Walden University

College of Education and Human Sciences

This is to certify that the doctoral study by

Hemamalini Srinivasan

has been found to be complete and satisfactory in all respects,
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Abstract

Nigerian Secondary Physics Teachers' Perceptions of Factors That Challenge

Information and Communication Technology Integration

by

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MSc, Manonmanium Sundaranar University, 1996

BSc, Manonmanium Sundaranar University, 1994

Project Study Submitted in Partial Fulfillment

of the Requirements for the Degree of

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Abstract

Challenges to integrating technology into educational institutions pose a significant issue that impacts students' performance and accomplishments. The research problem addressed through this study was that secondary school physics teachers were challenged to integrate information and communication technology (ICT) in a southwestern state of Nigeria. The purpose of this basic qualitative study was to explore secondary physics teacher perceptions of the factors that challenged ICT integration in the southwestern state of Nigeria, so that schools could be provided with research-deduced recommendations to take informed steps forward toward developing technology-integrated student-centered pedagogies. In this study, the unified theory of acceptance and use of technology served as the conceptual framework. Research questions were rooted in the conceptual framework consisting of four percepts: effort expectancy, performance expectancy, social influences, and facilitating conditions, all of which collectively influence teachers' adoption of technology in classroom teaching. The subjective sample was comprised of 12 participants who were secondary school physics teachers employed in a single school district. With a basic qualitative approach, data were gathered using an open-ended interview protocol. Subsequently, a thematic analysis of the collected data was conducted, focusing on each of the three research questions. The results of this study indicated how teachers' experiences and perceptions informed techniques to be adopted for effective ICT integration in physics education, in the target state. The outcomes of the study coupled with the planned professional development session for secondary school physics teachers in technology integration might result in positive change from more teachers integrating technology with efficacy and fidelity.

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Dedication

"The Soul is neither born nor does it die at any time. It does not come into being or cease to exist. It is unborn, eternal, permanent, and primeval. The Soul is not destroyed when the body is destroyed" (Bhagavad Gita 2.20).

In loving memory of my husband, Mohan Krishnaswamy, I dedicate this work of mine. You taught me the simple heuristic to respond and not react to situations. You have shown me that even when life doesn't move as expected or desired, it is worth cherishing. I am thankful to the Lord Almighty that we shared our time together, and I hold your memories dear.

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In expressing my sincere appreciation, I would like to acknowledge the unwavering support of my family. Their love has been a constant source of strength throughout this research endeavor, which marks the culmination of 3 years of online learning. For my children, sorry for not being there at your dance competitions and sports meets, for being grumpier than normal whilst I worked on my project study. For my mother, thanks for all the physical and mental support, without which my research journey would have ended a long time ago. I appreciate each of you for repeatedly guiding me toward the eventual resolution.

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Section 1: The Problem

This section encompasses the identification of a local problem in a southwestern state in Nigeria, featuring a description of the local context and the specific problem at hand. It also delves into the broader educational issue beyond the state under study and highlights a gap in educational practices. Additionally, it furnishes the rationale behind the study and outlines its purpose. This section also elucidates the research study's significance, presents the research questions, and proceeds with the literature review. Within this review, the literature pertaining to technology integration in the secondary school physics curriculum in Nigeria is discussed. The identified problem, its purpose, and the literature supporting the existence of the problem are summarized at the end of the section, after the concept that guided the study is proposed.

The Local Problem

The research problem addressed through this study was that secondary physics teachers were challenged to integrate information and communication technology (ICT) in a southwestern state of Nigeria. A first piece of local evidence that this problem exists was provided by Ifinedo and Kankaanranta (2021). Although the Nigerian national policy on education stresses the importance of ICT in improving student outcomes, lack of initiatives by administrators and effective strategies by secondary teachers have resulted in a struggle for technology integration in Nigerian classrooms (Ifinedo & Kankaanranta, 2021). Opeyemi et al. (2019) furnished the second piece of evidence in a case study of Nigerian teachers conducted on the barriers to integration of digital technologies in classrooms. Despite a strong interest among secondary students in embracing technology and the growing development of ICT tools, along with increased access to digital devices, the process of integrating and utilizing technological advancements within the Nigerian schooling system has not accelerated as rapidly as expected (Opeyemi et al., 2019). The existence of the research problem was further reiterated by Jimoh (2019). In many Nigerian schools, secondary-level teachers lack the necessary technological expertise to blend ICT into their pedagogy, compelling them to adhere to conventional chalk-and-duster teaching approaches (Jimoh, 2019).

A significant number of states in Nigeria have not fully embraced adoption of ICT tools for teaching, resulting in a limited influence of the initiatives aimed at ICT in the secondary school curriculum (Bolaji & Jimoh, 2023). This project study focused on a city in one such state in southwestern Nigeria where teachers faced challenges to integrating technology in the secondary school physics curriculum. This city comprises six education districts providing education to over 200,000 senior secondary school students. The pupil-qualified teacher ratio in public senior secondary schools reaches as high as 45, making it increasingly difficult for the teachers to practice conventional style teacher-centered pedagogy in the classrooms. The strategic integration of ICT within educational contexts can effectively enhance the pedagogical process for both educators and learners. This can be achieved through the improved delivery of instructional materials, supporting students' creativity and the cultivation of problem-solving skills (Bolaji & Jimoh, 2023). However, technology integration and adaptation to ICT tools to move away from teacher-subjugated teaching methods toward the newest educational system developments are far from having reached Nigerian public-senior secondary schools, according to the tutor-general permanent secretary of the state under study. Without addressing this problem, further deterioration in the students' outcomes in secondary school physics is possible.

Rationale

The application of technology in educational settings involves utilizing technological tools for information exchange and communication to inform and shape daily classroom teaching practices (Susanna, 2022). The expeditious growth in educational technology and the availability of technological tools have marked the onset of a new era in reshaping conventional teacher-centered pedagogical practices and shifting the global expectations for a learner-centered education system on educators (Langub, 2019). The Federal Republic of Nigeria's education policy (2013) identified these demands and issued guidelines to activate creative thinking and construct professional competence using current information technologies. However, according to the World Bank (2017), the education system in Nigeria is confronted with various challenges resulting in diminished quality of education, as assessed by students' academic achievements. The performance of secondary school students has been low to such an extent that higher education standards have substantially deteriorated (Birabil et al., 2020). New technologies and ICT integration in classroom practices can support students in securing a secondary school leaving certificate with good scores, further assisting them to gain admission into higher institutions of their choice.

Leveraging science and engineering education must be the critical driver of development in countries such as Nigeria, as the 21st-century workforce needs intensified technological skills (Fomunyam, 2019). Physics is the building block of STEM disciplines, and deep learning in secondary school correlates with securing a university degree in the STEM field (Fomunyam, 2019). Teaching and learning physics effectively in this digital era can be easily carried out using ICT tools and gadgets (Bogusesvshi et al., 2020). Unfortunately, physics teachers in Nigeria still teach using traditional methods that demand ICT integration into the senior secondary school physics curriculum. Despite the extensive advocacy for ICT-aided teaching and learning, there are challenges in integrating ICT to transform senior secondary school students' outcomes and equip them with the skills to face a world that is increasingly dependent on ICT-aided research productivity. The performance of the students at senior secondary schools in physics has been consistently poor and unpromising (National Bureau of Statistics, 2022), the significant factors for this being poor instructional material for teaching and learning. Teachers also experience low self-efficacy in integrating ICT-aided teaching methodologies due to inadequate training in handling ICT tools. This results in poor support for students' physics learning. The apprehension that teachers feel toward using computers presents difficulties, leading to limited ICT integration in teaching strategies (Awofala et al., 2019). Additionally, there is an inadequacy of professional development (PD) sessions and training programs to assist teachers in easing the difficulty in comprehending the concepts of physics (Samaila et al., 2021).

A global education monitoring report (UNESCO, 2020) documented that African school students, particularly in the field of science, specifically physics, have consistently demonstrated lower performance when compared to international benchmarks. This poor standard of science education in Nigeria results in decreased enrollment of students in technical vocational courses, indirectly affecting the country's economic development (Collins, 2018). Acknowledging that, teachers bear a broader responsibility in providing high-quality education to students, and this can be achieved by incorporating ICT into the learning environment, fostering the development of creative thinking in school students (Susanna, 2022). There is a need to identify the challenges teachers face in integrating ICT in physics education in secondary school classrooms. Consequently, the purpose of this research study was to explore secondary physics teachers' perceptions of factors that challenged integration of ICT in a southwestern state in Nigeria.

Definition of Terms

The following definitions clarify key terms used throughout this research:

Chalk-and-duster approach: A conventional approach to teaching where the instructional method is centered around the teacher, with emphasis on the teacher's voice (Khan, 2022).

Facilitating conditions: The extent of the user's perception of external factors that foster use of an educational technology (Kemp et al., 2019).

Information and communication technology (ICT): A technology platform that combines hardware and software functionalities, allowing for convenient retrieval of course materials, real-time information exchange, and collaborative learning experiences for teachers and students (Guzman et al., 2022).

Student-centered approach: Innovative and contextual pedagogy essentially involving students in interacting, collaborating, and discussing for knowledge construction and acquisition (Islam et al., 2022).

Teachers' perceptions: Comprehending a concept or an issue by means of the senses, insight, intuition, or personal experience that governs human behavior (Kennedy et al., 2023).

Technology barriers: Elements that restrain, test, or impede the adoption of technology-integrated pedagogies in instructional and educational experience or curricula (Xie et al., 2023).

Technology integration: The blending of technology in instructional delivery to facilitate learner-centered, self-directed learning and enhance students' analytical thinking and investigative abilities (Cheng et al., 2020).

Significance of the Study

Competency in physics constitutes the substratum of the development of science and technology in any country. Consequently, proficiency in physics should be given due importance during the secondary school years of aspiring students (Samaila et al., 2021). This study on challenges in ICT integration by secondary school physics teachers could offer valuable insights for school administrators and teachers. The state stands to benefit by recognizing the necessity for enhancing teachers' attitudes towards integrating ICT in their teaching strategies. The outcomes of the study could aid the school board to motivate physics teachers in developing classroom environments that inspire physics learning in secondary school students. The district administrators and board members of the schools may find this study fruitful in designing PD sessions for teachers to bring awareness about technology and impact teachers' technology usage in classrooms. This study may assist school authorities to realize the various challenges encountered by secondary teachers in blending technology and take appropriate action in overcoming them. This study may also assist teachers in planning technology-integrated pedagogies to enhance student achievements in secondary school physics.

Previous studies revealed the substandard performance of Nigerian students in physics courses due to poor teaching and learning resources, poor classroom didactics, and teacher-centered pedagogies (Agbele et al., 2020; Ugwuanyi & Okeke, 2020). Earlier research also suggested that incorporating technology can promote inquiry-based learning in physics, making the subject more practical and relevant to real-life situations (Ellermeijer & Tran, 2019), and can result in higher student outcomes compared to traditional teaching methodologies (Dasilva et al., 2019; Nggadas & Ariswan, 2019). I proposed to enhance comprehension regarding how Nigerian physics teachers perceive technological intervention and the associated challenges in this current research. By doing so, I intended to contribute insights into strategies that can effectively implement technology-driven teaching methods in the target state. The study's insights will be communicated to educational authorities and heads of schools in the state, highlighting the impact of teachers' perspectives on integrating ICT into physics education.

National educational authorities are making efforts to integrate technology into schools, but these efforts are not having a major positive effect on how teachers and students learn in classrooms (Awuor & Okono, 2022). Teachers in various African countries, including Nigeria, Kenya (Awuor & Okono, 2022), and Ghana (Ageyi & Ageyi, 2019), face challenges in blending ICT into their classrooms. Similarly, teachers in developed countries such as the United States face difficulties due to variations in schools, performance levels, contextual factors, and capacities of innovation (Makki et al., 2018). This research study may impact application of technology in physics classrooms across the globe. Positive social change is possible if state education authorities and school administrators allocate sufficient funds in educational technology and professional development of secondary school physics teachers to boost the confidence of teachers in technology use. The multitude of undesirable outcomes in secondary school final examinations in physics due to the immutable traditional teaching of abstract physics concepts will continue to prevail in the state if the problem studied is not addressed.

Research Questions

The purpose of this basic qualitative study was to explore secondary physics teachers' perceptions of factors that challenged ICT integration in a southwestern state in Nigeria. Integration of ICT is not just another way of teaching the concepts of physics but can make learning more relevant and linked to real life and instill self-directed learning in students (Ellermeijer & Tran, 2019). The secondary physics teachers of the state under study were unable to blend technology to its full potential. Drawing upon the unified theory of acceptance and use of technology (UTAUT; Venkatesh et al., 2003), I designed research questions to analyze teachers' perceptions of the barriers to ICT integration in physics classrooms. The outcomes of this analysis can potentially address these challenges and pave the way for enhanced cooperation between state education leaders and teachers, resulting in improved student outcomes.

RQ1: What are Nigerian secondary teachers' perceptions about integrating ICT into the physics curriculum?

RQ2: What are secondary physics teachers' perceptions of the facilitating conditions that challenge ICT integration in the state under study in Nigeria?

RQ3: What are secondary physics teachers' perceptions of the resources needed for ICT integration in the state under study in Nigeria?

Review of the Literature

The core of this review of the existing literature centered on findings from scholarly-reviewed academic articles that had been published in the last 5 years. I also reviewed current relevant dissertations and conference proceedings. To find recent articles and journals for my literature review, I searched EBSCO, ProQuest, Google Scholar, and Science Direct. To explore the intersection of teacher perceptions, integration of technology in physics education, student-centered learning, and the UTAUT model, this review aimed to identify relevant academic literature. The search strategy employed a combination of keywords including *teachers' perceptions, ICT integration, technology integration in physics teaching, technology barriers*, and *UTAUT*. The search process was iterative and conducted using different combinations of the aforementioned keywords to identify research work across the chosen search engines.

To explore all aspects of the topic, I began by identifying relevant scholarly sources. This initial search yielded a broad selection of peer-reviewed journals and articles. Next, I meticulously examined the abstract of each article to uncover the underlying factors of the research focus. This assisted me in assessing whether the study design adequately explored the research questions and presented valuable information to the overall topic. Finally, for articles that demonstrated promise, I conducted a thorough review, gathering every relevant detail to ensure a rich and exhaustive analysis of scholarly works. The analysis of prior research conducted in this study encompasses the guiding framework and its utilization to the qualitative research study. Additionally, it presents pertinent information concerning the problem of integrating ICT in secondary school classrooms. This in-depth examination ensured not only a firm grasp of the chosen framework's application in qualitative research but also a deeper understanding of the complexities surrounding ICT integration in secondary education.

This study's theoretical framework drew upon the UTAUT model developed by Venkatesh et al. (2003). Proposed specifically for technology-related studies, the UTAUT aims to identify drivers that determine the implementation of educational technology. The authors asserted that the model serves as a valuable instrument for assessing the efficacy of ICT integration across diverse domains. Researchers believe that UTAUT is a useful tool to measure how well different technologies are being used in various educational settings. Given that my research project centered on examining the beliefs of secondary school teachers concerning ICT integration, the UTAUT framework was instrumental in exploring teachers' beliefs related to adoption of ICT-integrated and digitally aided pedagogy. The UTAUT framework identifies four key percepts that influence how technology is adopted and used (Table 1).

Table 1

The Percepts of the UTAUT Framework

	Percepts	Description
1	Performance expectancy	The individual's viewpoint on the advantages of employing technology to improve job performance
2	Effort expectancy	The ease of utilizing technology during task execution
3	Social influence	The perceptions of a user about how important others think it is to use the technology
4	Facilitating conditions	The user's belief on organizational and infrastructural support for technological intervention

Note. Sources: Blut et al. (2022); Venkatesh et al. (2012, 2016).

Several theoretical models have been employed in the literature to understand ICT integration in educational institutions, such as the technology acceptance model (Jan et al., 2023); technology, pedagogy, and content knowledge (Li, 2023); and passive, interactive, and creative learning coupled with replacement, amplification, and transformation of technology use (Kimmons et al., 2020). In line with the UTAUT, the initial three percepts dictated the behavioral attitude for technology adoption, with the fourth percept impacting technology utilization (Blut et al., 2022; Venkatesh et al., 2016).

The qualitative research questions for this project work were formulated by applying the principles of these four percepts.

Recent Studies Employing the Unified Theory of Acceptance and Use of Technology for Technology Integration

Many researchers in education have used the principles of the UTAUT as the concept underpinning their studies in technology integration. The problems encountered by UAE secondary school teachers in integrating technology and building smart classrooms were investigated by Mohamed and Rahman (2023) through the UTAUT model. This model also illuminated the causes and influences affecting the adoption of microlectures among Chinese mathematics teachers and the impact of behavioral attitudes of teachers for successful blending of technology in mathematics classes (Wijaya et al., 2022). The aspects of classroom pedagogy affecting Filipino secondary teachers' adoption of ICT-based instruction were also established based on the UTAUT model (Kim & Lee, 2020). The education policy adopted by educational institutions and teachers' ICT usage habits directly influenced the integration of technology in curricula and pedagogy (Kim & Lee, 2020). Rahman et al. (2021) employed the UTAUT framework to examine how the adoption of a flipped learning approach, coupled with technology, enhances critical thinking skills among students in ESL classrooms. The study revealed that teachers' confidence in their pedagogical abilities and their perceptions and beliefs on organizational and infrastructural support significantly influenced their comfort and proficiency in using ICT. This aligns with the UTAUT's assertion that favorable facilitating conditions are key to teachers adopting ICT in their instructional strategies (Kundu et al., 2021).

The Unified Theory of Acceptance and Use of Technology's Influence on Research Questions

Nigerian secondary school teachers face barriers that impede blending technology in their pedagogies. To identify and comprehend the reasons for ICT integration, this project work employed the conceptual framework of the UTAUT, which consists of four key concepts propounded by Blut et al. (2022) and Venkatesh et al. (2016). In framing the three research questions, I have integrated these four concepts of the UTAUT. The purpose of this approach was to explore teacher perceptions related to the model of the UTAUT, ultimately shedding light on how these concepts guide teachers' efforts to blend technology in their classrooms' pedagogy.

Review of the Broader Problem

Integrating ICT for enhanced instructional and educational outcomes brings in struggles. As reported by Awofala et al. (2019), blending ICT into education is highly influenced by one's attitude toward computers, the level of tech-related apprehension experienced, and the degree of computer competence. Teachers have intense concerns regarding awareness of, management of, and information on ICT integration (Dele-Ajayi et al., 2021). A reoccurring theme in research is that teachers often view the integration of ICT in their curriculum as a threat to conventional teaching. The effective utilization of ICT facilities in secondary school education is contingent upon teachers' readiness, the availability of supporting conditions, their beliefs in the technological value, and participation in professional training sessions (Jimoh et al., 2020; Jogezai et al., 2020; Nwabeze et al., 2021; Raji, 2020). Professional training programs focused on developing technology skills can increase teachers' technology acceptance and utilization, regardless of their inexperience and unfamiliarity with ICT tools (Akram et al., 2022; Jadhav et al., 2022; Villena & Caballes, 2020). Consistent with the framework chosen for the study, this review subsection delves into research works carried out in the last 5 years examining the problem being studied and exploring the ease with which teachers adopt ICT as well as the effort and performance expectations associated with blending technology in their classrooms.

Recent Studies About ICT Integration in Secondary School Physics Education

It is evident from literature that ICT integration in teaching secondary school physics is more challenging due to the abstract concepts involved in the subject (Ageyi & Ageyi, 2019; Tenzin et al., 2022). Nevertheless, some researchers (Mwambela et al., 2019; Samaila et al., 2021) have indicated that students performed better in secondary-level physics when good-quality ICT resources were integrated in classroom teaching. A cross-sectional survey designed by Kamati and Shikongo (2023) revealed that the availability of instructional technologies significantly impacted the academic performance of students. Failure to adopt ICT-integrated techniques and following the traditional teacher-centered teaching strategies had a negative impact on student achievements in physics exams conducted at secondary school levels (Kamati & Shikongo, 2023), a problem that has also occurred in the state under study.

To understand teachers' views on and needs for integrating technology, Pappa et al. (2023) used a qualitative research method. The authors' study combined deductive and inductive mixed-method approaches of the semistructured interviews with 21 public school teachers, finding a critical lack of emphasis on preservice teacher training in technology-integrated pedagogy, resulting in limited ICT-integrated teaching practices. The findings also recommended PD programs to boost teachers' technological pedagogical content knowledge (TPACK), confidence, and self-efficacy and decrease inhibitions while integrating technology (Pappa et al., 2023). Ouahi et al. (2022) also studied ICT use in physics-chemistry and life sciences and concluded that despite obstacles that hinder the use of classroom technology, teachers and students were equally benefitted by technology-integrated science teaching and learning.

Conditions Facilitating Teachers' ICT Use

Recent studies established that lack of adequate digital resources, system-level restrictions, and training in using technology tools impeded teachers' ICT integration in physics classrooms (Assem et al., 2023; Coffie et al., 2020; Sharma et al., 2023). The blending of interactive digital simulations in the instructional approach of investigative science has proven to be effective in improving students' comprehension of complex concepts in standard and higher level physics (Ouahi et al., 2022). In one case, a few hundred students and 10 lecturers took part in quantitative research that investigated the influence of modern teaching techniques in the delivery of intricate concepts in quantum mechanical physics (Nyirahabimana et al., 2022). The revelations of this research showed that accessibility of multimedia and utilization of appropriate multimedia tools can make quantum mechanical physics more engaging and accessible to students.

Engaging in professional training and development sessions empowers educators to explore the potential of digital tools and integrate ICT into their curricula (Lee & Perret, 2022; Qadir et al., 2020). Qadir et al. (2020) considered two theoretical perspectives that affect teachers' learning through PD sessions. According to the authors, psychological factors (teacher cognition and motivation and teachers' understanding of students) and organizational factors (leadership, teacher collaboration and communication, and learning opportunities) ensure that PD sessions result in sustained improvement and student-learning enhancement. In another study, 89 teachers of physics engaged in a 108-hour PD refresher course designed to help them master technology-based blended teaching and learning approaches (Krasnova & Shurygin, 2020). After completing the PD program, teachers reported constructive feedback, improved professional skills and competencies, and higher motivation for technology-based knowledge acquisition skills (Krasnova & Shurygin, 2020). The PD refresher course strengthened teachers' attitude toward ICT.

Teachers' immediate environment, such as school pedagogical culture, policies of the local educational authorities, and adequate pre- and in-service experiences, also facilitated ICT integration in classrooms (Abel et al., 2022). The researchers recorded that teachers' in-service experiences with technology-integrated pedagogies increased confidence and more positive attitudes toward ICT for educational change (Abel et al., 2022). As reported by Hartman et al. (2019), a strong school infrastructure and financial support from local administrative authorities played a crucial role in teachers' technology utilization to influence learning outcomes of students. For ICT-integrated education to be successful, schools and educational institutions should focus on substantial investment in a technology framework, support educators and learners in adopting and adapting to technology practices in classrooms, and develop instructional materials that incorporate ICT effectively (Mohamed & Rahman, 2023).

Expected Performance of Teachers Using ICT in Teaching Practices

Teachers' performance expectancy is their belief about how much technology can foster their efforts to enhance their educational practices and student achievements (Blut et al., 2022). In a study evaluating Moroccan teachers' receptivity toward ICT adoption and utilization, the educators' attitudes towards accepting ICT tools in classroom instruction either facilitated or hindered their use of technology (Ghassoub, 2023). A descriptive-interpretive analytical study carried out in Taiwan revealed that mathematics teachers believed that technology could involve students in competitive problem-solving, enable them to identify crucial features of mathematical concepts by experiential learning, facilitate students' inquiry-based learning, and express knowledge related to new concepts (Yang et al., 2023).

Research works examining teachers' belief in succeeding revealed that educators are encouraged to acquire and assimilate advanced technological expertise as they recognize the relevance of ICT in improving classroom practices and student accomplishments (Shahali & Halim, 2023; Taimalu & Luik, 2019; Tondeur, 2018). Physics teachers in different teacher training institutions in Ghana acknowledged the positive impact of ICT-blended teaching of physics on higher order thinking skills and transversal skills of students (Owusu-Sekyere & Darkeh, 2022). The authors recorded that the teachers' confidence in blending ICT into their pedagogies, assessment, and research is above average, leading them to integrate technology in their curricula (Owusu-Seyere & Darkeh, 2022).

