementation of these tools in the classroom (Darling-Hammond et al., 2017).

Teachers must have access to the necessary technological resources, including computers or tablets and reliable internet connections, to use PhET simulations in the classroom. In addition, schools must support these resources to ensure consistent access for all students. Teachers need to understand how PhET simulations align with their specific STEM curriculum standards and learning objectives. This requires familiarity with both the content of the simulations and the curriculum requirements. Teachers who are more comfortable and experienced with technology are likely to be more prepared to use PhET simulations effectively. This includes familiarity with general classroom technology as well as specific software and tools used for simulations.

Collaboration with other teachers and support from the administration can enhance preparedness. Teachers can share best practices, resources, and strategies for integrating simulations into their teaching. Teachers need to develop effective pedagogical strategies for using simulations, such as integrating them into lessons, facilitating student exploration, and using them for formative assessment. Understanding how to use simulations to foster inquiry-based learning, critical thinking, and problem-solving is crucial. Teachers must be prepared to use simulations to engage diverse learners and differentiate instruction. This includes adapting simulations for different learning styles and needs. Teachers often face time constraints in their teaching schedules, making it challenging to integrate new tools and strategies. There can be significant variability in teacher preparedness within and across schools, often influenced by disparities in access to professional development and resources. Technical issues with computers, software, or internet connectivity can hinder the effective use of simulations.

Providing more targeted and continuous professional development opportunities focused on the use of PhET simulations and ensuring equitable access to the necessary technological resources across all secondary schools is urgently needed. Geelan and Fan (2014) stated that developing clear guidelines and resources that help teachers align PhET simulations with their curriculum is essential, while establishing support networks and communities of practice for teachers to share experiences and strategies. Teachers may not have received sufficient training on how to use PhET simulations in their lessons. Aligning PhET simulations with specific learning objectives and standards can be challenging. Evaluating the preparedness of teachers to use PhET simulations in teaching STEM subjects involves understanding various factors and addressing the challenges to create a supportive environment for effective STEM education. PhET simulations offer dynamic and interactive ways to engage students in STEM subjects. However, their integration into the secondary school curriculum can present several challenges for teachers. Not all schools have adequate access to computers or tablets, reliable internet, or updated software needed to run PhET simulations.

Another major issue with internet availability is technical issues, including glitches, crashes, or slow loading times that can disrupt lessons and cause frustration for both teachers and students. Some teachers might feel uncomfortable or lack confidence in using digital tools, which can hinder their ability to incorporate these simulations effectively. Teachers need to ensure that these technologies fit seamlessly into the existing curriculum and address the required learning objectives (Samphina Academy, 2023).

Designing assessments that effectively measure student understanding gained from PhET simulations can be difficult. Preparing lessons that incorporate PhET simulations can be time-consuming. Teachers need to familiarize themselves with the simulations, design appropriate activities, and ensure that they align with learning objectives. Fitting simulations into an already packed class schedule can be challenging, especially if there are strict curriculum requirements and limited time (Moore, Smith, & Randall, 2016). Teachers may struggle to find time for collaborative planning with colleagues to share ideas and strategies for using PhET simulations effectively. It can be challenging for teachers to monitor student progress and provide timely feedback during and after the use of simulations. Ziya'ulhaq (2021) agreed that students must remain accountable and engaged during independent or group work with simulations, which can be difficult without proper oversight from STEM teachers. Therefore, a multifaceted approach is necessary to prepare teachers for the integration of PhET simulations into the STEM curriculum.

METHODOLOGY

This section highlights the research design, population, sampling, an instrument used, validity and reliability, statistical treatment of data, and ethical consideration.

Research Design

This study adopted a descriptive survey research design. According to Apu, (2020) survey design is use to systematically collect data about a group of individuals who have same characteristics using questionnaires, etc., concerning participants responses on facts, opinions, attitudes etc. This enables researchers to study teachers from the forgoing assertion, the factors affecting teachers' capacity to teach STEM with PhET simulations in Nigeria.

Population

The population of the study was all secondary schools science teachers in Ido Local Government, Ibadan.

Sampling

From the population, ten public secondary schools were selected purposively based on the availability of computer laboratories and from each school, six (6) teachers were selected totaling sixty (60) teachers who were used as the sample size for the study.

Instrumentation

The instrument for data collection was a twenty-four (24)-item questionnaire developed by the researchers, title: STEM Teachers'& PhET Simulations (STEMT & PhETSIMS). STEMT & PhETSIMS is divided into two parts, I and II. Part I comprises of information on the personal data of the teachers used for the study while part II has statements in which the teachers are required to indicate their agreement or disagreement on teachers' capacity to teach STEM with PhET Simulations.

Validity and Reliability

Four experts in the department of Science & Environmental Education and a lecturer in department of Educational Foundation, University of Abuja, Nigeria, validated the instrument. Their corrections and inputs were accepted and this led to the modification of the questionnaire before administration of items. Internal consistency of the items was established using Cronbach alpha technique, which gave a coefficient of 0.85, suitable score for the study.

Data Collection Method

Sixty copies of the questionnaire were distributed and collected on the spot with the help of five research assistants but ten copies were mutilated, thus discarded, and fifty copies were used for the study.

