UNIJERPS
Unizik Journal of Educational Research and Policy Studies VOL.21 (2);
January-June, 2026 https://unijerps.org
2023 Impact Factor: **6.834;** 2022 ***Impact Factor***: 5.156; ***2021 Impact Factor: 5.641;***
2020 Impact Factor: 5.355. *Indexing and Impact Factor URL: http://sjifactor.com/passport.php?id=21363*

A STUDY OF PHYSICS TEACHERS' ATTITUDE TOWARD DIGITAL SIMULATIONS IN LABORATORY-DEFICIENT SECONDARY SCHOOLS IN ZARIA, KADUNA STATE, NIGERIA

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ABSTRACT

Secondary schools in developing nations face severe structural constraints in delivering practical science education due to deficient laboratory infrastructure. While digital simulations offer a scalable alternative to physical experimentation, successful deployment remains heavily dependent on instructor acceptance. This study investigated physics teachers' attitudes toward integrating digital simulations within laboratory-deficient secondary schools in the Zaria Education Zone, Kaduna State, Nigeria. Specifically, it examined the effects of perceived usefulness on teacher attitudes, the predictive capacity of these attitudes on adoption willingness, and the impact of infrastructural deficits. Utilizing a descriptive census survey design, data were collected from the entire population of physics educators (N = 39) across regional secondary schools using the validated 20-item Digital Simulation Attitude and Adoption Questionnaire (DSAAQ). Data were analyzed using descriptive statistics and linear regression modeling. Educators exhibited highly favorable attitudes toward digital tools (M = 4.61, SD = 0.55). Linear regression confirmed that perceived usefulness significantly predicted positive attitudinal shifts (β = .528, p = .001), accounting for 27.9% of attitudinal variance (R^2 = .279$). Concurrently, positive attitudes significantly predicted teachers' willingness to adopt virtual modules (\beta = .453, p = .004, R^2 = .205). However, a lack of technological infrastructure exerted a powerful negative effect on adoption willingness (β= -.641, p < .001), explaining 41.1% of the structural variance (R^2 = .411). Although secondary school physics teachers are highly motivated and possess positive psychological orientations toward digital simulation integration, systemic infrastructure deficits act as a critical bottleneck to practical implementation.

Keywords: Physics Education, Digital Simulations, Technology Acceptance Model, Laboratory-Deficient Schools, Educational Infrastructure.

Introduction

Science education plays a crucial role in national development, particularly in fostering scientific literacy, innovation, and technological advancement. Among science subjects, physics occupies a central position because it provides foundational knowledge for engineering, technology, and applied sciences (Osborne & Pimentel, 2023). However, the effective teaching of physics depends heavily on practical laboratory experiences that enable students to observe,

test, and apply scientific principles. Experimental activities allow learners to develop scientific inquiry skills, conceptual understanding, and problem-solving abilities (Marino, 2026; Muzammil & Muhammad, 2025). Educational theorists such as John Dewey emphasized that meaningful learning occurs when students actively engage in experiential and inquiry-based activities rather than relying solely on theoretical instruction (De et al., 2025).

Despite the recognized importance of laboratory activities in physics education, many secondary schools in developing countries face severe constraints in providing adequate laboratory facilities. In Nigeria, several studies have reported that many secondary schools lack functional laboratories, modern equipment, and adequate instructional resources for effective physics teaching (Mustari, 2025). This situation is particularly evident in public secondary schools located in resource-constrained regions such as Kaduna State. Laboratory-deficient environments limit opportunities for students to conduct experiments and visualize abstract physical concepts, which may contribute to poor academic performance and reduced interest in physics. Reports by the Federal Ministry of Education Nigeria and the West African Examinations Council have consistently indicated relatively low achievement levels in physics examinations among secondary school students, partly attributed to inadequate practical exposure (Sani et al., 2026).