Expected Efforts of Teachers Using Technology in Classrooms

In the review of the literature, it was found that teachers predominantly self-evaluate and introspect when integrating technology into their lessons (Basillota-Gomez-Pablos et al., 2022). Teachers' perceived ease of using technology tools partly explained the association of the effective and responsible use of technology with a high level of work engagement (Sang et al., 2023). Konakh and Akdeniz (2022) carried out a qualitative research work to examine the reasons for educators resisting changes in pedagogies. The study recorded that educators resisted changes in their pedagogies as they did not find the changes reasonable and perceived that adopting changes required extensive effort, created anxiety, and interfered in their traditional teaching and learning practices (Konakh & Akdeniz, 2022). Teachers also cited lack of time and interest being the major hurdles for technology adoption and ICT integration (Mulimani & Naikar, 2022). According to Yang et al. (2023), teachers must make efforts to identify educational objectives, articulate the link between these objectives and physics concepts, recognize students' thinking, and justify ICT integration based on knowledge acquisition.

Social Influences of Teachers Integrating ICT

The degree to which a teacher places high value on the opinions of influential people around him/her who believe technologies or technological systems must be used is referred to as social influence (Blut et al., 2022). Many research works have studied how the individual adoption of ICT by teachers is influenced by social factors, including family, administrators, peers, and colleagues (Kim & Lee, 2020; Shen et al., 2019). Consistent with Wijaya et al. (2022), the likelihood of teachers adopting ICT-blended pedagogies depended on their awareness of what key pedagogical stakeholders such as curriculum developers and instructional coaches want them to do. Interaction and collaboration with different schools that have integrated technology into their classrooms creates a learning climate that influences teachers' perceived satisfaction in ICT adoption and integration (Abdelrady & Akram, 2022).

Recent studies have measured the role of teachers' age as a moderator on ICT adoption (Nassar et al., 2019; Wang & Zhao, 2023). Teachers above the age of 45 expressed a sense of techno-insecurity and were subjected to technostress weakening their ICT integration intentions (Wang & Zhao, 2023). Nassar et al. (2019) recorded that, teachers with more working years adopted ICT in teaching practices to a lesser extent than their younger counterparts. A research study has also shown that social influence does not considerable impact teachers' use of ICT in classroom instructional strategies (Aldheleai et al., 2019). This research work illustrated that the availability to technological tools were not reliable indices of teachers' ICT integration and concluded that teachers' ICT skills and perceptions toward technology use alone facilitate ICT integration in classroom pedagogy (Aldheleai et al., 2019).

Publicly Available Information Relevant to the Problem

The education policy of Nigeria, as outlined by the Federal Ministry of Education (2013), advocates for the adoption of effective ICT-integrated teaching strategies that best fits the requirements of students. The Nigerian Ministry of Education, as outlined in its 2019 guidelines (Federal Ministry of Education, 2019) for blending ICT in educational system, acknowledges the substantial influence of technological pedagogy on students' achievements. Emphasizing the importance of blending technology, the ministry highlights the requirement for teacher training programs to buttress technology integration and equip educators to effectively leverage technological tools that improves the learning process. The ministry insists educational administrators to set-up ICT hubs positioned in key places, particularly in underserved rural areas, to enable teachers from such regions gain technological expertise. The ministry also guides educational institutions to conduct gap analyses, define the desired outcome and compare it to the existing conditions of its teachers, develop and implement training programs to bridge that gap and offer sustained technical assistance to teachers for maintaining and improving their technological skills. Realizing the fact that most of its schools lack adequate ICT infrastructure, the Federal Ministry of Education calls the attention of various stakeholders to develop a shared digital infrastructure that enables the exchange of resources and information between teachers, students, researchers, and educational administrators. The ministry identifies the need for using innovative methods to make ICT a core part of education and unsure its long-term sustainability.

Despite the emphasis placed on mandating ICT integration in schools by the Nigerian national educational policy (Federal Ministry of Education, 2013), literature indicated that teachers remain reluctant to incorporate technology that could positively impact learning outcomes. Teachers encountered significant challenges and political resistance to ICT integration, more so in complex subjects like physics and mathematics (Joel et al., 2019). The larger issue that this study addressed was the complexities encountered by secondary school physics teachers in blending technology, assisting development and delivery of curricula, reinforcing learning, and providing effective, time-saving, and conducive ICT integrated teaching practices.

Implications

Teaching is a complex process in which teachers need to rely on their content knowledge, pedagogical strategies, and expertise on learner understanding to enhance students' learning (Masangila et al., 2019). Teachers' beliefs regarding the purpose and effectiveness of technology influenced their application of ICT tools in classroom instructional practices (Pelila et al., 2022). Well-designed professional training initiatives that focus on effective use of technology should be developed taking into consideration teachers' opinions, thoughts, and ideas (Fahadi & Khan, 2022). Drawing on the participants' feedback on their views of ICT integration, strategies for strengthening technology integration in secondary school physics classrooms may be developed. My research questions helped me explore teacher perceptions regarding the difficulty of using technology, the extent of their performance to integrate technology, social and environmental factors that supported or hindered them in doing so.

The study's findings will lead to technology-related suggestions for school administrators and district authorities. Various project categories explored in the study encompassed a professional development initiative for high school physics teachers aimed at enhancing their efficacy in integrating ICT. By effectively collecting and analyzing data, this study identified the key challenges that hinder the digital transformation of secondary school physics classrooms. This newfound understanding can engineer effective approaches to overcome these obstacles and promote successful technology use in physics education.

Summary

In the first part of Section 1, secondary school physics teachers being challenged for ICT integration was identified as a local problem. The prevalence of the problem locally as well as a wider education problem were established with citations from the literature. The state under study was described as a state with well-rounded education system, teaching a wide range of subjects in K-12 levels in schools, in the southwestern part of Nigeria. The rationale section cited recent research to supporting various factors challenging secondary physics teachers' ICT integration in the state under study. The discussion covered the importance of the study, identified the purpose of the study, and outlined the primary advantages that may arise from both the study and the associated project. Potential societal transformations encompassed effective integration of ICT and efficacious professional training of teachers at the local level. The research question development process prioritized understanding the perspectives of secondary school physics teachers. This focus ensured to enhance the comprehension of the factors hindering technology integration, considering the specific elements of the study's theoretical concepts.

To begin my analysis, I outlined the databases searched and keywords used for the review of literature. I then established the UTAUT model as the study's theoretical framework. The four key percepts of this conceptual framework, along with recent research studies that embraced it, were discussed. Additionally, an elucidation of how the framework influenced the present study was presented.

While reviewing recent studies on ICT integration in secondary school classrooms, I investigated the larger issue by examining research findings that impacted ICT integration of teachers, positively and negatively. A few of the factors encompassed teachers' self confidence in technology integration, the comfort with which they use technology tools, willingness to learn and adopt current technology, and the time dedicated to acquire knowledge to effectively blend ICT in classroom pedagogy. Barriers that impeded teachers' ICT integration in secondary school physics classrooms were identified in research works. Implementation of beneficial teacher-training programs to develop and strengthen teachers' technology skills, accept, and apply new technology in their teaching practices, and enhance student outcomes were identified as common requirements. The key elements of this section were that challenges to ICT integration in secondary school physics classrooms, although not an unusual challenge, can be addressed in educational institutions through effective training and ongoing technical assistance for teachers.

Section 2: The Methodology

This qualitative study explored the perceptions of secondary physics teachers in a southwestern Nigerian state regarding the factors challenging the integration of ICT within their classrooms. To guide this exploration, the UTAUT model served as the conceptual framework. The central technique of data collection was semistructured interviews to gain in-depth and detailed perceptions from the participants (Merriam & Tisdell, 2016). The rationale for this method selection and its suitability for the study will be elaborated upon in this section. Additionally, participants' particulars, the methods employed to gather data, the strategies used for analysis, and the eventual outcomes will be explored.

Research Design and Approach

I employed a basic qualitative research design to investigate the perceptions of secondary school physics teachers of factors that challenged ICT integration in a southwestern state in Nigeria. Merriam and Tisdell (2016) characterized a fundamental qualitative research investigation as grounded in philosophical perspectives of interpretivism, subjectivity, and social interactionism and as a methodology favored by researchers investigating

> (1) how people interpret their experiences, (2) how they construct their worlds, (3) what meaning they attribute to their experiences, or (4) strategies, processes or techniques used by the participants. The overall purpose is to understand how people make sense of their lives and their experiences. (p. 24)

As an illustration, through a qualitative approach, researchers can gain insights into the specific action plans, interventions, and activities employed by exceptionally proficient teachers and administrators (Merriam & Tisdell, 2016). Quantitative approaches are limited in their ability to capture the depth and nuance of lived experiences. The current chosen research methodology attempted to reveal either (a) the perspectives of the participants, (b) the significance they attributed to those perspectives, or (c) a process, such as investigating how 12 secondary school physics teachers had blended technology in their pedagogy to improve student achievements.

Following a critical evaluation of diverse research methodologies, a qualitative research methodology was deemed the most suitable process for this research work. This decision aligned with the investigative nature of the inquiry, encompassing potential participant recruitment methods and data collection strategies. The study endeavored to examine the perceptions of secondary school physics teachers concerning the factors hindering the integration of ICT within the curriculum. By identifying patterns within the collected data, the study aimed to formulate recommendations for addressing the identified challenges. A targeted selection approach, purposive sampling, was employed to identify a group of secondary school physics teachers from the target state. Subsequently, semistructured interviews were scheduled and organized with these participants to gather qualitative data.

Reasoning for Adopting a Basic Qualitative Approach

The qualitative study methodology formed the support to explore this project study. Islam and Aldaihani (2022) posited that basic qualitative research methods are significant in educational research studies. This design generates rich data required to better understand experiences and provide meaningful contributions for improving educational practices (Colemann, 2022). A basic qualitative methodology has the potential to elicit and produce in-depth, intricate, and comprehensive descriptions derived from participants' perceptions (Muzari et al., 2022). The selection of this methodology by researchers arises from various factors. The conditions include ascertaining whether various strategies of collecting data are necessary to comprehend the problem, assessing the suitability of the methodology for the research, formulating appropriate plans for collecting data, and verifying that the design aligns with the resources needed for investigating the problem. Ravitch and Carl (2021) posited that a basic qualitative research method is used to study the social aspects of the exploration. Generally, this design constitutes interviews to obtain concentrated insights into participants' firsthand experiences, comprehend how participants respond to the problem studied, and understand how participants' perceptions relate to the research topic under study. Ahmadin (2022) suggested that the basic qualitative study methodology enables researchers to pose interview questions concerning subjects that are challenging to quantify, with the aim of grasping participants' perceptions more comprehensively. Building upon the work of Ruslin et al. (2022), who highlighted the strengths of semistructured interviews in qualitative research, the current study employed this method to collect data from participants. Semistructured interviews allowed for the gathering of in-depth information and participant perspectives while maintaining a focus on the core research questions, ensuring that the study remained grounded (see Creswell & Creswell, 2018).

Though no research design is superior to others, multiple factors were weighed before deciding on the best design to carry out the current research. Researchers use quantitative methods to comprehend specific phenomena by gathering numerical data that allow for the investigation of clearly defined research questions, while researchers use qualitative methodology to address societies' particular issues through naturalistic and interpretative approaches (Taherdoost, 2022). Data collection in quantitative research is largely carried out using random sampling (Consoli et al., 2023). This project employed purposive sampling to target secondary physics teachers with demonstrable knowledge and experience in the curriculum. Germane to the research focus, data collection strategies, and the intended application of the findings, a qualitative study was determined to be the tailor-made solution.

Additional Research Designs Not Selected

Various other research designs failed to meet the prerequisites of this project study for different reasons. Quantitative research approaches can be categorized as survey, descriptive, experimental, correlational, and casual-comparative, while qualitative research approaches can be categorized as narrative analysis, phenomenological approach, ethnographic studies, systematic methodology of grounded theory, case studies, and thematic analysis (Childers et al., 2023; Humble & Mozelius, 2023; Taherdoost, 2022). Such approaches did not address the different demands of the current study. Neither these approaches nor mixed methods fulfilled the demands of this project study.

The constructivist grounded theory design is mainly focused on emergence (Deepa et al., 2022). Studies based on grounded theory start with limited preconceived notions but conclude with emerging concepts and development of theories from the collected data (Jiang, 2022). I did not intend to develop any theory or concept from this project study. Hence, this project study did not use the systematic methodology as an appropriate research design.

Narrative inquiry, another qualitative approach, was also not selected for studying the current problem. Narrative inquiry is used by researchers to understand a problem through the stories of participants about themselves or a series of events (Ador et al., 2023; Akojie et al., 2022). In contrast, this project centered on exploring the perceptions of secondary physics teachers concerning the factors challenging the integration of ICT tools within their curriculum. It is important to note that both narrative inquiry and the qualitative methodology adopted in the current project study relied heavily on interview data for information gathering. While the research outcomes of the former research methodology are drawn from the stories of the participants' lives, employing diverse methods that encompass recreating, surmising, and chronicle segments, in the latter, the research outcomes are drawn by identifying and analyzing common patterns in the participants' perspectives (Creswell & Creswell, 2018). This study employed 12 qualitative semistructured interviews with secondary school physics teachers to explore their perceptions and identify thematic patterns concerning ICT integration within physics classrooms.

The ethnographic approach to qualitative research focuses on describing and interpreting a culture-sharing group through prolonged observations (Aladsani et al., 2022). This research methodology requires the researcher to take the role of a complete participant, have an experience as close as possible to the individual being studied, and become one among the participants' group during extended time in the field (Taherdoost, 2022). The research design excluded prolonged immersion within the participant group's culture. Therefore, the ethnographic study methodology was found an ill fit for this study.

In phenomenological research, the emphasis is on comprehending the fundamental nature of the experiences of multiple individuals. In case study research, on the contrary, a solitary case is usually chosen, exemplifying a problem, and the researcher assembles a detailed account of the case's background (Creswell & Creswell, 2018). These research designs were not conducive to reaching the intended focus of this project study. Therefore, phenomenological and case studies were not selected to answer this project study's questions.

Content analysis is a suitable research design to utilize when analyzing the content of textual data (Adams et al., 2023). This research design stems from quantitative methods, focused to gain frequency in patterns, biases, or themes. The researchers mainly use word clouds, bar graphs, frequency polygons, histograms, and pie charts to visually represent and present the gathered data (Wilson et al., 2022). Adams et al. (2023) posited that qualitative content analysis is a flexible method to simplify substantial amounts of textual data to identify new concepts. Based on the requirements, content analysis was not chosen for the current research work.

The fundamental principle of mixed methods research design lies in the conviction that integrating qualitative and quantitative data will offer comprehensive insight into the current problem (Creswell & Creswell, 2018). However, this methodology was not deemed suitable for my project study as it involved analyzing contrasting results obtained from qualitative and quantitative data. Bice and Tang (2022) opined that mixed methods design poses the challenge of using numerical data to interpret perceptions, which may not result in accurate interpretation of data. Given the emphasis on exploring secondary school teachers' perceptions of challenges related to ICT integration in physics education, a qualitative study methodology was preferred over mixed methods study to focus on the subjective realities of teachers and explore their experiences in detail.

Participants

In accordance with Ravitch and Carl (2021), "the choice of participants is clearly a central aspect of how and what you can and will learn in your research" (p. 142). A purposeful sample of secondary school physics teachers teaching in the state under study were considered to participate in this research work. This sampling method is best used when researchers intentionally select participants for a study based on their specific characteristics or experiences, pertaining directly to the research inquiry (Merriam & Tisdell, 2016). Following the ethical approval process established by the Walden University Institutional Review Board (IRB; 12-01-23-1107566) to initiate data collection, I distributed a social media flyer (Appendix B) across platforms such as Facebook and LinkedIn, and I also approached the physics teachers' association of the district, to invite teachers to participate voluntarily in the study.

Initially, from the responses received to the social media flyer and from the physics teachers' association of the district under study, only teachers teaching physics at the secondary school level for over 10 years in a specific administrative division were sent an invitation (see Appendix C) by email to participate in the study. When fewer than two teachers from an administrative division responded, I emailed the invitation to teachers with 5–10 years' experience in physics teaching. The email invitation was then sent to physics teachers with limited years of teaching physics within the state under study, until at least 12 teachers agreed to contribute to the study. A consent form for participation in the research study without obligation was shared with all the teacher volunteers, and their consent was recorded. Individual interviews designed to explore participants' perspectives in detail were held with each of the 12 teacher volunteers. Conducting these interviews enabled me to gather comprehensive and thorough data that mirrored the perspectives of secondary school physics teachers concerning the challenges to ICT integration in the target state.

Establishing Researcher–Participant Relationship

The researcher–participant interaction holds great significance in qualitative research. According to Stahl and King (2022), the researcher's approach to establishing mutual respect with the participants of a study is paramount for generating rich data. A good relationship might boost the participant's interest in the study, increasing the probability of the participant being happy to be a volunteer and giving up their time for the study (Thunberg & Arnell, 2022). To establish such a relationship, I made the participant feel valued and was appreciative of their time and effort. I was respectful of the participants' quotes and contributions and reported results truthfully and honestly. Furthermore, in accordance with the recommendations of Ravitch and Carl (2021), I adhered to the criteria to follow the standards of trustworthiness to guarantee that the outcomes of this study accurately represented the teachers' experiences.

Credibility

To establish the credibility of this project's findings and align with best practices in qualitative research (Muzari et al., 2022), several strategies were employed. Semistructured interviews with the selected teacher participants served as the primary data collection method. Member checking, a technique involving sharing interpretations with participants for verification, fostered the accuracy and truth-value of the results. Timely follow-up ensured that participants recognized their experiences reflected in the findings. Reflective journaling facilitated differentiation between researcher interpretations and participant perspectives, mitigating potential bias (Amin et al., 2020). This practice further ensured that the project's outcomes emerged solely from the teachers' perceptions and experiences, untainted by the researcher's preexisting beliefs.

Transferability

Both qualitative and quantitative researchers aim to broaden comprehension by applying findings from one framework to another (Stahl & King, 2022). In qualitative research, transferability denotes the applicability that can be extended to comparable situations and conditions (see Mohajan, 2018; Ravitch & Carl, 2021). Rich descriptions based on participant perspectives were provided alongside a comprehensive review of relevant literature. This detailed contextualization allows researchers to evaluate the results and generalize to other contexts.

Dependability

Dependability is that perspective of trustworthiness that means that the gathered data are accurate, consistent, and free of errors (Ravitch & Carl, 2021). As recommended by Merriam and Tisdell (2016), I offered an elucidation of the methodologies employed during the investigation in my study. This project study prioritized dependability, presenting comprehensive details of the research process, methods followed to collect data, and participant selection criteria (see Stratford & Bradshaw. 2021). Furthermore, one-to-one interaction with the participants and the implementation of member checking practices served to strengthen the dependability of the study's findings.

Confirmability

To minimize researcher bias and ensure objectivity, efforts were made to gather a variety of perspectives and critically examine all collected data (see Haven & van Grootel, 2019). To enhance confirmability and ensure the neutrality of the interview process, member-checking emails were sent to participants after each interview, allowing them to review key findings and contribute to the accuracy of the interpretations. I maintained transparency during my project study by offering clear explanations related to the research work, acknowledging prejudice at a personal or professional level, summarizing the procedures for gathering data and analysis, carrying out member checking, and engaging in reflective journaling to establish confirmability.

Data Collection

Qualitative data collection should be structured, conscious, and rigorous, yet not guided by extremely rigid rules or procedures (Ravitch & Carl, 2021). At the core of qualitative data gathering are interviews, which furnish profound, intricate, personalized, and context-specific data that delve into the first-hand experiences of participants (Merriam & Tisdell, 2016). I invited selected teachers to partake in interviews for data collection, aiming to study their perspectives on the challenges affecting ICT integration in physics classrooms. Though in-person interviews are considered as the benchmark for qualitative interviews, various factors challenge conducting such interviews. Due to geographical distance and transportation constraints on moving between schools in different administrative divisions, I conducted interviews using online interviewing modes. Taking research ethics into consideration, I held the synchronous online interviewing over Zoom video communications. Each interview on the Zoom platform was recorded and stored in my licensed password-protected Zoom account.

Instrumentation

The interview protocol consisted of an interview guide (Appendix D) and interview questions as presented in the interview plan (Appendix E). The effectiveness of the questions determines data validity that is contingent upon the intended purpose for which it is employed and is assessed through logical validity (Roberts, 2020). Content validity, being a necessary condition for other types of validity, needs to be initially assessed during instrument development and judgment stages (Shrotryia & Dhanda, 2019). I conducted an extensive examination of relevant scholarship to establish the gap in research within the foundation of the research problem at the development stage. The judgment stage necessitates the participation of a designated number of subject matter experts (SME) who can validate the degree of relevance of the instrument and confirm the appropriateness of the instrument (Ismail & Zubairi, 2022). Scholars in research suggest the engagement of at least three experts to assess content validity and not involve more than 10 which might decrease the chances of agreement (Shrotryia & Dhanda, 2019). In this qualitative study, for assessing the logical validity of the interview questions, five SMEs were selected based on expert knowledge in physics, mathematics or information technology curriculum, and educational technology tools, or professional experience in ICT integration in classrooms (Table 2).

Table 2

Particulars of the Subject Matter Experts

	Designation of the SME	Education qualification	Years of experience
1	Professor and head	PhD (Computer Science Engineering)	30
2	Associate professor	PhD (Physics)	28
3	Vice principal	PhD (Mathematics)	25
4	PGT	MSc (Physics), MEd	20
5	PGT	MSc (Physics), BEd	8

Note. PhD = Doctor of Philosophy, PGT = postgraduate teacher, MEd = Master of Education, MSc = Master of Science, BEd = Bachelor of Education.

The first SME was chosen for the length and breadth of experience in the realm of information technology. The relevant expertise of SME 1 in ICT helped in validating the research instrument for ICT integration in secondary school classrooms. The second SME was selected based on the vast experience in teaching of physics integrated with technology. Higher secondary school physics curriculum includes a large extent of complex mathematics principles and concepts. This led to the choice of SME 3, a mathematics teacher. SMEs 4 and 5 have more than five years of experience handling higher secondary physics curriculum in schools and also have integrated technology in classroom pedagogy of physics.

The subject matter experts were contacted via an email (Appendix F) to ask if they would willingly partake in the research. Following the acquisition of informed consent, the interview protocol was distributed to all SMEs. The viewpoints of the SMEs based on the relevance, necessity, and comprehensiveness of the protocol were received through email. Based on the feedback received from SME 3, the interview guide was supplemented with a concise overview of the problem studied and research purpose to furnish context for the participants. Two questions on technology integration in physics teaching were merged to one, as suggested by SME 4. As recommended by SME 1 and 5, different types of hardware and software ICT tools were added to the questions as probes to facilitate participants collaborate on developing and sharing best practices for technology integration. The term ‘administrative division’ was replaced by ‘Principal and other leaders of the school’ as SME 2 pointed out the reference to non-teaching staff in administrative division. The revised interview protocol, after incorporating the additions, corrections and necessary edits based on the SMEs recommendations, was used to gather relevant information for the research.

Interview Plan

Teacher-participants provided informed consent to partake in online semistructured interviews. Interview questions were designed to delve deeper into teachers' perceptions related to ICT integration. Each teacher-participant was asked all of the research questions during the comprehensive semistructured interviews. Semistructured interviews let me ask the same set of questions to all teacher-participants, but probing each of them in a unique and customized conversational path. To ascertain the protocol addressed the focus of the research, it was streamlined to examine participant perceptions of the UTAUT model's core constructs, specifically focusing on efforts and performance expected, social factors, and factors supporting ICT integration.

Due to geographical distance and transportation constraints on moving between the schools in different administrative divisions, I conducted interviews using online interviewing modes. Consent for the same was obtained from the participating teachers in the informed consent form. Online interviewing involves considerable challenges such as the obligation to seek the participant's consent before recording in video format (Krouwel et al., 2019), the possibility of excluding potential participants who lack technological resources (de Villiers et al., 2022), and missing visual cues (Heiselberg & Stępińska, 2022). But contemporary qualitative researchers have identified various practical advantages of semistructured interviews conducted on Zoom platform (Falter et al., 2022; Lobe et al., 2022). Żadkowska et al. (2022) posited that the Zoom platform provides the interviewees more control over self-presentation and personal space through its camera view options, including blurred or virtual backgrounds, and non-virtual background options. The Zoom platform also supports synchronized video and audio recording facilitating the researcher to read the facial cues of the participants and register individuating information (de Villiers et al., 2022). Most digital devices today, including laptops, mobile phones, and others have built-in microphones and cameras that support the video and audio-based formats on the Zoom platform, facilitating participants to take part in the interview.