Data Analysis

The research adopted the 4-point rating scale of strong Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD) to analyze data obtained from teachers. These have the values of 4,3,2,1 respectively; the data collected was analyzed using mean and standard deviation. The criterion mean was placed at 2.50 for agreement, while score below 2.50 means disagreement.

Ethical Consideration

Afore going to the field to collect data, we visit the schools with letter of introduction to the Principals of the four schools requesting permission to conduct research in their schools. Afterward we obtained the permission, the Vice-Principal Administration introduce us to other teachers for further introduction and process. Then we informed then about the research and fixed a date that we administered the questionnaire.

Results

Research Questions 1: To what extent do teachers prepared to teach STEM subjects with PhET Simulation in schools?

S/N	ITEMS	X	SD	DECISION
1.	Teachers are familiar with the PhET Simulation tool and they are implementing it in their classrooms.	2.42	0.92	Disagree
2.	Teachers are confident in their ability to integrate PhET Simulations into their STEM lesson plans.	2.28	0.88	Disagree
3.	Teachers are proficient in using the technology required to run PhET Simulations in teaching STEM subjects.	2.15	0.81	Disagree
4.	There are support or resources available to teachers who may struggle with the technical aspects of PhET Simulations in teaching STEM subjects.	2.34	0.89	Disagree
5.	There are ongoing professional development opportunities provided to teachers to enhance their use of PhET Simulations in teaching STEM.	2.00	0.74	Disagree
6.	Teachers regularly collaborate with colleagues to improve their use of PhET Simulations in teaching STEM subjects.	1.98	0.69	Disagree
7.	Teachers' teaching strategies in STEM subjects do employ maximize student engagement with PhET Simulations.	2.10	0.75	Disagree
8.	Teachers easily address varying levels of students' familiarity with technology when teaching STEM subjects with PhET Simulations.	2.10	0.75	Disagree
9.	Teachers have sufficient access to the technology (computers, tablets, and internet) necessary to effectively use PhET Simulations in their STEM classrooms.	2.10	0.75	Disagree

10.	There are pedagogical strategies that teachers employ when using PhET Simulations in their STEM instructions.	2.00	0.74	Disagree
11.	Teachers can assess the effectiveness of PhET Simulations in improving student understanding of STEM concepts.	2.15	0.81	Disagree
12	There are ways for teachers to encourage student engagement and interaction during lessons that involve PhET Simulations in teaching STEM lessons.	2.15	0.81	Disagree
	Grand Total	**2.15**	**0.80**	**Disagree**

From table 1, twelve (12) items on the instrument relating to the extent teachers prepared to teach STEM subjects with PhET Simulation in secondary schools were all disagreed with as they scored below 2.50 criterion reference point. With the grandt mean of 2.15 and standard deviation of 0.80 showed that teachers disagreed with their extent of preparedness to teach STEM subjects with PhET Simulation in secondary schools, in Ido Local Government, Ibadan.

Research Question 2: How do PhET simulations aligned with STEM learning objectives present challenges to secondary school teachers?

S/N	ITEMS	X	SD	DECISION
1.	Teachers find it difficult to integrate PhET simulations with existing STEM curricula.	3.15	0.65	Agree
2.	There are challenges that secondary schools teachers face in mastering the use of PhET simulations in STEM classrooms.	2.98	0.97	Agree
3.	Teachers confront challenging to keep students engaged during PhET simulations in teaching STEM subjects.	3.45	0.56	Agree
4.	Teachers manage the additional time required to incorporate PhET simulations into STEM lessons.	2.10	0.75	Disagree
5.	There are sufficient training for teachers to effectively use PhET simulations to teach STEM subjects.	2.00	0.74	Disagree
6.	Teachers have access to technical support for using PhET simulations to teach STEM subjects.	2.00	0.74	Disagree
7.	Teachers can manage challenges arise from STEM classroom during the use of interactive simulations like PhET.	2.15	0.81	Disagree
8.	Teachers use PhET simulations to cover the depth of content required for secondary STEM subjects.	2.42	0.92	Disagree
9.	PhET simulations are flexible to adapt in different teaching styles and student needs in STEM classroom.	2.42	0.92	Disagree

10.	Teachers do face challenges in ensuring that PhET simulations meet desired STEM learning outcomes in secondary schools.	3.15	0.65	Agree
11.	Teachers encounter technological limitations that may prevent them to effectively use PhET simulations in teaching STEM subjects.	3.80	0.54	Agree
12.	PhET simulations enhance or hinder the achievement of specific STEM learning objectives in secondary education	2.00	0.74	Disagreed
	Grand Total	2.64	0.75	Agreed

Results in table 2 indicated that the respondents agreed by items 1, 2, 3, 10 & 11 with mean value above 2.50, while items 4, 5, 6, 7, 8, 9 & 12 were below the criterion mean 2.50 and the respondents disagreed with them.