Recent advancements in educational technology have introduced digital tools that can support science teaching in resource-limited environments. One promising innovation is the use of digital simulations**,** which allow students to explore virtual experiments, manipulate variables, and visualize complex physical processes in an interactive environment (Badmus et al., 2026). Simulation-based learning environments have been shown to enhance conceptual understanding and facilitate inquiry-based learning when traditional laboratory resources are unavailable (Ajayan et al., 2025).

A growing body of research suggests that digital simulations can serve as effective alternatives or supplements to traditional laboratory experiments in science education (Koç & Kanadlı, 2025). Studies using platforms such as PhET Interactive Simulations demonstrate that interactive simulations can improve students' conceptual understanding of physics concepts such as electricity, motion, and wave phenomena (Solihat et al., 2025). Digital simulations enable learners to visualize invisible processes, manipulate experimental parameters, and repeat experiments without the limitations associated with physical laboratory equipment (Pribadi et al., 2025).

Nevertheless, the successful integration of digital simulations into classroom practice depends largely on teachers' attitudes, perceptions, and willingness to adopt technological innovations. Teachers play a

critical role in selecting instructional tools, designing learning activities, and facilitating students' engagement with technology-enhanced learning environments. Research in educational technology indicates that positive teacher attitudes toward digital tools significantly influence their adoption and effective use in classroom instruction (Lademann et al., 2026).

While expanding literature highlights the benefits of computer-aided science modeling, contemporary educational technology research remains fundamentally student-centric, focusing heavily on learning outcomes rather than the pedagogical perspectives of implementation agents. This empirical void is particularly acute within sub-Saharan diagnostic ecosystems, such as the Zaria Education Zone of Kaduna State, where acute infrastructure shortfalls make technological substitution highly necessary. Consequently, targeting physics educators in these specific laboratory-deficient environments addresses a vital blind spot: understanding how resource depletion shapes a teacher's baseline technology acceptance behaviour.

This study addresses this gap by examining physics teachers' attitudes toward the use of digital simulations in laboratory-deficient secondary schools in Zaria, Kaduna State, Nigeria. The study is informed by principles of technology integration in education and behavioural perspectives that emphasize the role of teachers' attitudes in shaping instructional practices. In particular, the study draws on the Technology Acceptance Model, which suggests that individuals' acceptance of technology is influenced by perceived usefulness and perceived ease of use.

Digital simulations provide opportunities for teachers to demonstrate complex physics concepts through visual and interactive representations, thereby compensating for the lack of physical laboratory equipment. By enabling students to conduct virtual experiments and observe dynamic physical processes, simulation-based learning environments can support conceptual understanding and inquiry-based learning. However, the effectiveness of such tools largely depends on teachers' willingness to integrate them into classroom instruction.

Using a quantitative research design, this study investigates physics teachers working in laboratory deficient secondary schools in Zaria. Data are collected using structured questionnaires to assess teachers' attitudes toward digital simulations and their perceptions of the usefulness of these technologies for teaching physics concepts.

Research Objectives

The study aims to:

1. Examine physics teachers' attitudes toward the use of digital simulations in laboratory-deficient secondary schools.
2. Determine the influence of perceived usefulness of digital simulations on physics teachers' attitudes toward their use in teaching physics concepts.

3. Assess the influence of teachers' attitudes on their willingness to adopt digital simulations for physics instruction.
4. Identify challenges affecting the integration of digital simulations in laboratory-deficient schools.

Research Questions

1. What are physics teachers' attitudes toward the use of digital simulations in laboratory-deficient secondary schools?
2. How does the perceived usefulness of digital simulations influence physics teachers' attitudes toward their use in teaching physics concepts?
3. How do physics teachers' attitudes influence their willingness to adopt digital simulations for physics instruction?
4. What challenges affect the integration of digital simulations in laboratory-deficient secondary schools?

Research Hypotheses

H1: Perceived usefulness of digital simulations significantly influences physics teachers' attitudes toward their use.

H2: Physics teachers' attitudes significantly predict their willingness to adopt digital simulations for teaching physics.