I scheduled a Zoom meeting with every participant following informed consent for online interviews. I provided my personal Zoom meeting ID and passcode to each of the participants to enable them access the meeting room. Keeping the ethical concerns of the participants in mind and to prevent entry of random guests into the meeting, the 'waiting room' feature was enabled before the participant entered the meeting room and the 'lock meeting' option was enabled after the participant gained access into the meeting room (see Santhosh et al., 2021). Prior to initiating each interview, the interview guide (Appendix D) was reviewed with the participant. We also revisited their signed consent form to make sure they retained awareness of their participant rights to refuse answering any question or withdrawing at any point without any obligations. To ensure participant anonymity, each teacher-participant was allotted a unique identifier code.

I hold a licensed Zoom account which enabled me to video record the interviews, prior permission for which was as documented in the informed consent form provided to participants. The interview recordings were securely uploaded to my personal Zoom cloud account. Each recorded interview was saved using the unique code allotted to the respective teacher-participant. NVivo, the qualitative data analysis software, and its data import features were used to process, synthesize, and analyze data from the interview transcripts (see Kraiwanit et al., 2023). The interview transcripts are of central concern as authentication of qualitative data and are substantial to meticulous data collection and analysis (Given, 2008; Ravitch & Carl, 2021). I utilized NVivo to convert the video recorded interviews into transcripts. The individual transcripts were then be shared with the respective teachers to enable them evaluate and amend them, ensuring that the interview perfectly captured the participants' perceptions (see Stavitz et al., 2023). I created an efficient, user-friendly indexing system for my amended transcripts to transform the spoken into the written. This helped me create a system to identify specific passages and quotes while coding the data.

Building Participant Rapport

Establishing a positive researcher-respondent working relationship began right after identifying the participants for the study. Before the commencement of the interview, every participant received a comprehensive explanation of their voluntary participation, including their right to confidentiality and the measures taken to ensure data security. A detailed consent form was then provided for their review and signature. Participants were interviewed only after receiving an emailed consent. I informed all participants that their personal information will be maintained with utmost confidentiality by assigning a unique code which will be a participant number, to each one of them, to be used in study notes, coding documents, and results**.** I outlined my roles and responsibilities pertaining to the research. I also ensured ample opportunity for participants to question about myself or the research. This open dialogue facilitated the establishment of trust and a collaborative rapport with the teacher-participants.

Validation of Data—Method of Triangulation

Triangulation, as employed in qualitative research, aims to bolster the research work’s validity. As outlined by Creswell and Miller (2010), this method necessitates merging of various sources of information to identify patterns in the study. But the goal of triangulation is not always to seek convergence but to engage with different perspectives and learn from them for addressing the research questions (Ravitch & Carl, 2021). I made sincere efforts to systematically and conscientiously pursue the gathering of reliable data, aiming to enable the emergence of the most genuine and consistent interpretations. This, in turn, contributed to addressing the research questions with confidence.

According to Denzin (1978), four distinct triangulation approaches exist: (i) Data triangulation in which a variety of sources providing data, including space, persons, and time are used. The accuracy and trustworthiness of the results can be enhanced by the strengths of one data compensating for any weaknesses in the other (Nunes et al., 2019). (ii) Investigator triangulation that involves employing multiple investigators, interviewers, observers, or researchers in the same research study. This approach amplifies the validity of the data by enabling the confirmation of the findings amongst all investigators who do not indulge in prior discussion or collaboration (Rugg, 2019). (iii) Theory triangulation refers to the utilization of many theories to analyze a particular problem. The idea of looking at a problem from different perspectives with different questions using divergent or compatible theories allows a researcher to identify the concerns of the research problem and increase correctness of the study (Rugg, 2019). (iv) Methods triangulation, a research design that utilizes different data collection techniques to explore a problem from various angles. This triangulation intends to decrease the biases that come from any one method and is similar to mixed methods research (Carter et al., 2014).

I chose data triangulation for my project study as it uses findings from different sources bearing in mind the robustness and debility of each of them. Research scholars adopting qualitative approach use data triangulation to combine the heterogeneous data to amplify the trustworthiness of their findings (Yin, 2014). I achieved triangulation through semistructured interviews with multiple teachers who taught secondary school physics in different schools within the administrative division of the state under study. Along with member checking and reflective journaling, I employed triangulation through peer debriefing, reaching saturation of data, and practicing subjectivity.

Member Checking

One of the significant aspects of qualitative research includes member checking. Described by Lincoln and Guba (1986) as an iterative and informal procedure, member checks involve the researcher presenting the interpretations of the data back to the participants to get their feedback. Member checking allows researchers to ascertain that they have accurately represented the participants' perspectives, thereby strengthening trustworthiness (Creswell & Miller, 2010). I shared the transcripts of my interviews with all teacher-participants to ascertain I have accurate data to analyze. I realized that if participants felt like the researcher as holding authority, were hesitant to contradict the results, and simply concurred, the member check would fail to validate the study (see Candela, 2019). Such was a possibility in this study's data collection, as expatriates are generally considered superior to the local people in the state under study. I hence balanced any power differential between the participant, a local school teacher, and myself, an expatriate, by making the intent of my project study very clear and providing the research background at the outset of the interviews (see Candela, 2019). I also eliminated the probability of power imbalance by revealing some details of my own identity so that the interview becomes more reciprocal and not one-sided (see McKim, 2023).

Peer Debriefing

Peer debriefing serves as a valuable tool for triangulation in qualitative research. Through discussions with colleagues about the research process and collected data, researchers can identify probable biases and strengthen the trustworthiness of their findings (Lincoln & Guba, 1985). This strategy assisted me in achieving four general purposes (i) probe for meaning, bias, and understanding (ii) test the theory that might emerge in my mind (iii) develop next steps that emerge in the methodological design and (iv) gain an opportunity for cognitive insight and positive change (see Cooper, 1997). During the peer debriefing process, the focus was to question my assumptions about the data, manage my personal biases, and offer different explanations for patterns in the data (see Barber & Walczak, 2009). Such a process was followed in pursuit of generating more robust and rigorously examined knowledge than I can produce on my own.

Though multiple debriefers may be helpful to strengthen credibility of this qualitative study, due to practical considerations such as availability, commitment, and dependability, I selected only one peer debriefer, an expert on the topic under study. This debriefer not only possessed adequate experience in secondary school teaching but also exercised caution and empathy, steered clear of discouragement, maintained flexibility in approach, and refrained from offering overly critical feedback (see Lee et al., 2023). I requested the peer debriefer to review my interpretations of the gathered data, suggest improvement in the research proceeds, and also to aid with consistency, credibility, and reliability throughout the data analysis stage. Such debriefing assisted in bolstering the trustworthiness of this research work. To maintain confidentiality, the peer debriefer was also requested to sign a consent-cum-confidentiality form (Appendix G).

Data Saturation

It is the most important factor in deciding if enough data has been collected in a basic qualitative design. Reaching data saturation ensures that the data collected during the research is reliable, and it also saves researcher's time and effort by eliminating the need to collect more data than is necessary (Mwita, 2022). This project study achieved data saturation through semistructured interviews. The interview questions (Appendix E) were meticulously crafted to ensure consistency across participants. Standardized questions facilitated comparison while allowing for exploration of nuanced details through follow-up inquiries. This approach aimed to gain data saturation (see Mwita, 2022). Aguboshim (2021) posited that deciding when to stop collecting data is a matter of researcher judgment and years of familiarity with the study environment. Being a novice researcher, data saturation became slightly complex for me.

Saunders et al. (2018) put forth four distinct data saturation approaches in qualitative research. The first type pertains to theoretical saturation with its principal focus in sampling, which is associated with the emergence of theoretical categories, especially in the context of grounded theory. Inductive thematic saturation, the second type, focuses on developing new codes or patterns during data analysis. The third type, a priori thematic saturation, ensures that the sample of data collected is large enough to represent the full range of preidentified codes or themes. The last type primarily focuses on data collection and is tied to how new data reaffirm and repeat what was expressed previously. The fourth model, data saturation, was earlier recorded by Charmaz (2014) as "nothing new happening" (p. 213). Also, Hennink and Kaiser (2022) argue that 9–17 interviews often result in data saturation, implying that most qualitative studies reach saturation after around 13 interviews. I looked for repetition of the same information from the participants, when nothing new was being added by fresh interviews, which indicated that saturation has been reached.

Reflexivity

Reflexivity is the collection of ongoing, cooperative, and varied actions adopted by researchers to carefully analyze, assess, and examine how their research agenda and assumptions, personal beliefs and emotions, and the context shape the context of the research (Olmos-Vega et al., 2023). Researchers engage in reflexivity to achieve various goals including balancing the impact of their personal biases, acknowledging it, explaining it, or taking advantage of it (Gentles et al., 2014). When engaged to balance the impact of researcher's personal biases, reflexivity refers to the researcher attempting to set aside their personal views, knowledge of preexisting theories, etc. that might influence the study. As a novice researcher, neutralizing and balancing researcher influence completely might be problematic and even impossible for me (see Holmes, 2020). Hence the balancing purpose of reflexivity was not adopted in this project study. With acknowledging personal biases in mind, reflexivity is seen as the process of acknowledging that the researcher's subjectivity has contributed in shaping every aspect of the study (Olmos-Vegas et al., 2023). Yet, simply acknowledging the impact might fail to clarify how this affects the data, participants, context, or the researcher. Cairns-Lee et al. (2022) posit that when the purpose of reflexivity is extended to explaining bias, the potential value of subjectivity is risked to taking a mere apologetic stance undermining the objectives of qualitative research. Contemporary qualitative researchers hence consider reflexivity as a means of taking advantage of the researchers' subjectivity and not something to be balanced, merely acknowledged, or explained away (Gentles et al., 2014).

My main goal in using reflexivity was to be aware of and use my own influence on the investigative technique, data collection, interpretation of the data and findings (see Jamie & Rathbone, 2022). As suggested by Watt (2007), the key will be to recognize how my viewpoint and opinions afford advantages while also imposing limitations. Along with maintaining interview transcripts and journal entries, I created research notes and maintained an audit trail. According to Vaismoradi and Snelgrove (2019), research notes support the practice of reflexivity and offer researchers, opportunities to contemplate their data analysis processes, enhance data interpretation, and refine the emergence of themes.

Trustworthiness

As discussed earlier in this section, to establish positive rapport with the teachers and amplify the trustworthiness of the data, the findings of this project study were demonstrated to be viable, reliable, communicable, and confirmable (see Lincoln & Guba, 1985). With the focus on gathering rich data, I listened intently to the participants' elaborations to the interview questions (see Lavee & Itzchakov, 2023). I maintained transparency with the participants and the audience by clearly defining the research design and questions. By prioritizing transparency, the study's credibility and the dependability of its findings were strengthened (see Reid et al., 2018). Additionally, NVivo software was adopted to streamline the process of organizing, coding, interpreting data, and uncover meaningful patterns and connections within the study.

Role of the Researcher

My primary function in this study was formal observation. I took on responsibilities such as selecting participants, conducting semistructured interviews, analyzing data to identify potential themes, and presented findings aimed at ICT integration in secondary school physics classrooms. I engaged with the participants during the semistructured interviews, allowing me to gather insights through both questioning and observation. Merriam and Grenier (2019) posited that a researcher working with a qualitative research methodology mainly uses the qualitative criteria of reliability, integrity, and being communicative in each stage of monitoring and mitigating bias, enhancing proficiency in one's methodologies, gathering and evaluating data, and presenting the research outcomes. To mitigate the impact of my personal biases, I made a conscious effort to recognize and document those (Phillippi & Lauderdale, 2018). I developed competence in the research methodology by providing a neutral and objective explanation of the research study to the participants, conducted interviews by acknowledging the researcher's position and subjectivity, critically self-reflected regarding assumptions, and ensured acceptability of the research findings (Reid et al., 2018).

An audit trial was documented to facilitate readers to independently verify the study's findings. In a qualitative study, this trail necessitates a comprehensive record detailing the research study's conduct, data analysis, category derivation, the decision-making process throughout the study (Merriam & Grenier, 2019). Jamieson et al. (2023) proposed to qualitative researchers to maintain field notes and a reflective journal to record the kinesics of the interviewees during interviews. To verify the information presented, I employed meticulous note-taking techniques that captured not only the core interview content but also any personal questions or comments that emerged during the discussions. This comprehensive approach allowed for a faithful representation of the participant experiences.

I am a secondary school physics teacher in the state under study. I was not a supervisor or senior leader of any of the selected teacher-participants during the data collection stage. In line with the recommendations of Collins and Stockton (2022), I played my part in interacting with the participants distancing from my full self. I cultivated an understanding of myself and was flexible and resolute during the interviews. I was careful not to overemphasize on the study or my classroom experiences as this might have influenced the participants' thoughts and become a potentially ethical issue.

I integrated additional strategies to mitigate prejudice in the way data is gathered. I had a prior conversation with the teacher-participant about something other than the study to get to know them better and created a friendly and relaxed atmosphere for the interview (see DeJonckheere & Vaughn, 2019). I maintained a consistent and neutral tone throughout the interviews, when posing questions, and purposefully refrained from expressing my alignment with the teacher-participants' statements (see Ravitch & Carl, 2021). Such a calm composure aligned with the concept of minimizing researcher bias. Following the planned interview arrangement created a professional and organized environment that helped to ensure that relevant data was collected (Creswell & Creswell, 2018). In accordance with this recommendation, I followed the interview plan to assist my interviews and the questions during the interviews, related to the problem being studied. I utilized NVivo for data analysis, coding, and uncovering themes to interpret data. As a researcher, I prioritized objectivity throughout the project. This involved meticulous collection and analysis of data to minimize bias and secure an unbiased deciphering of ICT integration challenges in secondary school physics classrooms.

Data Analysis

The current investigation focused on understanding the perspectives of secondary school physics teachers in southwestern Nigeria. Specifically, the research aimed to explore the challenges they perceive when integrating ICT tools into their physics curriculum. To gain these insights, I employed qualitative analysis methods outlined by Saldaña (2021). This involved applying appropriate coding techniques based on the content of the teacher interviews. Following an iterative process, I organized and reviewed the data using a multilevel approach, as suggested by Ravitch & Carl (2021). This multilevel approach allowed me to examine the data from various angles and comprehensively understand teachers' experiences.

After receiving IRB approval for my study (12-01-23-1107566), I introduced myself to the Tutor General/Permanent Secretary, Department of School Education in the state under study, explained my research study’s purpose, and furnished the approval letter of IRB for conducting interviews and gathering data from teachers. The Tutor General’s permission for my study was obtained following which senior secondary physics teachers of the district were recruited, and I began collecting data through interviews. Analysis of the gathered data commenced with transcribing the data, followed by participant validation and assessment of the observed themes (Creswell, 2015). The initial analysis began with a comprehensive review of participant responses. This review combined the transcribed interviews with my field notes, allowing me to capture both the verbal content and contextual details. To ascertain accuracy and trustworthiness, I employed member checking. Participating teachers were invited to review their interview transcripts and suggest any corrections that better reflected their perspectives. As highlighted by Lincoln & Guba (1985), member checking serves the primary purpose of data authentication and confirmation. However, Merriam and Grenier (2019) emphasized its additional benefits which comprised of establishing participant credibility, rectifying researcher assumptions, and potentially uncovering new insights or deeper understandings of the data.

An emailed confirmation (Appendix H) was collected from each participant for reviewing and approving the interview transcripts. I reviewed the recorded interviews carefully to identify patterns and themes in the transcripts. Rubin and Rubin (2012) posited that going over the interview transcripts multiple times by focusing on the depth rather than the breadth will assist the researcher in understanding specific situations or individuals that are significant in the collected data. Following re-reading of the transcripts of the interviews, I continued with Saldaña's (2021) stage-wise coding techniques to produce meanings and patterns and identify emerging themes. As recommended by Creswell (2015), further analysis of the interviews was executed by in vivo coding of the transcripts.

In qualitative research, codes act as identifiers for key elements and core ideas within the data (Saldaña, 2021). Codes can be grouped into categories based on their common characteristics. When research is carried out based on qualitative research methodology employing interviews, the practice of lean coding encourages researchers to consolidate various codes into themes. According to Saldaña (2021), coding, grouping codes into categories, critically reviewing, and analyzing the data to look for patterns, results in the emergence of themes. In simple language, a code defines an idea, a category represents a group of codes, and a theme describes a more general and comprehensive purpose. Through a process of iterative coding, I categorized and reorganized the data into thematic areas reflecting the core research questions. Though data analysis is an iterative process, I reached a point when no further insights or new evidence relevant to the theory were identified (Given, 2008). At this point, thematic saturation was accepted and data analysis was concluded.

Interviewee Recruitment

After obtaining consent from the Walden University IRB, I proceeded to send an invitation (Appendix C) by email to the volunteered physics teachers in the district of the state under study. The email comprised not only of an invite to the teachers to engage in my research investigation, but also an outline of my study's objectives, details regarding voluntary participation, and an appended informed consent form. I sent out email invitations to 12 participants. The informed consent document was attached with every email for participants' review and the teacher-participants had a chance to pose any queries before providing their consent. I received responses from all participants stating, "I consent."

After receiving participants' informed consent, I individually contacted them to find mutually agreeable interview dates and times via email. This personalized scheduling process, followed by a Zoom invitation confirming the details, helped establish rapport which is a crucial foundation for trust and acknowledging the value of their insights (see Olmos-Vega et al., 2023). Data gathering commenced on December

20, 2023, and concluded on January 6, 2024. On analyzing the data gathered from the 12 interviews, I established a satisfactory level of data saturation as the teacher-participants' responses began to repeat, in accordance with Ravitch and Carl (2021).

Semistructured Interviews

Participants were allocated a numerical identifier to safeguard their anonymity. Table 3 depicts participant identifier, years of instructional expertise, and grade levels handled by the teacher-participants. Participants included nine men and three women, all located in district I of the state under study in Nigeria. The participants' teaching tenure varied from 5 to 24 years, experienced in handling senior secondary physics classes, both in traditional mode, predominantly, and in ICT-integrated modes.

Table 3

Teacher-Participants' Identifiers and Experience

Participant	Years of teaching	Senior secondary levels taught
P1	16	1–3
P2	5	1–3
P3	14	2–3
P4	8	1–3
P5	5	1–3
P6	24	1–2
P7	8	2–3
P8	10	1–2
P9	13	1–3
P10	24	2–3
P11	7	1–3
P12	11	1–3

To ensure informed participation, I verbally presented the informed consent form to each participant prior to beginning the interview. This process ensured they fully understood their rights throughout the study. Participants verbally confirmed their comprehension of participant rights, their ability to decline answering questions or withdraw at any point, and the use of digital video recording during the interview. Only after participants acknowledged their rights, confirmed they had no further questions regarding participation, and verified they had reviewed the informed consent form in detail, did I proceed with the interviews.

To guide the interview process and encourage in-depth responses, I utilized a combination of an interview guide (Appendix D) and a set of semistructured questions (Appendix E). The interview guide introduced the study and set expectations. The semistructured questions aimed to spark open dialogue and elicit detailed accounts from the participants. While conducting the interviews, I referred to the questions on an alternate window on my laptop screen, for clarity. Reflective journaling played a crucial role during the collection and analysis of data. This practice allowed me to track the dependability and confirmability of the research work. The interview process itself proceeded smoothly without any unforeseen circumstances.

In educational research, semistructured interviews are commonly employed to collect detailed, descriptive data (Creswell & Creswell, 2018). I conducted semistructured interviews on the Zoom video conferencing platform. I uploaded the recordings to my personal Zoom cloud account. The IRB of Walden University concurred to the use of NVivo.com for data analysis. I chose NVivo.com because of its efficiency and rigorous privacy policy and proceeded to buy an NVivo one-year student license (License Key – NVT14-JZ000-1HA20-JR686-TLDNM).

As part of my data interpretation process, I repeatedly listened to the interview recordings, reviewing the transcripts of the corresponding interviews simultaneously and meticulously. This helped me to identify and rectify any errors in words and spellings and also to take notes on potential themes. Consistently applying this method ensured the correctness of the transcripts and facilitated collecting information from each teacher-participant. Additionally, this approach enabled me to adopt the role of an insightful investigator rather than a mere data collector, thus mitigating bias. The iterative process of reviewing and re-reviewing the transcribed interviews enhances credibility and authenticity of the data collected (see Shufutinsky, 2020). After validating the transcript data, I assessed their fidelity against the initial transcription. Once confirmed for accuracy, I conducted a coding process on each transcript, which involved initial coding, identifying patterns, deciphering meaning, and extracting themes.

Data Analysis Results

This part of the methodology section delineates the steps undertaken to interpret the data, detailing the data organization procedure and the method of constructing themes. Themes are explained here to elucidate my interpretation of the significance of every code. The findings of the data analysis pertaining to teachers' perspectives on technology integrated teaching of secondary school physics are presented in this part. This section specifically addresses the tenets of the UTAUT that impact technology integration, aligning with my project study's context.

Individual semistructured interviews were conducted with 12 secondary school physics teachers to gather qualitative data. Each teacher-participant was allocated a numerical identifier to safeguard anonymity and facilitate data organization. The initial stage of analyzing the data involved immersing myself in the interview data through repeated listening to the recordings and examining each and every interview transcript. During this stage, I actively engaged with the interview text, underlining, and highlighting key elements that warranted further exploration. I centralized my analysis on delving deeply into the content to comprehend specific contexts, characters, or significant moments captured in the data, prioritizing depth over breadth, as advocated by Rubin and Rubin (2012). Moving on to the next stage of analysis, the coding approach put forth by Saldaña (2021) was adopted. Saldaña’s (2021) coding encompassed three series of approaches: the first series to monitor key terms, words, and/or phrases, the second series to establish groups, essence, and patterns, and the third series to unveil emergent themes.

Through close analysis of the interview data, I identified key patterns and themes. Starting with basic codes, I refined them into a codebook and reorganized them repeatedly to uncover deeper insights. From 44 initial codes, I grouped and combined them based on recurring keywords and terms, ultimately forming nine themes aligned with my research questions. By examining meanings and patterns within these themes, I conducted a process of axial coding, which involved connecting and relating these themes to each other. This ultimately led to refined knowledge of the core area of the current inquiry and compilation of a comprehensive analysis document,

Three themes each were formed to examine each research question individually. Theme 1 focuses on secondary school physics teachers’ belief in effective instructional strategies to explain complex concepts in physics and present the concepts to students in an easier way. Theme 2 indicates physics teachers' desire to blend technology productively in their classrooms to simplify abstract physics concepts. Theme 3 spotlights the enhancement in student outcomes in physics with technology integrated instructional practices. Table 4 summarizes the connection between codes and themes aligned with RQ1.

RQ1: What are Nigerian secondary teachers' perceptions about integrating ICT into the physics curriculum?

Table 4

Codes and Themes Identified in Relation to RQ1

Codes	Themes
1. Abstract physics 2. Comprehend 3. Instructional materials 4. Manual methods	1. Physics is a complex subject that requires effective instructional methodologies to elucidate and deliver it to students.
5. Technology-driven teaching 6. Flipped classroom 7. Easy-to-understand 8. Real-life connection 9. Visualize physics	2. Technology integration in teaching simplifies and strengthens the understanding of abstract physics concepts.
10. Simulations 11. Theory with practice 12. Student engagement 13. Improved interest 14. Morale boost 15. Exam results	3. Technology integration in teaching ensures enhanced student engagement in learning and improves student outcomes in physics.

The second set of three themes were formed to align with the second research question framed. Theme 4 points out the complexities encountered by secondary school physics teachers in their attempts to integrate technology in their instructional methodologies. Theme 5 highlights the expectations of the school administration on its teachers to blend technology in instructional pedagogies. Theme 6 emphasizes that secondary school physics teachers in the state under study received very limited support from their school administration for integrating ICT in their classroom instructional strategies. Table 5 maps the codes used in the analysis of the corresponding themes that addressed RQ2.