Discussion

Results from table 1 revealed the extent to which teachers prepared to teach STEM subjects with PhET Simulation in secondary schools. These include teachers' familiarity with the PhET Simulation tool and it implementation, confidence in their ability to integrate PhET Simulations into their STEM lesson plans, proficiency in using PhET Simulations in teaching STEM subjects. Avaliabity of technical support for teachers to teach STEM subjects with PhET Simulation, teachers' professional development and the use of PhET Simulation to teach STEM. Collaboration and the use of PhET to teach STEM subjects, teachers' teaching strategies and engagement with PhET Simulations, access to the technology (computers, tablets, and internet) and the use of PhET Simulations to teach STEM subjects. Teachers' pedagogical strategies and the use PhET Simulations to teach STEM, teachers' effective use of PhET simulation to improve students' understanding in STEM concepts, students engagement and interaction of PhET by teachers encouragement, were those factors disagreed by teachers towards their preparation to teach STEM subjects with PhET Simulation in secondary schools. The above findings is in line with the work of Darling-Hammond el al., (2017) who agreed that professional development programs can help teachers become familiar with the range of simulations available and how to align them with their curriculum. Thus, for teachers to be prepared to teach STEM subjects with PhET Simulation in secondary school they need to be trained and retrained. That is, teachers require guidance on their readiness to prepare them to teach STEM subjects with PhET Simulation in secondary schools.

Results from table 2 showed teachers' agreement with how PhET simulations aligned with STEM learning objectives present challenges to secondary school teachers. Teachers agreed with factors such as: Difficulty situation to integrate PhET Simulation to existing STEM curricula, challenges to use of PhET simulations in STEM classrooms, confront challenges to engage students with the PhET simulations in teaching STEM subjects, face challenges in ensuring that PhET simulations meet desired STEM learning outcomes in secondary schools, encounter technological limitations. These factors are in agreement with the study of Moore, Smith, & Randall, (2016) who said that fitting simulations into the already packed class schedule could be challenging, especially if there are strict curriculum requirements and limited time. This indicates that adequate' attention should be given to teachers in order to teach them how to align PhET simulations to STEM learning objectives in secondary schools. Professional development programs can help teachers become familiar with the range of simulations available and how to align them with their curriculum (Darling-Hammond et al., 2017). Also, Ziya'ulhaq, (2021) agreed that students must remain accountable and engaged during independent or group work with simulations and this can be difficult without proper oversight for STEM teachers. Thus, teachers really need a multifaceted approach to get them ready for integration of PhET simulation into STEM curriculum. Thereby, teachers disagreed with factors such as manage the additional time required to incorporate PhET simulations into STEM lessons, sufficient training for teachers to effectively use PhET simulations to teach STEM subjects, access to technical support for using PhET simulations to teach STEM subjects, can manage challenges arise from STEM classroom during the use of interactive simulations like PhET. Use PhET simulations to cover the depth of content required for secondary STEM subjects, PhET simulations are flexible to adapt in different teaching styles and student needs in STEM classroom, and PhET simulations enhance or hinder the achievement of specific STEM learning objectives in secondary education. Teachers' disagreement with the above factors showed that teachers need more enlightenment on how to align PhET simulations with STEM learning objectives. Some of the present items in the questionnaire are those challenges that confronted secondary school teachers with the alignment of PhET of Simulation to STEM learning objectives. Moreover, there should be urgent intervention to help teachers in these areas, this aligns with Geelan and Fan (2014) who's stated that developing clear guidelines and resources that help teachers align PhET simulations with their curriculum is essential. While establishing support networks and communities of practice for teachers to share experiences and strategies. Also, Raufman and Rauve. (2020) asserted that teachers in developing should be guided on how to write lesson plans that seamlessly incorporate PhET simulations, aligning them with specific learning objectives and national curriculum standards. While Ziya'ulhaq, (2021) stated that when teachers possess a strong sense of confidence in their ability to implement technology-aided lessons, they are more likely to adopt and sustain the use of tools like simulations. It obvious that teachers are ready to align PhET simulations with STEM learning objectives but inherent challenges may deter them to do so. This means that teachers need necessary assistance on how to align PhET simulations with STEM learning objectives in secondary schools.

Conclusion

The study focused on building teachers' capacity to teach STEM using PhET simulations in Nigeria. The findings revealed that while teachers agreed with some factors related to their capacity to teach STEM with PhET simulations, they disagreed with others. The study also concluded that while some teachers recognized challenges in aligning PhET simulations with STEM learning objectives, others did not. Overall, the study found that secondary school teachers in Nigeria need further training to enhance their capacity to teach STEM using PhET simulations. Overall, the study found that secondary school teachers in Nigeria need further training to enhance their capacity to teach STEM using PhET simulations.

Recommendations

Based on the findings of the study, the following recommendation were made:

1. The government at all levels and other relevant stakeholders should provide platforms for continuous training on PhET simulations for STEM teachers across the country.
2. Additionally, the necessary equipment and resources should be provided to ensure the smooth implementation of PhET simulations in STEM teaching.
3. Technical support should be made available to teachers to assist them in effectively using PhET simulations in their STEM instruction.
4. Workshops, conferences, and seminars should be organized and sponsored to allow teachers to share ideas, collaborate with their colleagues, and gain insights from experts on the use of PhET simulations in STEM education.

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