H3: Lack of technological infrastructure significantly affects the willingness to adopt digital simulations in secondary schools.

Methodology

Research Design

The study used a descriptive survey research design, which is suitable for systematically collecting quantitative data on teachers' attitudes, perceptions, and barriers related to the use of digital experimentation tools in secondary school physics instruction. This design is appropriate because it allows the researcher to analyze existing conditions without changing variables, enabling valid generalizations to the target population. The population of this study comprises physics teachers in secondary schools located in Zaria, Kaduna State, with a total of thirty-nine (39) teachers.

In this study, the entire population was used as the sample size. This approach, known as a census survey, is appropriate when the population is small and accessible, ensuring comprehensive data collection without the risk of sampling bias (Creswell, 2014). Using the whole population eliminates errors associated with sampling techniques and provides a complete representation of the study group. According to Saunders, Lewis, and Thornhill (2019), using a full population sample is particularly beneficial when the study aims for in-depth analysis and precise conclusions applicable to the entire group. Therefore, this study adopts a census approach to ensure the accuracy and generalizability of the results. A structured questionnaire was used to collect data for a study on physics teachers' Attitudes toward Digital Simulations in Laboratory-Deficient Secondary Schools in Zaria, Kaduna State, Nigeria. The instrument titled "Digital

Simulation Attitude and Adoption Questionnaire (DSAAQ)", is a 20-item design questionnaire, utilizing a five-point Likert scale with responses ranging from Strongly Agree (SA) to Strongly Disagree (SD), including Agree (A), Undecided (UN), and Disagree (D). It is divided into four sections (A-D). Section A contains the biodata of the respondents, while Section B contains questions on the attitudes of physics teachers towards the use of digital simulation. Section C examines the willingness of physics teachers to use Digital Simulation Learning in improving students' understanding of physics. Section D addresses questions related to the challenges that physics teachers face in integrating digital simulation learning into physics instruction. The instrument was validated by three experts from the Science Education Department at Ahmadu Bello University, Zaria, and the Federal University of Education, Zaria. All corrections and observations made on the instrument were incorporated before administering it to the respondents.

A pilot was conducted in one of the senior secondary schools within the population of the present study but not part of the sample selected. The pilot test was done to familiarize the researcher with the feasibility and workability of the instrument that is the Digital Simulation Attitude and Adoption Questionnaire (DSAAQ). Other reasons for the pilot testing were to determine the appropriateness of the length of time required to take the test, determine the correctness of the workings of the instruments and to identify problems or difficulties that the subjects may encounter with the view of eliminating them in the final copy of the instruments.

To evaluate the psychometric properties of the Digital Simulation Attitude and Adoption Questionnaire (DSAAQ), internal consistency was determined via Cronbach's alpha coefficient, while temporal stability was established using a test-retest configuration analyzed via Pearson's Product Moment Correlation Coefficient (PPMC). The researcher obtained a letter of introduction from the university to the Ministry of Education, Science and Technology, Zaria Zone, Kaduna State, seeking permission to visit various schools in the study area and administer the questionnaire to the respondents. The questionnaire was personally distributed by the researchers in the selected schools. Thirty (30) minutes was given to respondents to complete the questionnaire, and it was collected on the spot to ensure a higher response rate. Respondents were assured of confidentiality, and the entire data collection process took two (2) weeks. The data collected from the field was analyzed using descriptive statistics, including frequencies, simple percentages, mean, and standard deviation. These statistical tools helped summarized and effectively interpret the data. The analysis provided a clear understanding of the trends and patterns related to the research questions.

Results

Research Question One: What is physics teachers' attitude toward the use of digital simulations in laboratory-deficient secondary schools?

In answering the research question, the responses of physics teachers to the attitudinal scale regarding the use of digital simulation were analyzed using mean and standard deviation, with the result presented in Table 1.