RQ2: What are secondary physics teachers' perceptions of the facilitating conditions that challenge ICT integration in the state under study in Nigeria?

Table 5

Codes and Themes Identified in Relation to RQ2

Codes	Themes
16. Unstable power supply 17. Inaccessibility of internet 18. Limited digital tools/devices 19. Large class strength 20. Ill-equipped ICT labs	4. Secondary school physics teachers faced challenges when integrating technology in instructional methodology.
21. Use of technology 22. Implementation 23. Motivation 24. Negative attitudes	5. Secondary school physics teachers believed their school administration expected regular use of technological instructional strategies.
25. Administrative support 26. Software/hardware support 27. In-house professional support 28. Personal devices/gadgets 29. Running costs 30. Projectors/smart boards	6. Secondary school physics teachers received very limited support from their administrative division

The last three themes were formed to align with the third research question framed. Theme 7 focuses on secondary school physics teachers' requirement for consistent support from their school administration and government authorities for successful ICT integration. Theme 8 highlights the beliefs of the teachers on professional development and training for strengthening their digital skills. Theme 9 draws attention to the aspirations of the teachers to learn and be trained to effectively integrate ICT in classroom practices and deliver physics as a fun-to-learn subject. Table 6 explores the link between the codes and themes derived for RQ3.

RQ3: What are secondary physics teachers' perceptions of the resources needed for ICT integration in the state under study in Nigeria?

Table 6

Codes and Themes Identified in Relation to RQ3

Codes	Themes
31. Financial support 32. Interactive boards 33. Well-equipped ICT labs 34. Uninterrupted power supply 35. Affordable Wi-Fi connection 36. Paid web applications	7. Secondary school physics teachers required strong support from the school administration and the local government for effective ICT integration.
37. Effective teacher training 38. Mental health 39. Professional development 40. Grooming 41. Teachers' confidence	8. Secondary school physics teachers perceived professional training and development to support their use of ICT in classroom teaching practices.
42. Blended classrooms 43. Modern instructional strategies 44. Self-development	9. Secondary school physics teachers yearned to learn from training sessions to create classrooms that incorporated a fun-way of learning physics.

Guided by the three research questions and an effective data analysis, I adopted a thematic coding approach. This approach facilitated the elucidation of nine distinct themes emerging from the interview data. By presenting the themes alongside their corresponding research question, as seen in Table 7, the comprehension of the analysis is enhanced. Each theme is delved into a greater detail in subsequent parts of the results section, to shed light on the various aspects of teachers' perspectives on ICT integration in secondary school physics classrooms. Table 7 presents a clear overview of the thematic connections and guides through the investigation of specific aspects of teacher experiences with technology integration, as explored in each research question.

Table 7

Themes' Convergence With Research Inquiries

Themes	Research questions
1. Physics is a complex subject that requires effective instructional methodologies to elucidate and deliver it to students. 2. Technology integration in teaching simplifies and strengthens the understanding of abstract physics concepts. 3. Technology integration in teaching ensures enhanced student engagement in learning and improves student outcomes in physics.	RQ1: What are Nigerian secondary teachers' perceptions about integrating ICT into the physics curriculum?
4. Secondary school physics teachers faced challenges when integrating technology in instructional methodology. 5. Secondary school physics teachers believed their school administration expected regular use of technological instructional strategies. 6. Secondary school physics teachers received very limited support from their administrative division.	RQ2: What are secondary physics teachers' perceptions of the facilitating conditions that challenge ICT integration in the state under study in Nigeria?
7. Secondary school physics teachers required strong support from the school administration and the local government for effective ICT integration. 8. Secondary school physics teachers perceived professional training and development to support their use of ICT in classroom teaching practices. 9. Secondary school physics teachers yearned to learn from training sessions to create classrooms that incorporated a fun-way of learning physics.	RQ3: What are secondary physics teachers' perceptions of the resources needed for ICT integration in the state under study in Nigeria?

Themes Aligned With Research Questions and Results

The following thematic discussion delves into the core themes extracted from the interview data. Specifically tailored to address the three research questions guiding the study, the interview design strategically guided participants towards insightful conversations that brought out their perceptions concerning the research focus. This deliberate approach culminated into rich data, providing a nuanced apprehension of the research inquiries and fostering the elucidation of relevant themes. A total of nine themes surfaced during data analysis.

Research Question 1

The UTAUT model's core percepts of performance expectancy and effort expectancy served to frame the study's first research question.

RQ1: What are Nigerian secondary teachers' perceptions about integrating ICT into the physics curriculum?

This question explored teachers' perceived impact of technology integration on their pedagogical performance. Ultimately, teachers' perceptions on technological tools and their potential to enhance instructional effectiveness significantly influenced their adoption and learning efforts. The first set of questions during the semistructured interviews explored secondary school physics teachers' perceptions about technology integration and experiences with instructional methodologies incorporating ICT in the classrooms. As teacher-participants answered the interview questions, they put forth their perceptions about the abstract nature of physics, as a subject. The participants recounted their lived experiences in blending traditional instructions with ICT-integrated pedagogies to intensify student outcomes. The participants also discussed the effectiveness of ICT integration in physics classrooms, leading to improved examination results. The discussions, after analysis, yielded three distinct themes grounded in the teachers' unique perspectives and lived experiences in physics classrooms. Themes 1, 2, and 3 highlighted teachers' credence in technology-integrated teaching techniques to amplify the understanding of complex concepts in physics. These themes confirmed the significance of performance expectancy and effort expectancy in technology integration decisions. Expressions and remarks such as *abstract, easy-to-understand, simulations,* and *morale boost* demonstrated the thoroughness and comprehensiveness of the codes in covering the theme areas.

Theme 1: Physics is a complex subject that requires effective instructional methodologies to elucidate and deliver it to students.

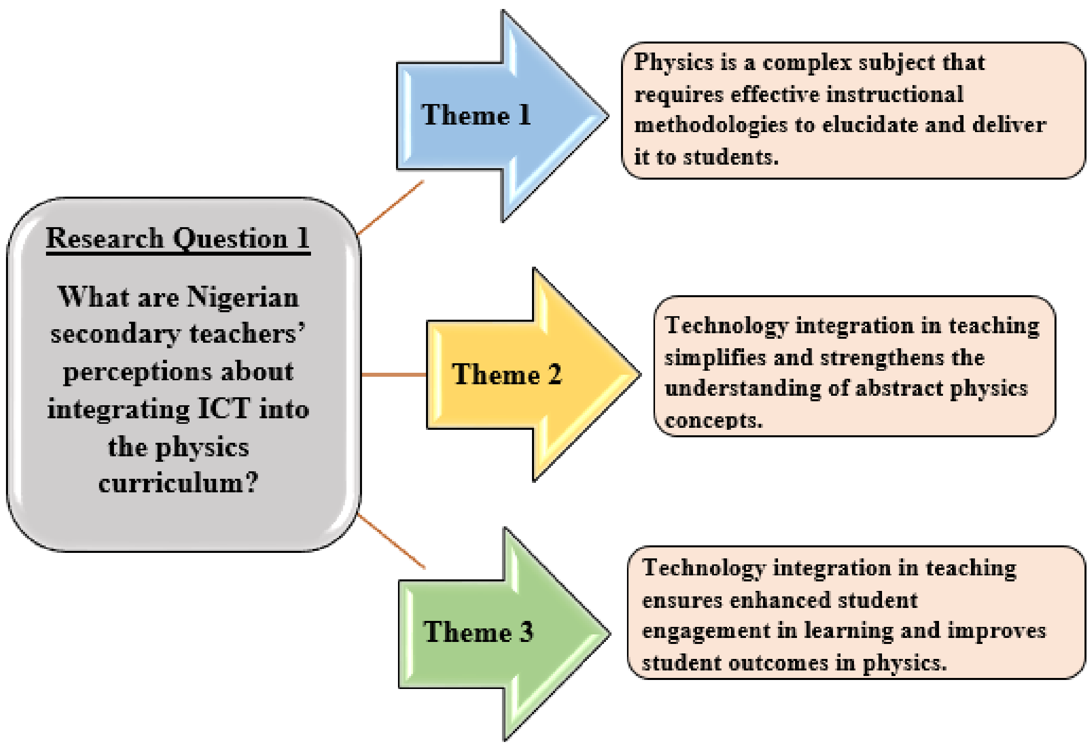
Theme 2: Technology integration in teaching simplifies and strengthens the understanding of abstract physics concepts.

Theme 3: Technology integration in teaching ensures enhanced student engagement in learning and improves student outcomes in physics.

The three themes brought to the forefront that students grappled with the intangible concepts of physics presenting a significant obstacle to understanding and classroom engagement. The themes also offered valuable insights into the advantages of ICT-integrated practices in physics education. The first research question and the three themes aligning with it are represented in Figure 1.

Figure 1

Themes Aligned With RQ1



Theme 1: Physics Is a Complex Subject That Requires Effective Instructional Methodologies to Elucidate and Deliver It to Students. This theme delved into the varied insights of physics teachers revealing the abstract and complex nature of physics. By exploring the teachers' unique lived experiences, this theme offered an in-depth acknowledgment for the individualities of the teaching community. While answering the set of interview questions related to RQ1, a notable consensus emerged regarding the perceived difficulty of secondary physics – its abstractness. Each of the 12 participants highlighted this factor as a major stumbling block for secondary students, hindering their

comprehension and enthusiasm for the subject, and presenting challenges in grasping and engaging with the subject's concepts.

Participant 1 stated, "Most students find it [physics] difficult...they think physics is abstract." Likewise, Participant 7 stated, "There are some concepts in physics that we may not be able to relate to the students. Talk of quantum physics." Participant 10 remarked, "Physics has a lot of abstract components that is very difficult to explain to the students," while Participant 8 expressed, "Most people will tell you that you teach physics in abstract." This shared concern of the physics teachers from the state under study pointed to the metaphysical nature of physics being a key contributor to its perceived difficulty among secondary school students.

The inherent complexity of physics emerged as a persistent theme in the initial narrations of the interviewees. They described secondary school students struggling with concepts like electrostatics, laser, nuclear physics, and fields, emphasizing the challenge of making these unseen realities relatable to students accustomed to the concrete world. While explaining about classroom experiences during a lesson in fiber optics, Participant 4 lamented, "Been so hard for the students to conceptualize or get…it [fiber optics] doesn't really make sense to them." Many participants expressed the frustration of seeing students struggle to visualize complex phenomena in physics, highlighting the disconnect between mathematical equations and lived experiences.

However, some teachers saw this abstractness as an opportunity rather than an obstacle. Participants 1, 5, and 9 discussed strategies like demonstrations, hands-on activities, simulations, and laboratory experiments to establish a connection between the theoretical and the tangible. Participant 1 excitedly shared her use of "virtual field trips" to immerse students in the world of rockets, while Participant 9 spoke passionately about taking the students to a football field, "When I am teaching projectile in physics…I use football field when a ball is being kicked. I use sports," where students explored concepts through hands-on activities. Participant 1 explained about improvising the locally available resources to make the class interesting. The participant expressed fervently:

> I go out of my way to bring physics to life… I use examples that are related in our own way to teach. When we are talking about friction, we have grinding machine here … and these students are used to grinding machine when old women want to use it in the morning. They dismantle it. They are holding it for lubrication … that's basically what I do … for the students to grasp the concepts better.

Through their contrasting perspectives, teachers emphasized the multifaceted nature of teaching physics and the diverse approaches adopted to navigate the inherent abstractness of the subject.

Mentioning their perceptions on the instructional strategies that support physics teaching, Participant 11 mentioned, "It [innovative pedagogy] helps to simplify the subject [physics] and then make the abstract to be simple and interesting for the students and all the learners." Although navigating the abstract nature of physics presented challenges, Participants 1, 3, and 4 also spoke of its unique allure. These participants described the subject's elegance and inherent logic, finding joy in unravelling its mysteries and revealing the interconnectedness of the universe. Participant 1 remarked, "It's like learning a secret language that unlocks the world around us." Participant 3 spoke of the awe inspiring nature of physics, noting how understanding abstract concepts like gravity could spark a sense of wonder and curiosity in students. Participant 3 stated:

> When we talk about the force of gravity … they [students] may understand how the force of gravity is really working … they will be able to understand … then they will be able to apply them since they know and really understand the concept.

This appreciation for the inherent beauty of abstraction aligned with the interviewees' perceptions to move beyond mere comprehension and foster in students a love for physics. Participant 4 expressed that by highlighting the elegance and wonder inherent in the abstract concepts of physics, teachers can pique students' interest and curiosity and motivate them to delve deeper into the world of physics. Participant 5 shared:

> There are some topics I love using simulations for. Example is heat, heat waves, …, heat is really, let me say, its kind of abstract. I won't say abstract anyways, but for students to understand it deeply, you have to use simulations. When I use simulation for heat, I can easily explain change of state. I can explain the quantity of heat required to melt a substance. I can easily explain the heat required to raise the temperature of a substance by 10°C. … to raise the temperature of a substance to any particular value…simulations have helped a lot in explaining.

This perspective added another layer to the first theme of this study, reminding teachers that teaching physics is not just about overcoming challenges, but also nurturing a sense of wonder and passion for the intricate working of the universe.

Theme 2: Technology Integration in Teaching Simplifies and Strengthens the Understanding of Abstract Physics Concepts. Technology integration in teaching holds immense potential to simplify and strengthen student comprehension of the abstract ideas in physics (Ageyi & Ageyi, 2019). The second theme, aligned with RQ1, emerged prominently while exploring interview data. Drawing on the physics teachers' perspectives, this theme delves into the various ways technology is blended in physics curriculum and how it can potentially bridge the gap between the theoretical and the tangible.

Every participant, regardless of their years of teaching experience, reported positive feedback on technology's impact in teaching and learning of physics. Participant 10 remarked, "Integration of technology has actually improved on teaching and learning … instead of students looking at it [physics] from abstract point of view, it brings it down in a real-world situation for them." For most of the teacher-participants, a central tenet guiding technology use was the conviction that students benefit academically throughout their schooling when exposed to technology integrated learning techniques. Aligning with the performance expectancy tenet of the UTAUT, the participants concurred that blending technology was based on their expectation that the digital tools would enhance student learning outcomes.

According to Participant 8, ICT-integrated teaching simplified difficult physics concepts such as satellite motion. Participant 8 expressed in a lively way,

> Gone are the days when we teach and we use ordinary mouth to tell them, this is how to launch a satellite … this is how to project an object. But with the

> integration of technology, they will see the way satellite is launched through the virtual lab, you know, how to project and they will see the path of the projectile object.

Teacher-participants highlighted the value of interactive simulations in allowing students to manipulate variables and observe the resulting changes in physical systems. This hands-on exploration breaks down complex concepts into smaller, more manageable components, promoting active learning and deeper understanding. Participant 5 stated passionately about the class on projectile motion where virtual simulations were used to assist students to understand a physical phenomenon in a better way:

> Projectile motion requires velocity, the angle needed to project an object to a distance with the required velocity … so, when you vary those using simulation … when you vary the period, the frequency, when you vary the angle and the velocity, you have different values of range … and the student sees the kind of wave pattern it's giving you, they will get to understand the phenomenon better.

The teacher-participants unanimously agreed that technology provides platforms for collaborative learning and communication. A significant number of study participants stated that shared documents and online group calls offer opportunities for students to collaborate, discuss concepts, and adopt peer-learning perspectives. This interactive exchange deepens understanding and reinforces learning, particularly for difficult concepts, remarked Participant 2. Participant 8 also mentioned about collaborative learning and communication, "By the time I group them into smaller groups, they communicate, they collaborate together, they think out of the box, and they give results."

Participants 4, 6, 8, and 9 mentioned about the flipped classroom model adopted on a few occasions in their classrooms. The flipped classroom pedagogical approach inverts the traditional structure, with introductory content delivered outside the class through online lectures, videos, or digital resources. During classroom time, the focus shifts to interactive activities, problem-solving, and collaborative learning, guided by the teacher (Rahman et al., 2021). Participant 4 supported the flipped classroom model by stating, "Downloading some videos online, and sending them to their [students'] personal WhatsApp group for them to watch at their own leisure time … really help the learning and teaching of physics." Participant 8 expressed happily:

> I do videos, video lessons. I send to my students, even to watch from the comfort of their own. They watch. They learn, even while at home. They come back to class to explain to others. It makes it [learning] so effective and efficient."

Participant 6 explained that the flipped classroom approach aligns with active learning, allowing students to revisit foundational concepts independently and engage in more meaningful experiences during class time. Participant 9 underscored the benefits of the flipped classroom in addressing the challenge of teaching complex physics concepts. The participant explained:

> Using my phone with data, I send the picture, the video to them [students], maybe prior to the class on WhatsApp … they view, and then when we come to class, we analyze all those pictures, videos. We indulge in discussions and hands-on activities.

Participants 2 and 4 elaborated on the potential for visualization using technology in simplifying the delivery of difficult physics concepts. Traditionally, visualizing abstract concepts has relied on static diagrams and figures. Participant 4 shared joyfully, "Making use of technology … you can bring it [physics] into classrooms and they [students] can see the life, even though they cannot touch it … it's like bringing the reality into the classroom." Participant 4 noted that video explanations and simulations offer unprecedented opportunities for visualization, fostering deeper understanding and student engagement. The participant went on to state,

> When I was trying to explain to them [students], this is optical fiber cable … I am just telling them verbally … it doesn't really make sense to them. Then I tried to download some videos from YouTube … I played the video … when they see the video … they learn more, then they try to resonate with it. It has really been helpful.

The potential of gamification to cater to diverse learning styles and make studying of physics more enjoyable was also brought up by Participant 12. The participant shared:

> If we can integrate some little games … something that would just take like three to four minutes … they [students] don't want to spend too much time on something … they want the visual … it will go a long way because I have tested some … it was very interesting … the students will be eager to come to physics class or to do anything you ask them to do pertaining to physics, in as much as there is technology, because they want to use technology.

Theme 2 addressed the first research question with an exploration about secondary school physics teachers' perceptions related to technology integration in teaching physics. Many teacher-participants shared their classroom experiences of ICT-integrated techniques to deliver complex concepts in physics. Several participants concurred that ICT-integrated pedagogies have the power to simplify and strengthen students' understanding of abstract concepts. Some participants also expressed concern over the continuing traditional methods of teaching being followed in their schools due to challenges in integrating technology.

Theme 3: Technology Integration in Teaching Ensures Enhanced Student Engagement in Learning and Improves Student Outcomes in Physics. Physics, with its abstract concepts and complex calculations, can often present a hurdle for students, leading to disengagement and low achievement (Assem et al., 2023). However, the emergence of educational technology offers a potential solution. Throughout the process of data interpretation, I gathered in-depth perspectives of the teacher-participants' from the interview transcripts on how technology influences students' motivation, classroom participation, and understanding of physics concepts. The analysis adopted an inductive approach allowing this theme to emerge naturally. My thematic analysis helped me identify codes such as *morale boost, improved interest,* and *student engagement,* assisting me in formulating Theme 3 aligned with RQ1. This theme delved into the lived experiences of teachers to explore how technology integration impacts student engagement and learning outcomes in physics classrooms.

All teacher-participants lauded technology's ability to promote active learning. Participant 12 stressed on the opportunities provided by digital simulations for student experimentation and engagement. The participant described the degree of student involvement resulting from ICT integration. The participant proceeded to state, "I remember…I brought a simulation to the class, projected it before we started the class. And I see how happy the students were. In fact, the class was very, very lively that day." Participant 5 added:

> Using simulations is very, very helpful because a student gets to interact with the experiment even more then they would, when performing it in reality … they can easily alter the values in simulations, and they will see the effect immediately without error. So it is kind of easier than even performing the experiment itself.

Students are more engaged when they can discuss their findings, shifting classroom learning from passive listening to active participation. Stressing on this fact, Participant 11 shared:

> There was a certain topic I taught in SS [senior secondary] on optical instruments. So the only optical instrument I was able to show them in school was the microscope. We had to make use of the internet to get videos of telescopes and other optical devices. And the students were really, really interested when I showed them the videos … integration of technology has really improved their learning and their performance.

The participant went on to add, "When we integrate [technology], it makes learning more interesting. Even students who don't like the subject are motivated to get more information. And it also develops critical thinking in students … brings out their creativity."

Teacher-participants emphasized the ability of technology to ensure inclusive learning opportunities, catering to "the average students and the upper students," imparting information "across to all types of learners," and "carrying everybody along." Such adaptive learning environments ensures students' progress on the learning pathways, commented Participant 6. This participant, when sharing about ICT-integrated teaching and its role in enhanced student engagement, stated:

> The aid of technology in physics … makes a great impact on them [students]. It has been able to improve them … you will see the eagerness in them, the heart in them … they really love it [ICT-integrated lessons] … they even prefer it rather than one standing and teaching.

Teacher-participants revealed positive correlations between ICT-integrated teaching and student engagement in secondary school physics classrooms, leading to better exam scores and a more positive attitude towards the subject. Participant 12 remarked, "This [technology integration] boosts their [students'] morale. This boosts their eagerness to learn, when they see you bring physics to real-life … they were eager to answer questions … just because there was technology integration in the class." The participant proceeded to state, "We should be expecting above 90% results from the students, I am very, very sure of that." Participant 8 reiterated that student outcomes go beyond school exams and stated:

> Eight, nine years ago, the result has not been encouraging … but today with integration of technology, at least we have 90% to 100% results … and the children are doing great. Even outside the classroom, they are doing great. Majority of them now even find more careers in physics.

Analysis of the interview transcripts brought out a strong consensus from the teacher-participants regarding the ease created by technology integration in the delivery of the lessons in secondary school physics classrooms, resulting in increased confidence in students to face their exams. Participants expressed ICT-integration making their teaching “seamless,” “delivered more easily than lecturing,” “easier than before,” and “easy for the teacher and for the learner also.” Participant 4 said, “For me, it [technology] makes my work easier … I don’t need to talk much. I just let the technology do the whole of the talking and the whole of the teaching.” However, Participant 10 pointed out the significance of effectively integrating ICT without compromising pedagogical soundness to lead students toward better achievements in their exams. Emphasizing on the crucial acknowledgment of the potential limitations of ICT integration, this participant underscored:

> We integrate technology in teaching physics, we have to align those tools with learning objectives. Because, at the end of the day, when the objectives are met, then the students will know what is expected of them in writing their final exams.

Participant 10 added:

> When we started integrating technology, we observed that the results of our students are improving. So, for the past five years now, when the state

> government actually trained most of the teachers to start integrating technology … we have been recording close to 90% pass in physics.

Teacher-participants shared that they were largely motivated by a belief system centered on the transformative power of educational technology. In their minds, the participants said, technology acted as a catalyst, igniting a spark of enthusiasm within students and propelling them towards academic success. Additionally, teacher-participants shared that witnessing enhanced classroom engagement and improved final exam results motivated them to invest time and effort in mastering technology tools. Such behavior of teachers aligned with the UTAUT principle that perceived ease of use influences technology adoption. Participant 4 put forth his perception about the efforts of teachers to learn technology in this manner:

> Technology has really, really facilitated an effective teaching learning process … it helps my students to become more acquainted to what they are learning. And it helps me as a teacher to learn more. Because nobody is an island of knowledge. With the help of technology, I am well prepared as a person.

Participant 9 stressed, "I would like to be upgraded on the delivery of my subjects and be trained on how to use ICT more and more." Participant 11 expressed a strong wish to acquire digital skills to facilitate delivery of technology-integrated lessons and cater to the requirements of the students. The participant shared:

> I would love to learn … improve my own technical skills … I would also like to learn how to create videos … lessons for my students. Because, once I am trained, my training, I'm sure, is going to meet the needs of my learners.

Participants contributed valuable insights into the nuances of physics teaching, the abstract nature of physics as a secondary school subject, their perceptions about the expectations in adopting digital pedagogies in their instructions, and the effect of ICT integration in physics education. The participants also identified student engagement as a visible manifestation of their interest through active participation, attentive behavior in the classrooms, and interaction with the instructor and peers. Teacher-participants' expectations on student performance aligned with the performance expectancy tenet of the UTAUT. Drawing upon the effort expectancy tenet of the UTAUT, these themes also explored the phenomenon of teachers actively seeking to learn technology tools.

Research Question 2

This question was formulated based on the percept of the user's belief on organizational and infrastructural support for use of technology, as seen in the UTAUT model.

RQ2: What are secondary physics teachers' perceptions of the facilitating conditions that challenge ICT integration in the state under study in Nigeria?

This question investigated secondary school physics teachers' perspectives on the support infrastructure and resources available for technology integration. Teacher-participants detailed the accessibility and the extent of technology resources offered by the school administration and district, illustrating its impact on their integration efforts. Varying perceptions of administrative support were reported by the teacher-participants while responding to the set of interview questions related to RQ2. Combing through the interview transcripts yielded the second group of themes aligning with the facilitating conditions percept of the UTAUT framework.

Theme 4: Secondary school physics teachers faced challenges when integrating technology in instructional methodology.

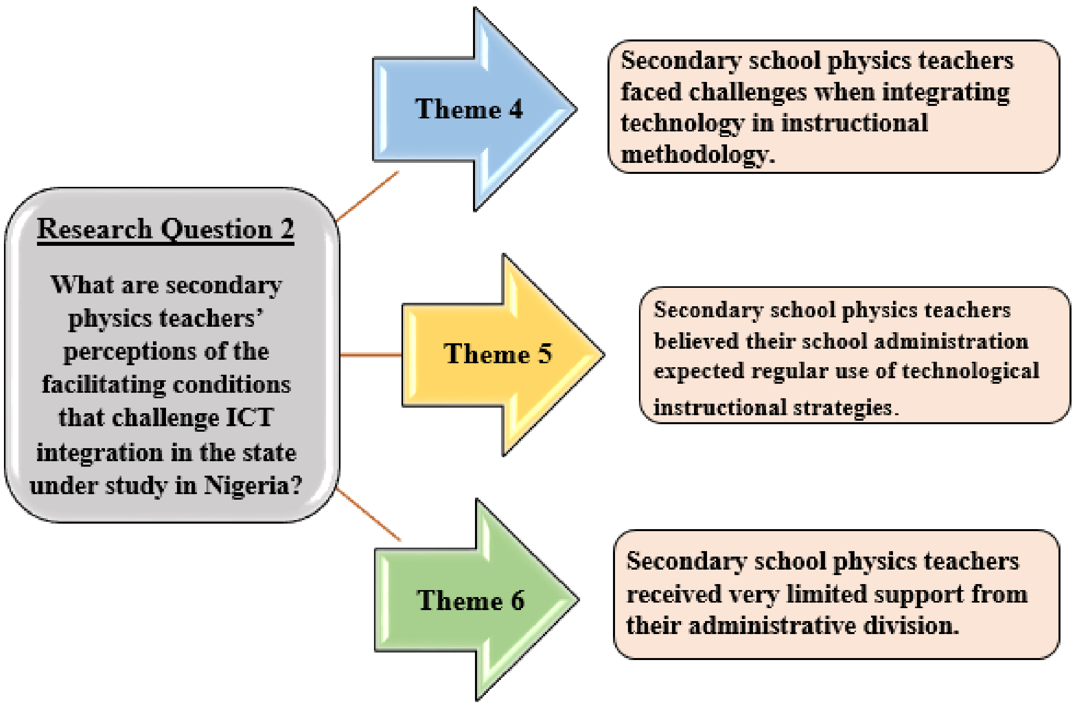
Theme 5: Secondary school physics teachers believed their school administration expected regular use of technological instructional strategies.

Theme 6: Secondary school physics teachers received very limited support from their administrative division.

The teacher-participants' responses to the second set of interview questions brought out their insight into the conditions required for effective ICT integration in secondary school classrooms. The participants spoke of the various challenges faced by them during technology integration. The teachers called attention to the limited, and in some cases, no support provided by the administration of various schools in the district to aid ICT integration in instructional methodologies. Themes 4, 5, and 6 deduced from the interview transcripts spotlighted on how secondary school physics teachers, in the state under study, struggled to integrate ICT in engaging their students during face-to-face classroom sessions. Remarks and expressions such as *no electricity*, *poor Wi-Fi, one projector, personal laptop, provided no support*, and *no motivation* created codes that directly captured the specific nuances of the emergent themes. Figure 2 represents the second research question and the three themes aligned with it.

Figure 2

Themes Aligned With RQ2



Theme 4: Secondary school Physics Teachers Faced Challenges When Integrating Technology in Instructional Methodology. Secondary school physics teachers shared a complex tapestry of challenges when attempting to integrate technology in their instructional methodologies, restricting or impeding students' utilization of technological tools. These challenges, ranging from pedagogical concerns to resource limitations, contributed to restricted technology access in classrooms. Teachers identified the challenges as significant barriers to ICT integration in physics education, resulting in reduced opportunities for students to engage with and benefit from such educational tools.

Teacher-participants shared a consistent perception of inadequate power supply as a major roadblock to ICT integration in the educational settings within the state under investigation. This pervasive challenge was universally reported by interviewees across all institutions of the district. “Electricity is one of the major challenges,” commented Participant 1, while Participant 2 remarked, “We do not have power supply all the time,” Participant 6 reiterated, “One of the greatest challenges is the electrical power,” and Participant 8 stated, “Challenges, oh, electricity. Constant electricity. That’s one challenge.” The narratives of the teacher-participants consistently highlighted the reliance on generators as the primary means of meeting their power needs, emphasizing the systemic nature of the electricity supply issue. This dependence on generators, in turn, was identified as another major obstacle to effective ICT integration due to the high fuel cost in this part of the world. Participant 4 shared:

> One of the major problems is power failure … and fuel is more expensive … I can remember a scenario … I had prepared a video, I had set up the laboratory, where I had already set up my projector, the screen, and everything. Unfortunately for me, before the class was about to start, the power was interrupted. And I had to go to my principal, to plead with her … and instantly, my principal was telling me that there’s no fuel … I cannot teach them [students] verbally … I was so sad. I wasn’t happy about it.

Participants revealed that the sheer number of students in a single class presented a significant hurdle to ICT integration. Participant 12 mentioned, “The class size is much … you can have 80, 85, 100 in a class.” “The population is too much … we have a classroom, you know, full of 150 students," pointed out Participant 8. This staggering student-teacher ratio in secondary school classrooms in the district was echoed throughout the interviews, limiting the ability of physics teachers to offer personalized guidance and share the available technical resources effectively to fully engage in student learning.

Teachers' lived experiences further indicated that limited access to technology resources exacerbated the challenges faced in large classes. Limited access to technology, from the teachers' perspectives, included inadequate devices, poor network facilities, and ill-equipped ICT labs. The participants expressed concern over equitable access to all students becoming difficult with inadequate devices. Participant 12 brought up this challenge, stating, "The equipment to use to able to carry everybody along, that's one of the major challenges we have." Participant 2 shared about the lack of digital resources disrupting technology integration, saying:

> In my school, we have the ICT lab. And in the ICT laboratory, not all the laptops, desktops, they are working. About less than 50% are working. And we have less than 20 computers. And in my classroom alone, I have over 50 [students] … so there's no way I can bring them to the computer lab to make use of it. So it's not going to help.

Some participants also mentioned about the insufficient number of projectors to cater to need of the whole school. "The projector, in my school, we have one. Sometimes, I want to use it. Another teacher wants to use it. We have to wait for ourselves … I'll wait for you to do first," said Participant 4. Participant 12 shared his experience with a single device, calling attention to the immense pressure placed by large classrooms on teachers to maintain order and deliver instruction effectively. The participant suggested that teachers often prioritize classroom management over technology integration due to time constraints and resource limitations. The participant shared:

> They [school] gave us a tablet. A tablet. Now, if I take a tablet to the class, a class of 80, before you know it, before you start showing everybody along the rules that you have, your time is gone. Unlike when you have it projected in front of the class … you just give them like probably 10 minutes … you see they will pay attention, they will be quiet, they want to hear what you are going to say and they want to add their own as well … you see their understanding.

Some participants also stated about the widening digital divide among students due to the socioeconomic disparities in the students' families. Adding to inadequate technological resources in the school buildings, the inability of parents to afford personal laptops, tablets, mobile phones, or internet connectivity for their children forces them to rely on shared devices, often their parents' phones. Families that could provide a mobile phone to their children had inhibitions allowing the use of phones, commented Participant 6. The participant expressed the anxiety of parents over the negative impact of phone, where students use paid data to play video games or watch other social media sites instead of using their phone for academic purposes. These anxieties stem from concerns for potential distractions, negative content exposure, and online safety risks, stated the participant. The fact about anxious parents was also supported by Participant 2. Though majority of the teachers utilized technology responsibly, the participant indicated concerns about instances of teachers engaging in inappropriate online interactions with students. Participant 4 summed it up sadly:

> Most times, our students complain about the network provider. Then the data … they don't have money for data … it costs to put data on your phone … sometimes your battery is low. There is no power supply. You need to buy fuel for your generator … it is really dragging us back.

To overcome such challenges related to insufficient devices, some teacher-participants mentioned that they make use of their personal devices. "I bring my laptop to the class," "I use my own personal computer," "All what I'm using is my personal material," participants shared. Participant 10 shared a unique pedagogical strategy employed within their classroom. The participant mentioned about the strategy followed when faced with limited digital devices, additionally stating the challenges faced when implementing this strategy:

> B-Y-O-D Bring your own device … I now begin to tell my students you need to B-Y-O-D … one major challenge I face is lack of constant supply of electricity. Even when you ask the students to come with their own devices, most of them come with dead devices … they don't have the means to charge their devices. Another challenge that I face is that students' parents are not exposed to technology. So now when you tell B-Y-O-D, parents, most of them frown at it … why the need for bringing laptop, bringing phones to school …that's a major hindrance.

Presenting a completely different viewpoint, Participant 10 put forth the challenge faced by teachers in balancing traditional teaching with ICT-blended teaching. The participant stated, “Another challenge I face is how to balance technology with traditional teaching … how to actually encourage my students to align with the use of technology in teaching.” Viewing these challenges from a different perspective, Participant 1 explained how the hurdle of insufficient devices was overcome in the class by a simple improvisation. The participant elaborately explained:

> I meet up with some of my colleagues. I had to recharge [data] their phones for this … I’m like, tomorrow I have physics at 10 a. m. … I want to make use of your phone … some of my colleagues, four or five of them will come to my class during my time … I have them in strategic places in my classroom when it is time for me to show it [digital content] to students … Another thing I do is I have some parents’ phone number ... I give these parents a call … Can you please allow your child to bring your phone to school so that we can do this [activity] together so that they are not left behind? Some of them might not send it because it’s also their business line … they will sacrifice to come to school in the morning so that after the class, they take their phone and go away.

The participant went on to add,

> It’s all about your dedication, your passion, and looking for ways to make sure you improvise, we try as much as we could do to make sure that we don’t deprive these students the access to knowledge, because they are our future.

Through their lived experiences, teachers brought to the forefront the efforts taken by them, despite challenges, to make ICT-integrated learning techniques accessible to their students.

Addressing the set of interview questions framed to explore physics teachers' perceptions about the factors that challenge ICT-integration in secondary school classrooms, participants discussed about the facilitating conditions percept of the UTAUT. Teachers perceived the interplay of electricity issues, resource-constrained school environment, socioeconomic factors, shared devices, limited internet access, and inadequate school infrastructure in hindering the efforts to integrate technology in their classroom pedagogies. A critical shortage of digital devices within schools, impeding equitable access for all students was suggested by the teachers. Participants brought to light that the limited technology access created a cycle of disadvantage, where students struggled to keep pace with their peers in other parts of the country and the world, impacting their academic performance and future opportunities. Participants also noted the compounding effect of limited internet access in school and at home, often unreliable and insufficient for completing assignments or accessing educational resources.

Theme 5: Secondary School Physics Teachers Believed Their School Administration Expected Regular Use of Technological Instructional Strategies. Theme 5 stemmed from the social influence percept of the UTAUT, analyzing the perceptions of the secondary school physics teachers about how important their school administration thought that technology should be used in teaching practices. Though most of the teacher-participants acknowledged a general emphasis on educational technology by their administration, perceptions about the specific expectation for its use in physics classes varied. Asked if the administrators expected its teachers to integrate technology in their instructions, Participant 1 answered instantly, “Of course they do,” while Participant 11 evaded the question and said, “That’s a big question.” But Participant 11 went on to add, “What we [teachers] do is to manage the situation on ground,” indirectly implying that though the school administration expected technology integration, teachers had to manage with the little resources available in schools, overcoming various technological barriers. Some participants understood the limitations of the administrators, owing to the economic conditions prevalent in the country and were supportive towards the school leaders. Participant 8 reassured, “Well, they [administrators] are trying their best … really doing very well. But, you know, they can’t do everything. We also assist.”

A few participants expressed dissatisfaction over the administrative support provided. When asked about the school’s expectation for ICT integration, Participant 5 conveyed, “Definitely! They [administrators] always say that. Without providing the support, they still want us to use technology. Even the minimal support that we [teachers] need, they are not providing it … how should I use it?” “The expectation is too high … they [administrators] want us [teachers] to do magic,” replied Participant 12. Participant 10 answered the interview questions regarding school administration’s expectation for technology integration from a different standpoint. The participant stated:

> What they [administrators] expect from us is that we should embark on personal development. Apart from the training they expose us to, they expect us to show

> more interest by personally developing ourselves. Then, they expect us to actually expose students to the training we received.

Participant 1 took the similar standpoint as Participant 10. The participant shared, “They [administrators] expect us to do [integrate technology] … because they want to tell you this is the 21st century … we [teachers] do more training and retraining for students and fellow teachers.” Such perceptions emphasized continuous learning for both teachers and students, promoting a dynamic and enriching educational environment.

Physics teacher-participants discussed the crucial role of leadership, specifically the variations in school administrators’ expectations, in influencing its success in secondary physics education. The participants shared that principals and leaders who hold a positive vision of technology’s potential for enhancing learning are more likely to reinforce its integration. Conversely, those with traditional views may resist or be hesitant to embrace change. Participant 4 expressed his despair:

> I can say it [expectation to integrate technology] varies with the head of the administration. There are some of them who are so much interested in technology … but some of these people who are our principals … they have been on the job for maybe 30 years … they don’t resonate with what technology is all about now … when you tell them, they just say, no, that’s not how we used to do it then … the way they taught then is not how we should be teaching now … a lot of things have evolved … some of them, technology does not concern them. It does not really make sense to them.

The participant also expressed his pleasure:

> We also have some that are supportive … they may not have everything but they will encourage you … they can buy fuel for you … some even buy you a drink, you know, to encourage and motivate you. A lot of challenges [to technology integration] could have been avoided if the heads of the administration are more concerned.

Two of the teacher-participants' narrative deviated significantly from the other observations, enriching my understanding of teachers' perceptions on administrator expectations related to technology integration and the facilitating conditions prevailing in some school buildings in the district. While the other 10 participants conveyed that the school administration expected the teachers to integrate technology in their instructional practices, even with the poor or no support provided for ICT integration, Participants 3 and 7 offered an alternative perspective. Asked if the administration expected teachers to integrate technology, Participant 3 replied:

> No! The major issue is most of those things [digital infrastructure], our government has not been able to provide them … so, we still make use of markers, the old way of teaching, which is already getting obsolete, which is not really making it in to the current society.

Participant 7 also echoed the viewpoint of Participant 3. While sharing the perceptions of administrator's expectations, the participant shared about the sorrowful state of the school:

> No! At the ministry level, they [leaders] are interested in integrating ICT into teaching and learning, but the school I am in, no such facilities now … that fact

> that being a teacher, you want your students to understand what you are teaching and you want them to come out fine in their examinations … but the provision [for technology integration] was not made at the school level … we have various schools and different localities, some are at advantage than others. Like where I am now, no structure. We are just managing a class of having students of 80, 120, 150 in a single class and with some students not even having seats.

Participant 2 perceived the available digital resources in school and the consequent expectations from the administration in a positive way, with self-motivation. The participant stated reassuringly:

> I am an optimistic person. They [administrators] always tell you to make use of ICT. But in cases where I don't have any means … I need to think outside the box … I am not going to say because those things [digital tools] are not available, I will not work. I need to be creative. I went to my class with my laptop … I went also with a tablet … and my phone. So I used all three gadgets … I connected to a Bluetooth speaker … I placed my laptop centrally on the table in front. I shared the tablet and phone in groups. I'm an IT person, so I make use of those devices. The creative mindset is what I have been working with all along.

This participant's perceptions and approach to challenges offered a compelling example of an individual teacher's dedication and resourcefulness in overcoming technology integration barriers. By leveraging personal devices and fostering collaborative ICT-integrated learning environment, despite limited administrative support, the participant demonstrated the remarkable lengths teachers can go to enhance student learning and cultivate joy in physics education.

The lived experiences of the secondary school physics teachers of the state under investigation, as answers to the interview questions aligned with RQ2, were analyzed. Participants highlighted the crucial role of physics teachers, their intrinsic and extrinsic motivation, and school administrators’ expectations in driving successful technology integration. Participants’ highlighted the dedication of teachers and administrators alike, in fostering a supportive environment to champion technology integration for the benefit of students.

Theme 6: Secondary School Physics Teachers Received Very Limited Support From Their Administrative Division. The semistructured interviews with secondary school physics teachers in the state under study delved into their lived experiences related to administrative support for ICT integration in their pedagogies. Participants identified two primary categories of technological support provided by the school administration: hardware support and software support. Participants affirmed a predominant sense of dissatisfaction regarding the limited, inadequate, or absent technological support provided for ICT integration in secondary school classrooms. Participants 1, 3, 5, 7, and 11 were quick to respond concerning the absence of perceived support from the school administration regarding technological resources for educational purposes. Answering to interview questions related to hardware support, the participants shared, “Nothing has really been done for us,” “We are not provided with any [support],” "They [administrators] are not providing the support I needed," and "None, absolutely none."

Participants 1 and 11 explained the substandard condition of the ICT labs in their schools. The participants characterized the shortcomings in the technological infrastructure available to both the students and teachers, inhibiting technology integration within their school buildings. Participant 1 shared, "We actually have a computer room without computers," while Participant 11 added,

> We have the ICT lab but with few computers and the computers are not even connected to any source of internet. They [administrators] can't really meet up because we have a very large population in the classroom, overpopulated classroom and they cannot cater for the population that we have on ground.

Narrating the absence of administrative support to ICT integration in the school, Participant 7 said, "The school where I am presently in, no structure … no such facilities [technology tools] for now."

Participants 2, 4, 5, 8, and 12 acknowledged that the school administration provided technological support to teachers. However, they emphasized that the support was inadequate, suggesting its limitations in meeting the needs of teachers and students. Characterizing the facilities available in the school's ICT lab as insufficient, Participant 12 stated, "Most of the technology [support] provided, it's not big enough to carry the students along," while Participant 2 remarked, "What we have is not enough for those people that are actually needed." Participant 5 expressed his dissatisfaction over insufficient resources in the form of a wish: “I will be needing more support. I will need more projectors, laptops.” Reiterating the inadequacy of ICT tools, Participant 8 added:

> We have an ICT laboratory. We have laptops, we have furniture. We have a projector and a projector board. The state [under study] gave the students phones that they can use of e-learning. We have a lot of them, but they are not adequate … when you compare it to the population of the students in the school … we have, let’s say, 10 computers to like 100 students.

Participant 4 conveyed deep dissatisfaction with the limited hardware support in their school building. The participant specifically highlighted the insufficiency of a single projector as a sole resource for facilitating technology integration within the secondary school classrooms. This shared experience further reinforced the perception that teachers are expected to personally source any additional resources deemed necessary for effective ICT integration. The participant shared:

> The only thing they [administrators] provide for us is the projector. Apart from the projector, we will bring our own computer system. Then the screen we use is usually our board, the whiteboard that we teach on … but apart from the projector … the school could not provide, probably because the government is also not funding them. But the only thing I know we have is the projector. Every other thing you have to provide or improvise yourself.

The qualitative analysis of the interview data brought out a divergence of perspectives among the teacher-participants with regard to the support from the school administration for technology integration. Though majority of the participants conveyed concerns about limited or absence support, Participants 6 and 10 shared distinct perceptions, focusing on their positive viewpoints about the school administration, district authorities, and the state government's efforts in supporting ICT integration within secondary schools. Participant 6 shared:

> The government, they really embrace it [technology integration] … the state in which I am … is still one of the best in terms of ICT supply to secondary schools. They are trying their best actually … but having a large school, having many secondary schools around … the little they have, they usually supply and support us.

Participant 10, along the same lines, stated:

> Most of the schools … the local state government schools … they have ICT centers … they have internet facilities … there is a ministry of science and technology department … they come around to help us … whenever we have hardware issues.

In terms of assistance with software for ICT integrated teaching of physics, teacher-participants acknowledged that they received some resources. However, they echoed familiar concerns expressed about hardware support, indicating that the extent of software support was also perceived as limited. Participant 10 shared about the e-learning platform provided by the government to enable students to access educational material. The participant shared, "One major software they [government] provide for us is what we call Nigeria learning passport. In that software, there are a lot of videos … a lot of simulations … I use for myself and my students."

Participants also voiced their dissatisfaction with the outdated nature of certain software installed by the school administration. The participants communicated the perception that these programs had limited pedagogical value, providing no clear advantages to either students or teachers. Participant 9 stated, "… some software, some programs are being downloaded onto them [computers] … but some of them are obsolete," suggesting potential issues regarding the compatibility of the provided software with the educational requirements of the school community.

The second set of three themes, themes 4, 5, and 6 explored the perceptions of secondary school physics teachers concerning challenges, administrative expectations, and the extent of support received from the school administration for ICT integration in physics education. Teachers raised concerns over several impediments to successful ICT integration in their physics classrooms, such as inconsistent electricity supply, unreliable internet facilities, and high student-teacher ratio. Several repetitive perceptions emerged from the semistructured interviews. In essence, participants reported lack of adequate resources, with some calling attention to the provision of only basic equipment for facilitating technology integration. Participants perceived the availability of only basic resources as insufficient for the large strength of students and effectively plan technology-integrated physics lessons in secondary school physics classrooms. A sense of responsibility for self-sourcing additional resources was also expressed by several participants.

Research Question 3

This question, informed by the effort expectancy percept of the UTAUT framework, sought to investigate secondary physics teachers' perceptions regarding the resources required for effective ICT integration within their classrooms in the target state in Nigeria.

RQ3: What are secondary physics teachers' perceptions of the resources needed for ICT integration in the state under study in Nigeria?

The effort expectancy percept underscores teachers' belief in administrative support, resource availability, and professional development for efficacious ICT integration in physics education. The interview questions encompassed the availability, accessibility, and productivity of professional development within the teachers' working environment. Answering the last set of interview questions put forward, the secondary school physics teachers explained about their obstacles and facilitators associated with technology integration. Additionally, the teacher-participants shared their thoughts and experiences on professional development offered by their district and state. The participants emphasized the need for training that equipped them to leverage various instructional platforms, from traditional resources to digital tools and online environments, within their classrooms. The participants also expressed their fervent wish for enhanced ICT infrastructure, characterized by well-equipped ICT labs, reliable power supply, and consistent internet connectivity to facilitate the seamless integration of technology into the educational experience. Themes 7, 8, and 9 derived while analyzing the interview data underscored the teachers' yearning for robust and unwavering administrative support for effective ICT integration. Remarks such as *effective teacher training, paid web applications, affordable Wi-Fi, grooming, supportive administration,* and *financial support* tailored the codes that reflected the recurring patterns in the gathered data.

Theme 7: Secondary school physics teachers required strong support from the school administration and the local government for effective ICT integration.