Table 1: *Descriptive Statistics of Physics Teachers' Attitudes Toward Digital Simulations (TATDS)*

SN	Item	Mean	Std. Deviation	Remark
1	I enjoy using digital simulations when teaching physics concepts.	4.44	0.50	SA
2	Digital simulations make physics teaching more effective in laboratory-deficient schools.	4.51	0.51	SA
3	I feel confident integrating digital simulations into my classroom instruction.	4.38	0.88	SA
4	Using digital simulations enhances my professional teaching performance.	4.79	0.52	SA
5	I am willing to adopt digital simulations as a regular instructional strategy.	4.92	0.35	SA
	TATDS	**4.61**	**0.55**	**SA**

Table 1 presents the descriptive statistics of physics teachers' attitudes toward the use of digital simulations in laboratory-deficient secondary schools. The results revealed that physics teachers generally exhibited a highly positive attitude toward the use of digital simulations, with an overall mean score of 4.61 (SD = 0.55), indicating strong agreement with the attitudinal statements. Among the items, the highest-rated statement was "I am willing to adopt digital simulations as a regular instructional strategy" (M = 4.92, SD = 0.35), suggesting that most teachers expressed a strong readiness to incorporate digital simulations into their teaching practices. This was followed by the perception that digital simulations enhance professional teaching performance (M = 4.79, SD = 0.52) and improve the effectiveness of physics teaching in laboratory-deficient schools (M = 4.51, SD = 0.51). Teachers also indicated that they enjoy using digital simulations when teaching physics concepts (M = 4.44, SD = 0.50) and felt confident integrating digital simulations into classroom instruction (M = 4.38, SD = 0.88). The findings indicate that physics teachers have a positive attitude toward the adoption of digital simulations and recognize their value as instructional tools for improving physics teaching in laboratory-deficient secondary schools.

Hypotheses Testing

Hypothesis 1: Perceived usefulness of digital simulations significantly influences physics teachers' attitudes toward their use.

Table 2: *Regression Analysis Predicting Physics Teachers' Attitude from Perceived Usefulness*

Predictor	B	SE	β	t	p
(Constant)	12.643	2.755		4.588	.000
Perceived Usefulness	.431	.114	.528	3.785	.001

Model Summary

R	R^2	Adjusted R^2	F	p
.528[a]	.279	.260	14.329	.001

Table 2 presents the regression analysis examining the influence of perceived usefulness on physics teachers' attitudes toward the use of digital simulations. The result showed that perceived usefulness significantly predicted teachers' attitudes toward digital simulations (β = .528, t = 3.785, p = .001). This indicates that teachers who perceive digital simulations as useful are more likely to develop positive attitudes toward their use in physics instruction. The model summary revealed that perceived usefulness accounted for 27.9% of the variance in teachers' attitudes toward digital simulations (R^2 = .279, Adjusted R^2 = .260). The regression model was statistically significant (F = 14.329, p = .001), indicating that it adequately explained variation in teachers' attitudes. Since the p-value was less than the 0.05 level of significance, hypothesis 1 was not rejected. Therefore, the perceived usefulness of digital simulations significantly influences physics teachers' attitudes toward their use in laboratory-deficient secondary schools.

Hypothesis 2: Physics teachers' attitudes significantly predict their willingness to adopt digital simulations for teaching physics.

Table 3: *Regression Analysis Predicting Willingness to Adopt from Teachers' Attitude*

Predictor	B	SE	β	t	p
(Constant)	10.489	4.340		2.417	.021
Attitude	.581	.188	.453	3.088	.004

Model Summary

R	R^2	Adjusted R^2	F	p
.453[a]	.205	.183	9.539	.004

Table 3 presents the regression analysis predicting teachers' willingness to adopt digital simulations from their attitudes toward the technology. The result revealed that teachers' attitudes significantly predicted their willingness to adopt digital simulations

for physics instruction (β = .453, t = 3.088, p = .004). This suggests that teachers with more positive attitudes toward digital simulations are more likely to express a willingness to adopt them as instructional tools. The model summary indicated that teachers' attitudes explained 20.5% of the variance in willingness to adopt digital simulations (R^2 = .205, Adjusted R^2 = .183). The regression model was statistically significant (F = 9.539, p = .004), indicating that attitude is a meaningful predictor of willingness to adopt. Given that the p-value was less than the established significance level of .05, hypothesis 2 was not rejected. Therefore, physics teachers' attitudes significantly predict their willingness to adopt digital simulations for teaching physics concepts.