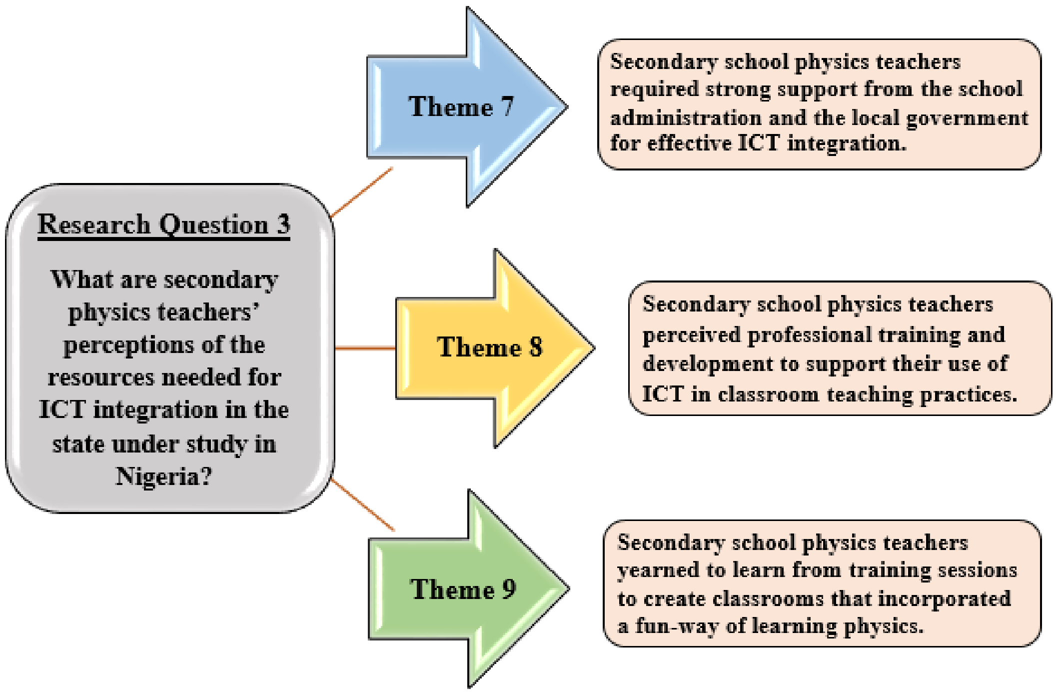
Theme 8: Secondary school physics teachers perceived professional training and development to support their use of ICT in classroom teaching practices.

Theme 9: Secondary school physics teachers yearned to learn from training sessions to create classrooms that incorporated a fun-way of learning physics.

Figure 3 represents the last three themes evolved, aligned with RQ3, to address teachers' needs in the creation of supportive environment conducive of effective ICT integration in the classrooms.

Figure 3

Themes Aligned With RQ3



Theme 7: Secondary School Physics Teachers Required Strong Support From the School Administration and the Local Government for Effective ICT Integration. This theme emphasized the critical role of strong support from both school administration and local government in enabling secondary school physics teachers to effectively blend digital pedagogy into their classrooms. Participants expressed that the support included not only the type and scope of resources considered essential, but also the adequacy of these resources in secondary schools. Several recurring perceptions emerged from teacher-participants emphasizing the need for a better administrative support structure for ICT integration. All participants expressed the imperative for

uninterrupted power supply, adequate digital tools, and internet facilities to facilitate technology integration in their pedagogies. “Need power supply,” “I would want an interactive board in my classroom,” “I will need data [internet] from the school,” “I will need a laptop of my own,” “If [digital] devices can be provided for us,” “We need some equipment for simulations,” commented the teachers.

Teacher-participants emphasized the need for administrative intervention to ensure uninterrupted power supply. Participant 5 remarked,

> The school should be able to provide alternative means [to electricity], like the generator or the solar power supply, such that when the power supply from the government goes off, we can switch to the generator or the solar power supply.

Offering a pertinent remark that emphasized the crucial role electricity in facilitating technology integration in secondary school classrooms, Participant 9 commented:

> I will need a projector that is permanently in my laboratory. I will need a screen that is permanently in my lab. I will need some equipment to simulate … but without an electric power source … you may not even have access to it in a time or a section, as the case may be.

Although majority of the teacher-participants expressed dissatisfaction over interrupted power supply and a perceived lack of administrative support for ICT integration, Participant 6 offered a distinct perspective, bringing forward a remarkable example of teacher dedication despite challenges concerning electricity. Participant 6, demonstrating a deep commitment to improve student learning through ICT integration, shared their personal initiative to overcome the challenge of unreliable power supply.

Despite facing barriers to electric power, the participant took initiative independently to fund the installation of a solar inverter. The participant shared:

> I know the importance of ICT. Even presently, with the much we are having in, let me say salary or whatsoever, I have tried to get my own projector. I even got what we call a solar inverter so that when the electrical power is off, I will have my own because I believe that when I've been able to do all my work at home, then prepare the instructional video for them, the whole thing will be well packaged. The only thing I will have to do is to get to the classroom, play it for them … students seeing this will be very impressive or will be very happy.

Through this proactive initiative, the participant ensured uninterrupted delivery of technology-integrated lessons, keeping student learning and engagement in the forefront. Additionally, the participant brought to light the resourcefulness of some teachers in overcoming infrastructural challenges and building positive learning environments. Participant 6 also highlighted the extent to which teachers proceed to bridge the gap between available resources and desired academic outcome. However, the participant also acknowledged that such individualized solution to technology barriers may not be scalable across all educational scenarios.

Beyond seeking administrative support in addressing resource limitations and power supply challenges, the participants revealed another crucial area of teacher expectations: financial support from the government and school authorities. First, teachers emphasized the need for financial investment in equipping schools and ICT labs with adequate tools. Participant 3 stated:

> The main support is financial support … there's no money, there's no way you can really do enough [technology integration] … may be you have enough laptops … that can really help, it is very easy to integrate these assets into the system.

Participants also highlighted the importance of investing in software compatible with the procured hardware to ensure its effective utilization. Participant 7 said, "If I can have support for all that educational software … that will help me to pass across my teaching and learning easily to students," while Participant 8 said, "If I can have access to updated software, resources, and tools or more devices … then I can integrate technology into my teaching process."

Second, a desire for financial support to acquire paid applications emerged as a recurring theme. Teacher-participants recognized the potential advantages of certain paid applications in improving integration of ICT in physics teaching, but indicated that they couldn't afford them due to limited funding. "You are expected as a teacher to go online, download, register, buy, pay for the software, quizzes," stated Participant 12, sharing their expectations from the school authorities to provide funds for buying digital applications crucial for successful ICT integration. Participant 5 shared:

> For the software, I would need the Scholarlab application. But it requires payment. If the school can pay for the application, I will be so happy. We have an application here in Nigeria, which is called MySchool … it also requires payment. If they [the school] can pay for that also … on that application, I can easily simulate … I can generate questions. I can prepare a simple test for students, which will assist a lot in evaluation.

Finally, some participants expressed a desire for financial incentives to motivate teachers and recognize their sincere efforts in blending technology into their instructional strategies. Participant 1 expressed, “I just wish we [teachers] had more support anyway … to acknowledge the time we invest in developing technology-based lessons … as a reward.” Participant 7 shared:

> The generation we are teaching today, they are not interested in chalk and board method anymore. Anything you want to put across to them must be related to ICT. With that you catch their attention, and they listen to you more. But if they [the administrators] can appreciate us for our work … provide us better salary … that will be appreciable.

Likewise, Participant 4 commented:

> I think the teachers themselves need to be motivated. The amount the teachers are being paid in this part of the world is meagre … they are given a salary that does not take them anywhere. This is the foundational problem, why many teachers have lost passion for teaching. Imagine a teacher that is just paid minute salary and you want him to come to class, you want him to use projector, you want him to teach effectively … so some of them just go the classroom and do whatever they like … So I feel like if there is an aid that can be raised towards technology integration that will support the teacher as a person, may be that will spur the motivation to integrate technology.

Teacher-participants emphasized the need for increased funding from the school administration and the government. The participants perceived that this funding would enable the acquisition of essential technological resources, including hardware, software, and digital applications. Additionally, teachers advocated for supplementary incentives to motivate the teaching community towards technology integration.

Theme 8: Secondary School Physics Teachers Perceived Professional Training and Development to Support Their Use of ICT in Classroom Teaching Practices. Theme 8 emerged consistently throughout the interviews, revealing a strong emphasis on the significance of professional training in supporting the teachers in their use of ICT for classroom teaching. Secondary school physics teachers perceived that additional support encompassing professional development opportunities could enhance their skills and confidence in using technology effectively for instruction. All participants echoed that professional training programs could cater to the specific need of physics teachers and address the challenges of teaching physics using technology.

Answering the interview question about the effect of professional training sessions, Participant 9 stated, “They [training programs] go a long way in supporting and helping,” “It keeps educators updated,” commented Participant 8, while Participant 7 said, “Professional training can enhance teaching and learning in such a way that we learn every day and we grow every day.” Participant 5 drew attention to the significance of professional training by stating:

> No matter the amount of knowledge you have, you always need to improve yourself professionally. Professional development develops myself, my skills, I learn new things about technology and how to implement it in my teaching and learning in the classroom … it helps a lot. When you go for professional training,

> you learn new things. The more you learn, the more you know … you get to see things which you've not seen before … learn about the ways and technologies in teaching which you can integrate in your classrooms … you get new certifications. You learn a lot.

Resonating with Participant 5, Participant 4 discussed the advantage of comprehensive training and its effect on technology integrated physics education. The participant shared:

> As a teacher, you must not be rigid. You must not be stagnant. You have to know that learning is a continuous process. That's why they tell you that sometimes you have to unlearn and relearn … If a teacher does not train, if a teacher does not go for professional development programs or does not go for capacity building programs, you know that in a little time he or she has, he is light years behind. But if you want to be up to date and know what is happening, even in the world of teaching, you have to go regularly for professional development training. It will help our teachers become digital literates and it will enhance our teaching learning process. And not only that, it will help us integrate technology more because you cannot give what you don't have.

Sharing such a perception, Participant 4 signified the critical role of effective professional development in empowering secondary school physics teachers to integrate technology within their classrooms. Likewise, Participant 10 reiterated the benefits of training programs and stated:

> Technology is evolving. Then, we need to keep up with the pace of the evolvement in technology … it [professional training] will help me gain more

> knowledge. It will also help me to be exposed to the evolving technology. Then, from there, it will make my job easier. It will enhance my teaching. It will enhance students' learning. And that will now result in better results for the students.

Participants discussed their experiences with professional development programs focused on ICT integration. Participant 8 stated, "It [professional training] keeps educators updated. And they're proficient in utilizing technology for effective teaching." Highlighting the benefits of such trainings and suggesting that the training programs equipped teachers with the necessary skills to utilize technology within their classrooms, the participant shared:

> Of recent, I registered for Microsoft Educators Centre, where we do a lot of teachers' courses. 21st century learning design, flipped classrooms, a lot of these things, we learn them. It has really been helping us in the classroom, my lessons are more interesting and more enlightening.

One participant shared a divergent perspective regarding professional development programs. Emphasizing the importance of prioritizing teachers' mental health alongside technology integration training, Participant 1 stated:

> First of all, before we go into any other thing, we need our sanity. So I believe mental health is the key … because even when you want to bring in other professional development and their mental health is nothing to write home about, then we might not actually get that. Digital teacher training is key because once mental health is taken care of, I think their [teachers'] passion will be addressed.

> And once they are passionate about it … they will make teaching of physics interesting and impactful.

Participant 9, acknowledged that the administration supported teachers with professional development, yet expressed frustration with the limitations hindering its practical application. The participant lamented that inadequate digital devices, persistent electricity issues, classroom space, and time constraints faced, prevented teachers from effectively utilizing the acquired skills and knowledge. Emphasizing the interplay between teachers' training and infrastructure support for successful ICT integration, Participant 9 said:

> They [training programs] go a long way in supporting and helping. Some that I have gone through, yes, personally has improved me. But in the delivery, we just learn and we may not necessarily have opportunity to deliver because of the space, time, electricity, and some of these hardware provisions.

Theme 8 addressed RQ3 and how secondary school physics teachers perceived professional development sessions to equip them with necessary skills and knowledge for effective blending of technology in their classrooms. Majority of the participants appreciated the professional development opportunities extended by their school administration and the government education authorities. Some participants highlighted the need for additional support to successfully implement and leverage digital instructions in their pedagogies. A few participants voiced concerns regarding the lack of adequate resources. These participants argued that this resource inadequacy hindered the effective application of knowledge and skills acquired during the professional training sessions.

Theme 9: Secondary School Physics Teachers Yearned to Learn From Training Sessions to Create Classrooms That Incorporated a Fun Way of Learning Physics. Secondary school physics teachers in the state under study perceived a strong desire to learn from professional development opportunities. The participants expressed their willingness to utilize the knowledge and skill gained from the training sessions to incorporate engaging and interactive elements into their classrooms. Participants communicated a shared yearning to shift from traditional lecture-based methods and create learning environments that foster curiosity for the subject. "I would love to learn technical skills," I would like to learn how to create video lessons for my students," "I'll be very happy to go for any professional training," "I really have an interest in the area of hands-on training," "If I'm trained more on the use of technology, it will facilitate my own delivery," teachers expressed fervently. Words like "fun," "engaging," and "interactive" emerged frequently throughout the interviews, signifying the teachers' commitment in making physics education joyful and accessible to all secondary school students.

Actively seeking training in technology integration and recognizing that traditional teaching methods may not fully address the needs of the current generation of learners, Participant 3 stated:

> I'm still very young. I always work my fingers to the bone. Any of those things [ICT training] that'll really help me and make me improve myself, I'm willing to blend to all … I have to learn a lot because I am eager to use technology to make my teaching and learning effective … My own view about integration of ICT and

> physics is, without ICT, there's no way physics can be taught effectively based on the way technology is going. Technology has been existing but every day new things are changing … any training is put across to teachers, teachers will really grow up.

Likewise, Participant 4 wished to learn "coding skills," to transform classrooms into dynamic spaces that ignite students' interest in physics using innovative technology-integrated pedagogies. Participant 4 shared:

> For me personally, I must be sincere, I want to learn. There are a lot of technological skills I wish to learn, starting from coding, programming … Teaching has gone beyond this learning of regular mathematics and English. Honestly speaking, I wish to learn it [digital skills] because it will avail me the opportunity to expose my students to a series of things that are even beyond the four walls of the classroom.

Some participants expressed a broader desire for professional development, revealing their interest in acquiring specific technological skills for creating digital teaching and learning resources. Participants 5, 7, and 10 shared their interest in learning about creating simulations and animations. The participants' interest extended beyond using these resources in their classrooms and disseminating the valuable resources to enrich the learning experience of a larger population of secondary school students. "I really have interest in learning simulation … it helps especially in the area of virtual laboratory," commented Participant 10. Answering the interview question on what the participant would like to learn about technology integration, Participant 7 remarked:

> What would I like to learn? Oh… I would love to learn more about animation. How to create my lessons using animations, to create instructional materials for my students … Also, I would like to learn how to use Canva, to make different designs … to make my classroom, my lessons more interesting and more enlightening.

Participant 5 mirrored this thought and mentioned:

> The aspect I would like to learn is how to create simulations myself … I have been using simulations of others, but I would like to learn how to develop one myself. How to develop a simulation that will be interactive, a video-based animation … I would like to learn how to design animations … so that I can design one myself and also provide it for other teachers to use.

Participant 5 also mentioned about the advantage of learning to create simulations and animations. The participant was self-motivated to address the financial barrier faced by teachers in the state in utilizing paid digital applications for teaching. The participant said:

> So when we have more animations that are readily available for teachers, even without paying for all these applications that require more funding, teachers can easily use it in their classrooms locally … because simulations are interactive … I will do my best for the students' interest.

Participant 6 offered a noteworthy example of personal initiative in gaining knowledge about online digital tools and applications to support technology integration. The participant enthusiastically described their independent research into the various digital toolkits available for creating quizzes. However, Participant 6 also expressed concern over the high cost in securing an account to use these tools, highlighting the barrier in the adoption of such tools within the teaching community of the state under study. Participant 6 stated:

> What I would love to learn is the usage of internet to impart knowledge to them [students] … I'm still trying to do research, especially on the aspect of quizzes because I believe students learn faster when they see quizzes … I did some research on this software, the Articulate Storyline, trying to compare it with the Adobe Captivate, then also with another one, iSpring … But I think all these software are very expensive … I'm still looking at a way to get a software in order to accommodate the quizzing aspect of teaching.

Theme 9 addressed RQ3 and how secondary school physics teachers yearned to learn through training sessions to support technology integration in instructional practices. Several participants expressed profound interest in gaining deeper knowledge about technology integration. Some participants revealed a passion in acquiring training in technological applications that would empower them to independently develop digital teaching resources. Participants recognized that lecture-method of teaching has ceased to engage students in physics classrooms. Expressing their interest in learning particular digital techniques, participants highlighted the impact of technology in enhancing the effectiveness of instructional materials in physics. A few participants shared the special efforts put forth by them to finding cost-effective solutions to enhance the learning experience of secondary school students.

Evidence of Trustworthiness

Creswell (2015) posited that to ensure rigor and trustworthiness, a qualitative study must demonstrate both internal and external validity. This project study prioritized trustworthiness through methods discussed in this part of the section, as recommended by Ravitch and Carl (2021). As evidenced by the detailed description of the research methods, reliability, and validity analyses (Creswell, 2015) fostered strong data collection, ultimately bolstering the study's trustworthiness.

Credibility

To ascertain credibility for my project study, I adhered to the rigorous data collection methods outlined in this section. This included a multifaceted research strategy, integrating diverse methods across the design, data collection, and analysis phases to enhance the perceived truthfulness and believability of the findings (see Creswell & Creswell, 2018). I employed approaches like semistructured interviews with 12 eligible secondary school physics teachers, combined with member checking, reflective journaling, and emergent coding. These methods and approaches allowed me to verify the accuracy and credibility of my interpretations. Notably, member checking, where participants confirmed the capture of their experiences, yielded positive feedback. While all 12 participants responded to the process of member checking, none disputed the representation of their perceptions, and one participant expanded upon their interview data with additional reflections.

Transferability

Qualitative research prioritizes on rich descriptions and deep understanding, but transferability, the potential for findings to resonate beyond a specific case, ensures findings reach beyond the immediate study and inform broader contexts (Ravitch & Carl, 2021). To achieve transferability, I meticulously documented participants' perceptions and experiences, drawing rich context from supporting literature. Throughout the data collection and analysis processes, I maintained reflective journals, ensuring transparency, minimizing subjective bias, and keeping my own thoughts separate from participant data. This combination of detailed descriptions and self-reflection allows other researchers to assess the generalizability of my findings and explore their potential application in their own areas of study.

Dependability

Establishing dependability, the consistency and stability of findings, is crucial in qualitative research (Ravitch & Carl, 2021). I achieved this by offering a transparent and detailed account of my research processes, as guided by Merriam and Tisdell (2016). This comprehensive documentation allows future researchers to replicate my methods and obtain similar results. Additionally, semistructured participant interviews and member checking served as foundations of dependability, fostering trust and accuracy in the data collected. While replicating the present study with identical outcomes is unlikely due to the inherent dynamism of qualitative research, the meticulous documentation provided serves as a guideline for future scholars wishing to explore similar territory.

Confirmability

Ensuring the findings of this qualitative research were objective and unbiased was a key priority. Informed by Patton (2015), confirmability principles guided the approach to data collection and analysis. Drawing on Ravitch and Carl (2021), neutrality and minimizing personal biases were actively pursued. Throughout the study, I sought to have confirmable data and maintained transparency by explaining potential personal and professional biases upfront, outlining the research topic, data collection methods, and analysis approaches, and conducting member checking through emails to clarify concepts and seek feedback on overall findings. The steps followed during the member checking process were (i) clarifying concepts - member check emails helped refine understanding of participant perceptions and experiences (ii) reviewing overall findings - participants were invited to verify the accuracy of the research conclusions and (iii) opportunity to confirm - all participants had a chance to provide feedback on the broader study findings.

By actively employing these strategies, confirmability was established, strengthening the confidence and objectivity of the research results. As additional feedback provided by the teacher-participants was crucial for conducting accurate and relevant data analysis, I meticulously followed up with each participant for the member checking process. All 12 participants responded to the email invitation to complete the member checking process. Table 8 outlines the summary of the participant responses to the member checking process.

Table 8

Summary of Participants' Responses to Member-Checking Process

	Total participants	Sent email for member-checking	Approved interview transcript with additional feedback	Approved interview transcript with no correction	Did not approve interview transcript
Number of participants	12	12	3	9	0
Participants	P1-P12	P1-P12	P4, P7, P10	P1, P2, P3, P5, P6, P8, P9, P11, P12	NA

Along with the email invitation sent for member verification, I attached the interview transcripts and shared the Zoom link to their recorded interview with the respective participant to examine the comprehensive transcripts drawn from the data analysis. The participants readily participated in the member checking process and were enthusiastic in verifying the presented information. One teacher-participant messaged in the response email, "All information well captured," validating the study's findings. One of the interviewees who approved the interview transcript with additional feedback remarked, "I am always ready to be of assistance whenever the need arises," showing the participant's readiness in assisting the research study.

Reflective Journaling. To maintain objectivity and distance myself from participants' perceptions, I actively engaged in reflective journaling. This introspection helped me identify and mitigate any personal biases that might influence my interpretation of the data. I prioritized ensuring the study faithfully represented participants' unique ideas, authentic perspectives, and experiences (see Patton, 2015). Such focus extended beyond journaling, as I implemented additional strategies to guarantee that the study's findings purely reflected the participants' narratives, untainted by any researcher subjectivity.

Summary

In the first part of Section 2, the choice of a basic qualitative approach for the current research study was justified. Data collection and validation procedures were subsequently described. Data analysis techniques were then discussed in detail, following which thematic analysis of interview data collected from 12 secondary school physics teachers was presented. Data analysis laid the foundation for deeper understanding of the complexities surrounding technology integration in the state under study in Nigeria and yielded the identification of three distinct themes for each research question. Table 9 summarizes these nine themes, encapsulating the core insights that gleaned from the data and addresses the specific inquiries posed by the research questions.

Table 9

Nine Themes Aligned With the Research Questions

Themes	
1	Physics is a complex subject that requires effective instructional methodologies to elucidate and deliver it to students.
2	Technology integration in teaching simplifies and strengthens the understanding of abstract physics concepts.
3	Technology integration in teaching ensures enhanced student engagement in learning and improves student outcomes in physics.
4	Secondary school physics teachers faced challenges when integrating technology in instructional methodology.
5	Secondary school physics teachers believed their school administration expected regular use of technological instructional strategies.
6	Secondary school physics teachers received very limited support from their administrative division
7	Secondary school physics teachers required strong support from the school administration and the local government for effective ICT integration.
8	Secondary school physics teachers perceived professional training and development to support their use of ICT in classroom teaching practices.
9	Secondary school physics teachers yearned to learn from training sessions to create classrooms that incorporated a fun-way of learning physics.

The results of this study indicated how teachers' experiences and perceptions informed techniques to be adopted for effective ICT integration in physics education, in the target state. The first theme resonated with existing literature on physics education, where the abstract nature is often identified as a barrier to student understanding. However, the teachers' voices in this study enriched this conversation by offering practical insights and diverse perspectives. The teacher-participants' experiences and their answers to the initial set of questions highlighted the need for innovative instructional methodologies that addressed the abstractness of physics head-on, fostering deeper student engagement and understanding.

Aligned with RQ1, the second theme laid emphasis on the practical applications of ICT integration, suggesting that the teachers recognize the potential of technology to simplify and enhance student comprehension of abstract topics in secondary school physics curriculum. The theme also revealed concerns among some participants regarding the prevalence of traditional teaching methods within their schools. These concerns pointed towards barriers faced by secondary school physics teachers in constructively blending ICT into their existing instructional design.

The third theme affirmed the crucial role played by technology integration in boosting student engagement and academic achievement. Participants acknowledged the effectuality of interactive simulations that can bring complex physics concepts to life, resulting in better comprehension of the underlying principles. Technology-driven classroom practices shifted the focus from didactic to inquiry-based learning, enhancing student participation, sparking curiosity, and igniting passion for the subject.

Consequently, secondary school students became more invested in the learning process, resulting in improved academic achievement in physics.

The fourth theme brought out the barriers hindering the ICT integration in secondary school physics classroom, in the state under study. Electricity issues, limited digital devices, and inadequate school infrastructure were identified as significant obstacles to ICT-integration, as reported by the teacher-participants. This theme found that unreliable and insufficient internet access hindered the access to online educational resources. A critical shortage of digital devices in the school ICT labs and limited access to technology at home led to unequal access for students. This restricted technology access prevented some students to keep pace with their peers, having a greater impact on their academic performance and future academic opportunities. Overall, teachers' perceptions indicated the major role played by reliable access to online educational software and tools, strong school infrastructure, and digital hardware availability in facilitating successful ICT integration within secondary school physics classrooms.

The fifth theme acknowledged that a significant portion of the secondary school physics teachers believed their school administration expected regular use of technological instructional strategies, aligned with the social influence aspect of the UTAUT framework. Valuable insights with regard to effective pedagogical practices for ICT-integrated physics education, even under circumstances when appropriate technological tools are insufficient in school buildings, were shared by the participants. A fundamental disconnect between physics teachers and their school administration regarding the support teachers require for effective ICT integration was identified.

Administrators' commitment to student engagement transcending limitations and paving way for transformative learning experiences were also put forth by a few participants. Collectively, teachers perceived the various challenges to ICT integration and the inadequate support from the school administration to constrain their capacity to effectively utilize technological resources for creating engaging and joyful learning experiences in physics classrooms.

The sixth theme sought to uncover the nature of support, hardware, and software, from the school administration for technology use, its effect on teachers' classroom practices, student engagement, and students' academic achievements. Teacher-participants' responses to the set of interview questions leading to Theme 6 contributed valuable insights into the important issue of limited support in school environment, unfavorable to effective technology integration in physics education. Data analysis also revealed diverse experiences among participants concerning the level of hardware and software support provided by their school administration. Additionally, the extent of the broader support offered by the administration varied considerably.

The seventh theme explored teacher expectations of the support required for successful blending of ICT in the secondary school educational settings in the target state. Teachers expected the school administration and the government to identify funding mechanisms to support the acquisition of adequate hardware, software, and digital applications and supplement teacher incentives. Teacher-participants perceived that educational resources should be created, and support structures should be developed to ensure effective use of ICT in learning. Additionally, teachers expressed their wish to move beyond a purely technological approach to ICT integration and focus on comprehensive support to teachers, students, and parents alike to unlock the effectiveness of ICT-blended methods to improve teaching, learning, and engagement within the educational settings.

The eighth theme identified a perceived need for professional development opportunities to bolster secondary physics teachers' confidence and competence in utilizing ICT within their classroom pedagogy. Teachers expressed their desire for professional training that would extend beyond technical proficiency and focus on integrating technology meaningfully within the specific context of physics education. Concerns regarding insufficiency of digital resources and unreliable electricity supply were reiterated by the participants. Analysis of interview transcripts revealed that such an insufficiency impeded the successful application of the knowledge and skills acquired by teachers from professional development sessions.

The ninth theme brought out the interest in secondary school physics teachers to learn from training programs and blend technology in their pedagogies. This interest extended beyond personal use for their own students, with participants advocating for training that would empower them to share these resources with the wider teaching community, ultimately benefiting a broader student population. A vision of physics teachers to independently create digital learning resources and eliminate the need for purchasing paid applications, evolved during data analysis. This vision underscored the resourcefulness of some teachers and their commitment to finding cost-effective solutions to enhance the learning experience of students.

A consistent theme that recurred throughout data analysis of the current study was that all interview participants expressed a strong desire in acquiring skills to create digital resources. Additionally, majority of the participants also revealed their inclination towards using simulations to simplify complex concepts in physics. However, despite receiving professional training and acquiring technological skills, a paramount concern emerged among participants. The participants expressed uncertainty regarding the feasibility of implementing the acquired skills due to limitations within their educational environment. These limitations included inadequate digital tools, unreliable internet connectivity, inconsistent power supply, and the lack of readily available alternative power sources. The recognition of this critical need informed the development of a white paper focused on illuminating the challenges faced in ICT integration for physics education, while proposing potential solutions for stakeholders within the state under study. This capstone project, hence, utilizes a white paper format to address these pressing needs.

Section 3: The Project

Introduction

Section 3 outlines the rationale for choosing a white paper as the focus of the project study (Appendix A). The decision to focus on a white paper was informed by the research findings and the purpose to enhance the conditions facilitating technology integration by the secondary school physics teachers, in the state under study, through recommendations to the state education department. This section comprises a literature review discussing recent scholarly articles pertinent to the project and research findings. Furthermore, the section elucidates the project's objectives, describing its implementation plans, and offers a project evaluation strategy. Lastly, it explores the implications of the project and engages in discussions surrounding them.

Description and Goals

A white paper is a detailed report explaining a problem and a practical solution by presenting research and evidence to support its claims (Hayes, 2023). Through this white paper presentation, I aim to highlight the challenges faced by secondary school physics teachers in ICT integration and propose recommendations based on research findings. This white paper has been crafted to inform stakeholders within the state's education community, particularly policymakers and school administrators, about the potential of effectively integrating ICT into higher secondary physics classrooms. By outlining a series of implementable steps, this project aims to influence positive change and facilitate a shift towards technology-enhanced physics education that fosters a joyful experience for students.

The analysis of responses to three research questions yielded deeper insights into secondary school physics teachers' perceptions regarding ICT integration within their classrooms. Drawing on data gathered through individual semistructured interviews with 12 secondary school physics teachers, this project study identifies key challenges to ICT integration and proposes actionable recommendations. The teachers' feedback, compiled, coded, and thematically analyzed, offers valuable discernment for stakeholders interested in fostering effective technology within their educational contexts. The white paper presents a comprehensive overview, including an introduction, background information on the research context, a description of the methodology, research findings, specific recommendations for improvement, and a conclusion.

Rationale

Throughout the semistructured interviews, a recurrent theme became apparent—all teacher-participants conveyed a keen interest in augmenting their proficiency in technology integration to enhance lesson delivery and student outcomes. This initial observation steered my project study towards the development of a professional development program. However, upon further consideration, the implementation of a 2- to 3-day training program for secondary school physics teachers in the state presented logistical hurdles.

The hurdles included (a) disruption of teacher schedules—the training program required teachers to miss valuable instructional days; (b) financial considerations—as the researcher, I would have been responsible for securing funding for refreshments, lunch, and any necessary training materials; and (c) unreliable infrastructure—the unreliable power supply in the region posed a significant risk of disruption. Securing access to a backup generator and ensuring consistent internet connectivity would have added additional logistical and financial burdens. Considering these constraints, I opted to alter the format of my project study.

Despite demonstrating a shared commitment to utilizing technology-integrated pedagogies for physics instruction, secondary school physics teachers participating in this study encountered numerous challenges in ICT integration within their classrooms in the southwestern state in Nigeria. The outcomes of this study yielded a deeper understanding of the physics teachers' perceptions towards technology integration and the challenges in integrating ICT within their classrooms. Additionally, thematic analysis of the qualitative data from the interviews of the 12 physics teacher participants provided valuable insights into the potential for more effective and efficient implementation of technology within secondary school physics education.

Furthermore, data analysis revealed a crucial finding that alongside professional development, teachers expressed a significant need for a robust technology-support system to facilitate successful ICT integration in physics education. This identified need informed my decision to choose the white paper format as the most viable and enduring method to present the outcomes of the current research. Through the white paper, I aim to recommend potential solutions to stakeholders, ultimately minimizing barriers to effective technology integration in the state studied. This, in turn, may enable the creation of technology-aided learning environments for secondary school physics education. Such environments can foster students' subject understanding, support an enhanced grasp of complex physics concepts, and lead to improved academic performance.

Review of the Literature

To establish a strong theoretical foundation for this study, a comprehensive review of relevant literature was conducted. Scholarly and peer-reviewed articles were obtained from credible academic databases, including Walden Library database, Google Scholar, and ProQuest. Given the international context of the research site, the review specifically included research findings from different countries with similar educational environments. Keywords such as *white paper, physics education and ICT integration*, *challenges in teacher technology integration*, and *professional development for technology integration* guided the literature search.

White Paper

A white paper serves as a platform for researchers to present their findings on a specific issue and offer actionable recommendations to a targeted audience (Basu et al., 2021). A white paper also adheres to a fixed format to ensure clarity and comprehensibility for the reader (Shih et al., 2020). This format aligns well with the current project study's goal, as it allows for the dissemination of research findings and recommendations to stakeholders within the state regarding the specific challenge to effective ICT integration in physics education. To gain a deeper understanding of this format and its intended purpose, I conducted a review of existing white papers. Through the review, I examined the role of white papers, focusing on the strengths and limitations of this approach.

Strengths of White Papers

White papers offer several advantages in presenting research findings. Researchers use white papers to target stakeholders within specific contexts, such as school districts or industry leaders. Through their white paper, the Korea Ministry of Education (2017) informed stakeholders with the particular case of transforming computer-literacy education to ICT-supported and ICT-integrated smart education. Hamadan et al. (2013) presented a white paper to foster awareness of the flipped classroom model, enhance student interaction, and increase students' engagement in hands-on learning. The authors advocated for change in classroom pedagogy based on the findings of their research. A review of the research by Hamadan et al. (2013) and the Korean Ministry of Education (2017) highlighted the disseminating and advocating benefits of a white paper.

Literature review revealed that white papers were also designed to be solution-oriented. Basu et al. (2021) highlighted the challenges faced by computer science teachers and proposed a solution to mitigate them. The authors suggested computer science teachers' capacity building through sustainable and scalable teacher professional development programs as a potential solution, focusing on promoting the teachers' ability to effectively teach the subject. Likewise, in their white paper presented on teacher education, Shih et al. (2020) offered essential insights and approaches aimed at enhancing ethical standards, accountability, diligence, and long-term viability among teachers in Taiwan. The researchers identified these as fundamental principles to support educators who are deeply committed to their profession and dedicated to upholding the values of education. Such white papers, focused on actionable recommendations, make this format particularly valuable for project studies aimed to influencing policy or practice.

A white paper presented by an independent nonprofit organization (Education.org, 2021) utilized clear and concise language, avoiding overly technical language. The paper advocated for collaboration among all involved in education to bridge the divide between theory and practice. The organization, with utmost clarity in its white paper, called for teachers to establish a repository of educational research findings. This simple yet comprehensive language ensured that stakeholders readily understood the research implications and recommendations, regardless of their academic background. Furthermore, a review of the white paper created by Haley and Jack (2023) affirmed that white papers adhered to a specific structure, often including an introduction, background information, methodology, findings, recommendations, and a conclusion. Presenting the research findings in such a structured format, the authors ensured a logical presentation of the research components.

Limitations of White Papers

Researchers opined that white papers do not undergo the same rigorous peer-review process as academic articles (Dev et al., 2024). The authors suggested that this limitation raised concerns regarding the methodological rigor and validity of the research presented. Stelzner (2006) recommended that project studies incorporating white papers might need to address these concerns by ensuring methodological soundness and providing clear references for further exploration. Haley and Jack (2023) pointed out the possibility of potential bias in white papers as the papers often aim to influence stakeholders or advocate for specific solutions. To avoid bias, project studies using white papers should strive for objectivity in presenting findings and ensure that recommendations are grounded in the research area. Furthermore, white papers are concise documents when compared to academic journal articles (Stelzner, 2006). This might limit the depth of analysis and discussion.

A comprehensive review of the literature revealed that white papers serve as a valuable tool for researchers and practitioners within the context of project studies, in terms of dissemination, actionable recommendations, accessibility, and structured format. However, it is important to recognize possible constraints, such as the lack of thorough peer review and the potential for bias. When utilized adeptly, white papers can enable studies to connect research with practical applications. This thorough review process ultimately established the white paper as the most suitable method for presenting recommendations within the framework of the current qualitative research project.

Physics Education and Information and Communication Technology Integration

Physics education is important in nurturing scientific literacy and critical thinking skills in students. However, educators using traditional pedagogies often struggle to effectively engage students with complex physical concepts. Integration of ICT has emerged as a powerful pedagogy for enhancing physics education by creating dynamic and interactive learning environments (Hasas et al., 2024). Research has suggested that ICT integration offers a range of benefits for physics education.

Enhanced Visualization and Simulation

ICT tools allow for the creation of interactive simulations and visualizations of physical phenomena. These tools help students visualize abstract concepts and processes that are difficult to grasp through traditional methods (Ameziane et al., 2023). Realistic visualizations and virtual experiments in simulation-based learning provided a tangible representation of theoretical principles in physics, making the ideas more accessible and comprehensible (Banda & Nzabahlmana, 2022). Physics educators and researchers have posited that simulations foster active learning and critical thinking skills by allowing students to control different parameters and test hypotheses in a controlled environment (Ali et al., 2023; Dachraoui et al., 2023; Hasas et al., 2024). Literature on ICT-integrated physics education has also highlighted the immersive approach of virtual-reality-based instructions and experiments to not only enhance understanding, but also cultivate curiosity, enthusiasm, and confidence in tackling challenging physics concepts (Dier & Asrizal, 2023).

Improved Engagement and Motivation

ICT-enabled learning environments have the potential to cultivate heightened student involvement with the subject matter. Studies by Tuyizere and Yadav (2023) and Moro and Billote (2023) have shown that ICT integration can increase student motivation and induce active participation in physics lessons. The authors recorded that animations, virtual labs, and interactive simulations make physics learning more dynamic and exciting, encouraging students to explore concepts in depth and independently. Neroni et al. (2021) documented that collaborative technological educational tools facilitate peer interaction and knowledge sharing, promoting problem-solving skills and strengthening real-world applications of the theories in physics. The impact of activities that were computerized simulations on the academic performance of 200 high-school students in physics was studied by Batuyong and Antonio (2018). The authors concluded that the students' academic achievements improved noticeably on blending technology into educational processes.

Personalized Learning and Assessment

Technology-integrated pedagogies can be used to create individual and differentiated lesson plans for students in physics education. Studying the outcome of ICT-integrated simulations on physics learning of 20 high school students, Trikollis (2021) concluded that adaptive learning platforms tailored content and difficulty levels to individual student needs and pacing. Additionally, Wibowo (2023) recorded that simulations accommodated diverse learning styles and abilities, allowing students to gauge their understanding and adjust their learning strategies. Furthermore, Banda and Nzabahimana (2023) highlighted the real-time feedback and assessment opportunities provided by ICT-integrated pedagogies, allowing educators to monitor student progress, identify areas of difficulty, and provide timely support.

Collaboration and Communication

ICT tools facilitate collaboration and communication between students and teachers. Online platforms allow for asynchronous communication and discussion forums where physics students in senior high school can share ideas and work on projects remotely (Novitra et al., 2021). The authors recommended that these tools can be particularly beneficial for collaborative problem-solving activities and peer learning in physics education. Studies on physics students' collaborative skills by Kauts and Samita (2024) also revealed that video conferencing tools facilitated virtual meetings and peer tutoring sessions, breaking down geographical barriers and promoting interaction among students from diverse backgrounds. Kauts and Samita posited that web 4.0 tools provide channels for creating a sense of community among physics students, enhancing their learning experience.

Augmented Learning Experience

Mobile technologies and augmented reality (AR) offer new possibilities for learning physics outside the classroom (Gurevych et al., 2021). Gurevych et al. (2021) investigated recent advancements in AR technology for improved quality of physics education in higher education institutions. The authors concluded that AR can intrinsically motivate students for self-directed learning by fostering a deeper engagement with educational materials. This increased interest can cultivate a desire to explore and utilize modern interactive technologies, potentially leading to a shift away from traditional static resources such as textbooks and towards multimedia computer models within physics classrooms. In other research, Rahmat et al. (2023) examined the effect of mobile AR on physics learning outcomes for junior high school students in Indonesia. Their findings, based on student feedback, suggested that AR offered a novel and effective learning environment in physics and facilitated comprehension of abstract physics concepts. Furthermore, the study indicated that students perceived an improvement in their understanding of physics concepts after utilizing mobile AR technology. Recent research with 370 teacher-students in Morocco explored the effect of AR-based learning on physics experiments (Laila et al., 2024). The research highlighted the potential advantages of incorporating AR technology within physics laboratory settings. The authors advocated for the exploration of this technology by educators, emphasizing its ability to enrich the learning experience for students.

Challenges in Teacher Technology Integration

Although the advantages of incorporating ICT in classroom instructions are widely acknowledged, several challenges impede teachers' successful adoption. Literature delves into the complex array of these hurdles, concentrating on barriers related to hardware availability, training opportunities, administrative backing, time limitations, teacher confidence, and other factors influencing the effective integration of technology. Unequal technology access and unreliable internet connectivity remains a significant obstacle in many schools. This digital divide created an environment where some students had access to advanced technology tools while other lacked the necessary resources to participate in technology-driven learning activities (Ifinedo et al., 2020). Restricted access to hardware, such as computers, tablets, or specialized lab equipment, limited teachers' ability to implement innovative ICT-based lesson plans (Munje & Jita, 2020). Munje and Jita (2020) studied how insufficient technical assistance for maintaining ICT equipment disrupted the seamless delivery of instruction within classrooms. An extensive literature review was conducted by Hunduma and Mekuria (2023) to inquire into the barriers impeding technology integration in the public schools in Ethiopia. The findings of the study illustrated that deficient infrastructure and the lack of well-equipped computer laboratories created a setback in teachers integrating technology to enhance classroom instructions.

Successful technology integration requires teachers to possess a strong foundation in both pedagogy and technology (Karim & Zoker, 2023). Investigating the perceptions of senior secondary school teachers in Sierra Leone about the issues in technology integration, Karim and Zoker (2023) recorded many teachers being ill prepared to blend technology into their classrooms due to limited training opportunities. Additionally, traditional teacher education programs often lack a strong focus on technology integration, leaving teachers struggling to navigate complex hardware, software functionalities, and identify appropriate learning technologies for specific curriculum objectives (Wong et al., 2023). Furthermore, a study on Nepal's teacher education revealed the absence of planned teacher training strategies leading to ineffective implementation of ICT-integrated teaching practices (Rana & Rana, 2020).

The level of administrative support also plays a critical role in fostering technology integration within schools. Studies showed that without clear administrative vision and dedicated resources, teachers felt unsupported in their efforts to adopt new technologies (Dong et al., 2020). Research findings also revealed that lack of administrative assistance created an environment where ICT integration turned into an additional burden for the teachers, hindering their motivation and enthusiasm for innovation (Rintaningrum, 2023). Manubag et al. (2023) studied the significance of technology within technical vocational education in the Philippines. Their findings suggested that administrators who display reluctance or resistance towards embracing technological progress inadvertently discourage educators from adopting innovative teaching methods or experimenting with ICT tools. This resistance to change among teachers hampers creativity and innovation within the classroom, consequently hindering the integration of technology into pedagogical approaches, diminishing student engagement, and impacting learning outcomes.

The constraints of a teacher's schedule restrict the opportunity to explore and incorporate new technologies into established lesson plans (Kucuk, 2023). Numerous studies identified educators being overwhelmed by curriculum obligations, the pressures of standardized tests, and administrative responsibilities, leaving them with minimal time to engage in the learning and application of new technologies into their classroom pedagogies in a meaningful manner (Francom, 2019; Pappa et al., 2024; Starks & Reich, 2023). These researchers recorded that technology integration required meticulous planning, selection of appropriate digital tools and applications, familiarity with software features, modification of existing lesson plans accordingly. Teachers participating in these research studies expressed that without dedicated time for such necessities, ICT integration became a mere rushed and superficial endeavor, ultimately falling short of realizing its potential benefits.

Another crucial factor that challenges teachers in classroom technology integration is teacher efficacy. This concept refers to a teacher's belief in their ability to positively influence student learning outcomes (Hershkovitz et al., 2023). Studying the elements influencing teachers' self-efficacy in ICT integration, Williams et al. (2023) posited that educators with low self-efficacy regarding technology exhibited reluctance to blend new technologies into their pedagogies. The authors' findings suggested that this reluctance stemmed from a fear of failure, a sense of inadequacy when faced with technical challenges, or a general anxiety around technology itself. A recent research was carried out by Al-khresheh and Alkursheh (2024) to study how teachers' confidence on ICT-integrated instructional practices influenced students' academic achievements. Their findings explained that teachers felt overwhelmed by the rapid pace of technology advancements which in turn contributed to their anxiety to experiment with new technological tools and experiments.

Professional Development for Technology Integration

The 21st century classroom demands a shift towards technology-integrated pedagogies. Although the advantages of blending ICT into instruction are widely recognized, successful implementation hinges on the professional development (PD) provided to educators (Yurtseven Avci et al., 2020). Through this part of the literature review, I explored the crucial role of PD in building teachers' confidence towards ICT-integrated innovative instructional methodologies. I also examined the different requirements for effective PD programs through the strategic use of instructional technology.

Traditional instructional methods may no longer adequately prepare students for the demands of a technology-driven world. Educational technology (EdTech) offers a plethora of tools and resources that can enhance student learning, engagement, and critical thinking skills (Shin et al., 2023). However, Shin et al. (2023) posited that simply providing teachers with access to technology is insufficient. The author examined that effective integration of technology necessitated teachers to possess a strong foundation in pedagogy, technology skills, and a critical understanding of these elements. Bowman et al (2022) investigated the influence of professional development exposure on teachers' quality of ICT integration among 724 teachers from middle and high school. Many teachers in the study reported feeling inadequately prepared due to limited opportunities for technology-focused training. They expressed that traditional teacher education programs often lack a robust focus on technology integration, leaving them with limited knowledge of specific tools, pedagogical strategies for using technology effectively, and the ability to navigate the ever-evolving EdTech landscape.

The review of literature carried out in this section of the current study informed various requirements for successful professional development programs in teachers' technology integration. The foremost requirement identified in the review was the focus on pedagogy over technology. Researchers argued that technology should not be the end goal but should serve as a catalyst to enhance the knowledge gaining process (Fawns, 2022; Rapanta et al., 2021). Rapanta et al. (2021) recommended that professional development programs should focus on the pedagogical significance of ICT integration, aligning the use of specific tools with clear learning objectives and curriculum frameworks. Presenting an entangled pedagogy model, Fawns (2022) outlined that instead of simply training teachers on the use software, professional training sessions need to support teachers in understanding how technology can support differentiated instruction and foster problem solving skills in students.

Research studies affirm another requirement of teachers' professional development as the need to address teacher needs and curriculum alignment. Identifying the specific needs, challenges, and technology comfort levels of participating teachers ensures that the professional development content is relevant and addresses their immediate concerns (Warr et al., 2023). Emphasizing on alignment with curriculum frameworks and learning objectives, Huang (2023) posited that professional development programs should provide teachers with practical examples and strategies for integrating technology into existing lesson plans, ensuring a seamless implementation within their specific disciplines. Schmitz et al. (2023) highlighted the other requirement of professional development programs – teachers' technology skills and confidence. Although pedagogical knowledge and alignment with curricular objectives is crucial for teachers integrating technology, Schmitz et al. (2023) reiterated that teachers also require a solid foundation in technology skills. The author affirmed that professional development programs should offer hands-on training and active learning experiences that equip teachers with the technical proficiency to navigate chosen tools effectively. However, Williams et al. (2023) argued that continuous learning for teachers should also place focus on building confidence in their ability to utilize technology effectively.

An additional requirement of teachers' upskilling initiatives identified is the ongoing support and collaboration provided to teachers. Kilag et al. (2024) studied that effective educators' upskilling programs should recognize the need for ongoing support as technology integration is not a one-time event. The authors recommended for providing access to online resources, technical support personnel, and opportunities for collaboration that can assist teachers in overcoming challenges and sharing best practices throughout the integration process. The final requirement of professional development as examined by this literature review is addressing the issue of digital literacy disparities among students. Addressing the digital divide among students, Afzal et al. (2023) recorded that teachers' professional development should involve equipping teachers with strategies for differentiated instruction and providing resources to bridge the digital divide within the student body. Additionally, the authors also recommended that the ethical considerations, such as data privacy and responsible online behavior, demand resolution within teachers' learning programs to ensure safe and responsible technology integration.

Project Description

The current project's data analysis revealed critical areas for improvement regarding technology integration within the studied school buildings. Analysis of infrastructure data highlighted the need for strengthening digital infrastructure, including potential upgrades to equipment and network capabilities. Additionally, the analysis indicated the necessity for exploring alternative solutions for ensuring reliable electric power supply and internet connectivity. Furthermore, interviews with teachers revealed a significant need for additional training to support teachers in effectively integrating technology into their teaching practices. To present these findings and propose evidence-based recommendations for change, a white paper was chosen as the primary communication format for this project. White papers offer a strategic approach to disseminating research findings and targeted solutions to a specific audience. Their structure allows for a clear presentation of the identified challenges, supported by relevant data from the conducted research (Basu et al., 2021). Moreover, white papers provide a platform to propose actionable recommendations and potential solutions, ultimately aiming to facilitate positive changes within the target context (Shih et al., 2020). In this case, the white paper format enabled the project to present a comprehensive overview of the identified needs alongside practical recommendations for improving technology integration within the school environment.