Hypothesis 3: Lack of technological infrastructure significantly affects the willingness to adopt digital simulations in secondary schools.

Table 4: *Regression Analysis Predicting Willingness to Adopt from Lack of Technological Infrastructure*

Predictor	B	SE	β	t	p
(Constant)	27.611	.765		36.085	.000
Lack of Technological Infrastructure	-.523	.103	-.641	-5.082	.000

Model Summary

R	R^2	Adjusted R^2	F	p
.641[a]	.411	.395	25.828	.000

Table 4 presents the regression analysis examining the influence of the lack of technological infrastructure on physics teachers' willingness to adopt digital simulations in secondary schools. The result revealed that lack of technological infrastructure significantly predicted teachers' willingness to adopt digital simulations (β = −.641, t = −5.082, p < .001). The negative regression coefficient indicates an inverse relationship between the two variables, suggesting that increases in technological infrastructure deficiencies lead to decreases in teachers' willingness to adopt digital simulations for physics instruction. The model summary showed that lack of technological infrastructure accounted for 41.1% of the variance in teachers' willingness to adopt digital simulations (R^2 = .411, Adjusted R^2 = .395). This implies that technological infrastructure is a substantial factor influencing the adoption of digital simulations in laboratory-deficient secondary schools. The regression model was statistically significant (F = 25.828, p < .001), indicating that the predictor explained significant variation in teachers' willingness to adopt digital simulations. Since the probability value was less than the 0.05 level of significance, hypothesis 3 was not rejected. Therefore, the lack of technological infrastructure significantly affects physics teachers' willingness to adopt digital simulations in secondary schools. The finding suggests that inadequate access to technological resources, such as computers, internet connectivity, electricity, and digital devices, may hinder the successful adoption

and implementation of digital simulations in physics teaching. Consequently, improving technological infrastructure is essential for promoting the integration of digital simulations into science education, particularly in laboratory-deficient schools.

Discussion

Physics teachers in this cohort exhibited highly favorable attitudes toward digital simulations, explicitly recognizing them as viable countermeasures to physical laboratory resource deficiencies. This positive receptive baseline likely stems from the interactive, visual nature of modern simulations, which render abstract physics equations legible without dedicated physical apparatus. The result echoes Salame and Makki (2021), who found that implementing PhET simulations positively affected students' attitudes and learning outcomes in science education. Likewise, Rutten et al. (2012) reported that computer simulation can effectively facilitate science learning, particularly inquiry-based and exploratory learning. The finding also corroborates the findings of Badmus et al. (2026), which reported that physics teachers have embraced simulation technologies because of their ability to bridge the gap created by a deficiency in physics laboratories. Moreover, interactive simulations were shown to enhance students' learning of scientific concepts and foster computational thinking (Atalay & Mutlu, 2023). The positive attitude of teachers in this study indicates that the use of digital simulations is increasingly recognized as useful for enhancing physics learning in situations where learning resources are insufficient.

The finding revealed that perceived usefulness significantly influences physics teachers' attitudes toward using digital simulations. This means that teachers are more likely to have a positive attitude towards digital simulations when they believe that the technology will make teaching more effective, engender student engagement, and fill the gap left by the non-functioning laboratory. The discovery reinforces the idea that teachers' attitudes toward technology adoption and use are influenced by their perceptions of technology's educational value. This finding aligns with Ikwuka et al. (2024), who found that teachers' acceptance and use of digital technology in educational settings are strongly influenced by their attitudes towards it. Likewise, Lademann et al. (2026) reported that teachers' attitudes towards emerging technologies improve when they see the potential of these technologies to make teaching more effective and to improve their professional lives. The finding is also supported by Ajayan et al. (2025), who showed that interactive simulations can promote conceptual learning through scaffolded instructional activities, thereby making them more useful to educators. Furthermore, Zawacki-Richter et al. (2019) found that teachers are more likely to adopt technological innovations when they perceive instructional value. Hence, the strong relationship between perceived usefulness and teachers' attitudes indicates that it is important to demonstrate the

educational value of digital simulation so that teachers can accept and integrate it into physics learning.

The finding showed that physics teachers' attitudes significantly predict their willingness to adopt digital simulations for teaching physics concepts. Teachers who have positive attitudes toward digital simulations are more likely to use them in their teaching. A positive approach can positively lead to increased motivation, commitment and willingness to try new and innovative teaching methods. The study results indicate a need to pay attention to teachers' perceptions and attitudes toward digital simulations for successful implementation. This result aligns with Badmus et al. (2026), who reported that teachers' attitudes towards the integration of ICT have a significant impact on its use in the classroom, particularly when using simulation technologies. Likewise, Lademann et al. (2026) found that positive attitudes, learned from professional learning experiences, had a significant impact on teachers' readiness to use educational technologies. This finding is also in line with Mustari (2025), who stated that positive perceptions of the virtual laboratory environment motivate teachers to adopt technology-based teaching methods. Moreover, Koç and Kanadlı (2025) found that interactive learning has positive effects on education and makes teachers more innovative in their teaching methods. Thus, the discovery places strong emphasis on the role of training, exposure, and supportive mechanisms in fostering positive attitudes towards teachers and in supporting the use of digital simulations in physics education, so that they can be used continuously.

The finding revealed that the lack of technological infrastructure significantly affects physics teachers' willingness to adopt digital simulations in secondary schools. This indicates that, even though teachers may have positive attitudes towards the use of digital simulations and recognize their usefulness, insufficient technological facilities remain a key challenge for digital simulation. The supporting infrastructure needed for digital simulations includes computers, electricity and power supply, internet connection, projectors, and appropriate software applications. If these resources are unavailable or limited, teachers may be discouraged from adopting simulations in their teaching. This discovery aligns with Nirmani (2025), who found technological barriers to be the major challenges to technology adoption and digital participation in developing countries. Likewise, Muzammil and Muhammad (2025) found that the lack of laboratory and technological facilities is still an obstacle to the effective teaching of science in secondary schools. The finding also corroborates the findings of Ngozi and Halima (2015) that inadequate provision of laboratory facilities negatively affects science teaching and students' academic performance. Moreover, Badmus et al. (2026) noted that the readiness of infrastructure in physics classrooms is a key factor in the successful integration of ICT. It highlights the importance of governments, educational stakeholders, and school

administrators to invest in school technological infrastructure to facilitate teachers' use of digital simulations as alternatives to traditional laboratory experiences.

Conclusion

The study provides important evidence concerning how secondary school physics teachers utilize technology acceptance when using physical laboratory facilities constraints. The study indicates high positive attitudes toward digital simulations indicating high receptive use of technology. This shows the readiness of teachers to bypass long-standing laboratory shortages and elevate overall physics teaching quality.

Recommendations

Based on the empirical insights investigated in this study, the following are recommended:

1. Kaduna State ministry of education and other relevant stakeholders must prioritise outfitting secondary schools in Zaria local government.
2. Due to unreliable internet connectivity which severely limits web-based tools, school authorities should deploy fully offline pre-installed educational suits such as localized PhET interactive libraries.
3. Educational authorities should launch mandatory teacher training workshops that move past basic literacy among physics teachers in secondary schools in Zaria local government.
4. There should be integration of virtual and digital simulation models into the secondary school physics curriculum by the Nigerian Educational Research and Development Council.

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