The local problem addressed through this project study was that secondary physics teachers were challenged to integrate information and communication technology in a southwestern state of Nigeria. A review of ICT implementation in education across various states within the country reveals promising results, with potential for significant improvements across educational sectors (Ambe et al., 2024; Bolaji & Ajia, 2023; Bolaji & Jimoh, 2023). However, achieving long-lasting and substantial change necessitates a long-term commitment from all stakeholders involved. A comprehensive, systematic, and phased approach, tailored to address specific needs and adapting to evolving environments, is crucial for successful implementation of technology integration. Drawing upon these insights and informed by the perspectives of teacher-participants in this study alongside experiences from other countries, this project proposes four key recommendations to guide the successful implementation of ICT in education within the state under study. These recommendations have been formulated with a focus on four major factors critical for successful ICT integration in educational institutions: access to technology resources, teacher training and support, cost considerations, and a strategic implementation plan.

The first recommendation is to ensure equitable access to high-quality ICT resources for all students and educators across the state being studied. This includes establishing infrastructure for reliable internet connectivity, providing schools with necessary devices, and ensuring software and technology tools are aligned with curriculum requirements. The second recommendation is to furnish ongoing professional development opportunities for teachers to develop their skills and confidence in blending technology into their pedogogy. These programs should address pedagogical approaches for effective technology use, troubleshooting skills, and content-specific applications of ICT in lesson plans. The third recommendation is to develop a sustainable funding model to support the ongoing costs associated with ICT in education implementation. This may involve public-private partnerships, cost-sharing initiatives between schools and districts, and identifying potential grants or federal funding opportunities. The fourth recommendation is to implement ICT in education in a phased approach, starting with pilot programs in select schools and gradually scaling up based on successes and identified challenges. Regular monitoring and evaluation should be conducted to assess the effectiveness of the implementation and make adjustments as needed.

The current study’s white paper project utilizes data analysis findings gleaned from semistructured interviews of 12 secondary school physics teachers from the state under study. The project proposes to inform the district administration regarding the nine key themes that emerged during the research. The project description part of this section delves deeper into the four key recommendations for successful ICT integration in education within the investigated state, considering current availabilities, potential barriers, and necessary additional requirements.

Recommendation 1: Ensure Equitable Access to Information and Communication Technology

The first recommendation is made to ensure equitable access to ICT in schools across the state. The current state of internet connectivity in schools needs to be assessed and areas in the state with reliable internet access and those requiring upgrades or new installations to be identified. The availability of computers, tablets, or other technology devices within schools needs to be identified, considering factors like the student-to-device ratio and the types of devices currently available. The existing software applications and educational technology tools utilized in schools needs to be reviewed. The degree of alignment of these software applications with curriculum requirements and learning objectives need to be assessed. The potential barrier to this recommendation in the project would be sufficient funding. Upgrading infrastructure and purchasing new devices can be expensive with limitations on funding faced by the district. This makes identifying sustainable funding sources crucial. As analyzed from the semistructured interviews, schools in remote areas may require extensive infrastructure development compared to schools in urban areas. A comprehensive plan for infrastructure upgrades and expansion, prioritizing underserved schools is to be developed. Alternative electrical power supply options such as solar panels is to be explored. Partnership with educational technology companies needs to be established to provide curriculum-aligned software and resources at discounted rates.

Recommendation 2: Invest in Teacher Training and Support

Investing in ongoing teacher training and support is paramount for successful ICT integration in physics education. This recommendation requires a comprehensive approach. In the first instance, a critical evaluation of existing professional development opportunities for teachers regarding technology integration should be conducted. Additionally, teacher assessments through surveys or self-assessments are necessary to gauge current skill levels and confidence in using technology within the physics curriculum. Understanding these needs allows for the development of targeted training programs that address specific skill gaps and equip teachers for effective technology use in their classrooms. Recognizing the heavy workloads faced by educators, dedicated time and resources must be allocated for participation in these training programs. School administration plays a crucial role in supporting this initiative by ensuring that both teachers and leadership teams have the time needed to participate effectively. Furthermore, school leaders should actively participate in the implementation process and dedicate time to share training experiences and best practices with their faculty. This collaborative approach fosters a supportive environment for ICT integration within the school community.

The training itself should be multifaceted. A multitiered approach that caters to various skill levels and technology needs will ensure all teachers are adequately prepared. Additionally, providing on-site technical support personnel within schools can be invaluable. These individuals can assist teachers in troubleshooting issues and utilizing technology effectively for instructional purposes. Finally, fostering collaboration through teacher learning communities focused on sharing best practices and creative approaches to ICT integration can provide pedagogical advancement opportunities for teachers. By implementing these strategies, teachers will be better equipped to leverage technology for improved physics education and ultimately, enhance student learning outcomes.

Recommendation 3: Address Cost Considerations

A critical challenge to integrating ICT in physics classrooms is cost. This recommendation emphasizes strategic financial planning to address these barriers. The first step involves a thorough analysis of current school technology budgets. This analysis should also identify existing funding streams, such as grants or state initiatives that can support ICT integration efforts. However, technology costs extend beyond initial infrastructure and devices. Ongoing expenses include software licenses, maintenance, and potential upgrades. To address these ongoing costs, schools must explore diverse funding avenues. Potential sources include grants, public-private partnerships, or dedicated technology acquisition budgets.

Given the high costs of ICT tools, software, and subscriptions, a strategic investment approach is essential. This involves meticulous planning to prioritize needs. Exploring innovative funding models, such as cost-sharing initiatives or open-source software options, can be highly beneficial. Additionally, fostering collaboration and resource-sharing networks between schools can maximize efficiency and minimize overall expenditures. Implementing bulk licensing agreements can further contribute to cost savings. By adopting a comprehensive and strategic approach to cost considerations, this recommendation lays the groundwork for sustainable ICT integration within physics education programs. This ensures long-term success and maximizes the potential of technology to enhance student learning experiences.

Recommendation 4: Implement a Phased Approach with Evaluation

To ensure successful and sustainable ICT integration within the target state's educational system, a phased approach with ongoing evaluation is recommended. This approach prioritizes a methodical and data-driven implementation process to maximize the impact of ICT on student learning outcomes. The initial phase should involve a comprehensive analysis of existing ICT initiatives within the state. This analysis should identify past successes, areas for improvement, and probable challenges associated with previous ICT integration efforts. A key barrier to successful implementation is the lack of a comprehensive plan, often leading to inefficiencies, wasted resources, and a lack of direction. Furthermore, without established evaluation tools, it becomes difficult to ascertain the impact of ICT integration on student outcomes. Building upon this analysis, a detailed implementation plan outlining clear phases is crucial. This plan should strategically implement pilot programs in select schools, chosen based on factors such as specific needs and readiness for ICT integration. Measurable goals and objectives for ICT integration should be established for each phase.

Additionally, clear metrics to track progress and assess the impact on student learning outcomes must be defined. These metrics could include student engagement, academic performance in physics, and overall satisfaction with the learning experience. A robust evaluation system that utilizes data to identify challenges and areas for improvement is essential for ongoing success. This system should provide valuable insights into the effectiveness of the implemented strategies and allow for course correction as needed. Furthermore, fostering a culture of data-driven decision making within schools empowers educators to leverage evaluation results to inform future ICT integration efforts. This iterative approach ensures that the implementation process continuously adapts and improves based on real-world data and feedback from stakeholders. By adopting a phased approach with ongoing evaluation, this recommendation lays the groundwork for sustainable ICT integration within the state's physics education curriculum.

Dissemination and Implementation of the Recommendations

The successful implementation of the recommendations outlined in the white paper hinges upon effective dissemination and review by key stakeholders within the investigated state in Nigeria. The dissemination process commences with the presentation of a white paper summary report to the tutor general and the district commissioner of education. A dedicated meeting will be scheduled to facilitate a comprehensive review of the full white paper. To enhance comprehension and encourage informed discussion, a concise, two- to three-page executive summary of the research will be provided alongside the white paper. This summary serves the dual purpose of informing the reviewers and allowing them to formulate any questions, comments, or concerns regarding the proposed recommendations. To broaden stakeholder engagement, the executive summary will be made readily available to all state education leaders who express interest in reviewing it.

Should the tutor general and the commissioner require further dialogue to discuss their initial feedback, an additional meeting will be convened prior to presenting the report to the entire board of education.

Following the initial review by the tutor general and the commissioner, a subsequent meeting will be held to engage in a collaborative exploration of the recommendations. This discussion will focus on potential implementation steps and the development of a practical action plan. Crucially, approval for presenting the findings to the full board of education will be sought at this juncture. With the approval of the tutor general and the commissioner, a dedicated session will be conducted to present the white paper's recommendations to the board of education. The board will then be granted a designated period to meticulously examine the full white paper and raise any questions concerning the study methodology, data collection procedures, or the proposed recommendations themselves. Upon receiving board approval, a one-month window will be allocated for the tutor general and the commissioner of education to conduct a more in-depth review of the white paper. This timeframe allows for the development of any constructive feedback they may wish to share with the researcher or broader district leadership.

My primary responsibility throughout this project encompassed conducting the research and presenting the white paper summary report to the state education department leaders and the board of education. Following the delivery of the white paper and executive summary, the state department of education leadership team will engage in a deliberative process to reach informed decisions regarding the proposed recommendations. If the leadership team requires clarification or deeper insights on specific points within the white paper, I will transition into a consultant role to provide further explanation and address any lingering questions. Ultimately, the onus of determining the next steps for implementing the recommendations within the schools falls upon the state department of education leadership, including the tutor general and the commissioner of education. Their collaborative efforts will be crucial in translating the research findings into a practical and actionable plan for successful ICT integration within the schools in the southwestern state of Nigeria.

Project Evaluation Plan

The current project utilized a white paper summary report as the primary research communication tool. This format allowed for a clear presentation of the research findings and recommendations in relation to the project's initial goals. By analyzing data on the beliefs of secondary school teachers, the study aimed to identify everyday challenges, ideas, and facilitating conditions needing improvement within the state's ICT integration efforts in secondary school physics classrooms.

The initial reviewers of the white paper’s recommendations will be the tutor general and the district commissioner of education. Their assessment will concentrate on determining the purposefulness, significance, and overall value of the proposed recommendations for potential presentation to the state education board. If the tutor general and the commissioner approve the white paper, it will proceed to the education board for further review, during which additional modifications and questions may be proposed. Ultimately, the board of education holds the authority to determine how to proceed based on the project findings. They may choose to implement all, some, or none of the recommendations outlined in the white paper. Additionally, they might request further research or a more extensive evaluation process for specific recommendations.

To assess the effectiveness of the suggested recommendations, a multipronged approach comprising of (a) a cover letter for stakeholder feedback, (b) stakeholder survey, or (c) focus group discussions can be adopted. A cover letter, collaboratively developed with key decision-makers, can be added to the white paper. This document provides stakeholders with the opportunity to note informal remarks, ideas, and feedback regarding the research findings and recommendations. An online survey, subject to approval by the state commissioner of education, can be administered to the board of education and other relevant stakeholders. This survey can be designed to gather quantitative and qualitative data on their perspectives concerning the implemented recommendations. Focused group discussions with teachers, administrators, and other key stakeholders can furnish insights into the effect of the implemented recommendations on ICT integration practices within secondary schools.

Throughout the review and evaluation process, I will maintain a supportive role. This includes answering questions from decision-makers, clarifying specific recommendations or findings within the white paper, contributing to the development of evaluation tools, and synthesizing the evaluation data. By employing these comprehensive evaluation methods, the project can achieve a nuanced understanding of the effectiveness of the implemented recommendations. This information can be used to refine future ICT integration initiatives within the secondary schools in the investigated state in Nigeria.

Project Implications

Information and communication technologies offer immense potential to revolutionize physics education, fostering deeper engagement and enhancing learning outcomes. This subsection explores the implications of the qualitative research study project investigating the challenges faced by secondary school physics teachers in a southwestern state of Nigeria, regarding ICT integration within their classrooms. The study's findings, presented in the accompanying white paper, offer valuable insights for stakeholders interested in promoting effective ICT integration in physics education across the state. This subsection also delves into the impact of the proposed recommendations on various educational aspects, highlighting potential benefits and considerations for successful implementation. The implications of this project study is discussed under four subheadings – implications for educational outcomes, implications for teachers, implications for educational policy and leadership, and implications for educational equity and accessibility.

Implications for Educational Outcomes

Effective ICT integration has the potential to significantly enhance student learning outcomes in physics education. The findings of the current study revealed that interactive simulations, visualizations, and online learning resources can bring abstract physics concepts to life, fostering deeper student engagement and comprehension. Effective adoption and execution of ICT-integrated pedagogies can facilitate personalized knowledge gaining experiences, facilitating students to explore physics content at their own pace and revisit challenging concepts as needed. The research also holds promise in motivating physics teachers to blend technology in their lesson plans, fostering avenues for developing vital skills such as critical thinking and problem-solving. By addressing the benefits of ICT-integrated teaching techniques, this study reinforces the notion that interactive learning environments created through technology can make physics more appealing and increase student motivation to learn.

Implications for Teachers

The proposed recommendations in the white paper can empower physics teachers and improve their professional development in ICT integration. Investing in professional development equips teachers with the necessary skills and confidence to utilize ICT effectively within their classrooms. Training programs on pedagogical approaches for ICT integration can introduce teachers to innovative ways to leverage technology for physics instruction. By addressing teacher workload concerns and exploring options for support staff, more time can be allocated for lesson planning and integrating ICT into existing curriculum. Providing opportunities for teachers to experiment with new technologies and share best practices can foster a sense of accomplishment and enhance professional satisfaction.

Implications for Educational Policy and Leadership

By documenting the challenges faced by physics teachers regarding ICT integration, the white paper sheds light on critical issues that may not have received sufficient attention from policymakers and school administrators. Recommendations requiring infrastructure upgrades and technology acquisition necessitate a commitment from the state ministry of education and district authorities to allocate adequate resources for ICT initiatives. The study reiterates on collaboration between curriculum developers and educational technology companies which is crucial to ensure that available technology tools are well-aligned with the defined learning objectives of the physics curriculum. The white paper project advocates for incorporating dedicated time within the school schedule for ICT-focused professional development, demonstrating a commitment from school administrators to supporting teachers in integrating technology effectively. Strong leadership support from school principals creates a positive environment and promotes collaboration in ICT integration efforts.

Implications for Educational Equity and Accessibility

The recommendations proposed in the project strive to promote ICT integration in a way that fosters educational equity and accessibility. Ensuring all schools have access to reliable internet connectivity and technology devices is crucial to prevent technology from becoming a barrier to learning for students from under-resourced communities. The white paper recommends developing curriculum-aligned technology resources which will ensure that students across the state benefit from ICT integration and engage in physics education with enhanced curiosity and engagement. The findings of this project study can also influence educators to invest in offline learning resources and create alternative solutions in situations where internet connectivity is unreliable, promoting universal access to physics educational materials.

Considerations for Implementation

While the proposed recommendations provide a clear path towards successful ICT integration, several considerations require careful attention during the implementation phase. Long-term funding has to be secured for ICT infrastructure upgrades such as internet connectivity, devices, etc., teacher training programs, and device replacement plans. Such funding is crucial for sustained ICT integration efforts. Fostering a collaborative environment where educators can exchange best practices and navigate challenges can cultivate a sense of ownership among teachers. This collaborative approach can significantly enhance the success of ICT integration initiatives. It is essential to ensure readily available technical support within schools for troubleshooting technical issues and assisting teachers in integrating technology seamlessly into their lessons. Regularly evaluating the effectiveness of ICT integration through data collected from student assessments, teacher feedback, and resource utilization data is crucial to determine the impact of these recommendations and make adjustments as needed.

Summary

I commenced this section by outlining the overarching goal of the project, followed by the rationale for selecting a white paper as the project study format. I centered my justification on the white paper's ability to effectively communicate research findings and recommendations to a target audience of policymakers and stakeholders within the educational system. A comprehensive literature review was the presented to critically examine existing literature on white papers, challenges and opportunities related to ICT integration in secondary school physics education, particularly within the state under investigation. I then proceeded to offer a detailed description of the project itself encompassing a clear articulation of the four key recommendations presented in the white paper. After presenting an evaluation plan for the project, I concluded this section by presenting the broader implications of the research findings and project recommendations. The potential impact of the project on various stakeholders, including students, teachers, school administrators, and educational policymakers within the state, were also discussed.

Section 4: Reflections and Conclusions

Introduction

This section delves into a critical evaluation of the qualitative research study presented in the previous sections. The strengths and limitations of the chosen methodology are explored in relation to the research objectives. The section highlights aspects of the study design that contributed to its robustness and acknowledges limitations that may influence the generalizability of the findings. I engage in the process of research reflexivity in this section. As the scholar and developer of this project, I examine my own role and potential biases throughout the research process. This self-reflection will consider how my background and experiences may have shaped the research design, data collection, and interpretation of findings. I share my experiences in project development, scholarship, and leadership relevant to this research project. By sharing these experiences, I seek to allow the reader to gain a deeper understanding of my academic background and qualifications for conducting this study. Finally, I conclude Section 4 with a reflection on the significance of the knowledge gained from this research project. I discuss the importance of the research process itself, beyond the specific findings, and highlight potential areas for further or future research endeavors based on the insights gleaned from this study.

Project Strengths and Limitations

This project study offers a valuable contribution to the effort of improving ICT integration in physics education in the secondary schools of a southwestern state in Nigeria. In this subsection, I acknowledge both the strengths and limitations of my project study. By recognizing the strengths, I demonstrate transparency in my research process and highlight the quality of my project study. By acknowledging the limitations, I avoid overstating the significance of my findings and maintain the credibility of my research. Identifying limitations also may help other researchers determine avenues for future research and areas where further methodological improvements are needed.

Strengths

By utilizing a white paper format, this project study demonstrates a focus on practical solutions and an action-oriented approach. Semistructured interviews with 12 secondary school physics teachers of the state and further analysis of the interview data collected resulted in four recommendations presented in the white paper. The clear recommendations presented in the white paper will allow the state education department, policymakers, and stakeholders to readily grasp the proposed course of action for enhancing ICT integration within physics education in the state's secondary school classrooms. Additionally, the project targets a particular state and education system in Nigeria. This focus led to the recommendations being tailored to address the unique challenges faced by the physics teachers of this state, explore opportunities within the specific context of the secondary schools in the state, and enhance the prospects for successful implementation of ICT-integrated teaching practices.

By incorporating data collected through semistructured interviews with secondary school physics teachers, the current project prioritizes the perspectives and experiences of those who are directly involved in implementing ICT-integrated teaching and learning practices. Consequently, this study offers valuable insights into the real-world challenges and opportunities faced by teachers on the ground. Moreover, these data revealed crucial information about the factors that motivate or hinder teachers' use of technology in the classroom, resulting in the proposed recommendations to be more targeted and effective. The challenges and concerns identified by teachers through the interviews are directly addressed in the white paper. This makes the white paper more responsive to teachers' needs and enhances the feasibility of teacher buy-in.

The qualitative data gathered through the interviews can serve as a rich starting point for further research endeavors. Although the current project study focuses on proposing solutions through the white paper, the interviews and data analysis may reveal a wealth of nuanced experiences, challenges, and opportunities related to ICT integration in physics education. The analysis of the interview data may also likely reveal unexpected concerns or barriers faced by physics teachers that require further investigation. The insights gained from the thematic analysis of the interview data may be used to formulate focused research questions for future studies, delving deeper into the specific themes identified in the interviews.

A thorough review of the existing literature on ICT integration in physics education was carried out to present the white paper project of the current study. Such a review ensured that the recommendations are grounded in a strong theoretical foundation. Furthermore, this strengthens the credibility and persuasiveness of the proposed solutions. The study site is one of the largest states in Nigeria, comprising six education districts providing education to over 200,000 senior secondary school students. An effective dissemination of this white paper has the likelihood to influence educational policies and practices not only across this state, but also in the neighboring smaller states, impacting numerous schools and ultimately benefiting a large number of senior secondary students.

Limitations

One of the major limitations for the implementation of the project's recommendations may be the funding required for significant investments in infrastructure upgrades, technology acquisition, and teacher training. Given the economic hardship faced by the country during the proposal of the recommendations, securing long-term funding for such initiatives may be difficult. Though the project study focuses on the challenges faced by physics teachers within a specific state, certain recommendations, particularly those pertaining to establishing consistent electric supply or providing alternative power sources alongside reliable internet connectivity, may necessitate intervention beyond the state government's capacity. The state government and relevant government agencies within the state may face limitations in implementing specific recommendations in the white paper due to budgetary constraints, lack of authority over federal infrastructure projects, or logistical challenges associated with large-scale infrastructure upgrades. The white paper, in its current form, may not be sufficiently persuasive to address these infrastructure-related issues directly with the federal government. Therefore, to effectively address these critical infrastructure needs, the project acknowledges the importance of fostering broader collaboration. This may involve engaging the federal government and exploring opportunities for public–private partnerships. By acknowledging the limitations of state-level implementation and advocating for multistakeholder collaboration, the project recognizes the need for a more comprehensive approach to addressing critical infrastructure challenges that hinder ICT integration efforts.

Recommendations for Alternative Approaches

This study employed a qualitative study methodology to explore the challenges faced by secondary school physics teachers regarding ICT integration within their classrooms. This approach prioritized in-depth exploration of the teachers' lived experiences and perspectives on this problem. After receiving permission from the state tutor general, I employed a purposive sampling strategy to identify 12 physics teachers from one of the education districts of the state under study who met the established criteria for participation. Purposive sampling ensured that the selected participants possessed the relevant experiences and characteristics to provide rich and informative data within the context of the research questions. Each of the 12 participating teachers provided informed consent before engaging in online semistructured interviews. The online platform facilitated data collection despite geographical constraints.

The project acknowledges the value of a professional training program as an alternative approach to address the challenges identified. Implementing a 2- to 3-day training program for secondary school physics teachers across the state was considered. However, upon closer examination, the project encountered significant logistical hurdles associated with such an initiative. A training program would necessitate teachers missing valuable instructional days, potentially impacting student learning. As the researcher, I would have been responsible for securing funding to cover refreshments, lunch, and any necessary training materials, which could have posed budgetary constraints. The region's unreliable power supply posed a significant disruption risk. Securing access to a backup generator and ensuring consistent internet connectivity for the training program would have further amplified logistical and financial challenges. In light of these substantial logistical hurdles, opting for a white paper project proved to be a more feasible and practical approach to address the research questions within the project's constraints.

Scholarship, Project Development, and Leadership Change

Scholarship

My engagement in research has been a transformative experience, promoting my growth as a scholar in several key ways. In the first instance, it instilled in me a rigorous approach to knowledge acquisition. Research demands a critical evaluation of sources, employing methodologies that ensure the validity and reliability of information. This has sharpened my ability to discern credible evidence for navigating the vast and often-contradictory landscape of academic literature.

Secondly, the research journey has honed my analytical and problem-solving skills. Formulating research questions, designing methodologies, and interpreting data all required a structured and logical approach. Through this process, I have developed the ability to identify patterns, synthesize complex information, and draw well-supported conclusions. The program's structure, featuring weekly assignments and collaborative discussions, proved instrumental in preparing me for the rigors of the capstone project. Through this process, I developed crucial skills such as setting achievable goals, meeting deadlines effectively, and building professional networks within the educational community.

Furthermore, research has nurtured my intellectual curiosity and independence. The pursuit of new knowledge necessitates a proactive and inquisitive mindset. I have learned to identify research gaps, formulate original questions, and delve deeper into areas that spark my intellectual interest. By tackling a significant research project, I have developed a heightened sense of purpose and a stronger work ethic, fueling my professional determination. This newfound independence has empowered me to approach research with a sense of ownership and a drive to contribute meaningfully to my chosen field of education.

Finally, my research journey has fostered my ability to communicate effectively. Disseminating research findings necessitates clear and concise writing, as well as the ability to tailor communication for different audiences. Through the process of writing my capstone project and engaging in scholarly discussions, I have honed my communication skills, which are essential for success in the field of education. As I continue on this path of inquiry, I am confident that my research abilities will continue to evolve, allowing me to make valuable contributions to the ever-expanding body of knowledge.

Project Development

This white paper project originated from a basic qualitative study investigating the challenges faced by secondary school physics teachers in integrating ICT into their lessons within a southwestern state in Nigeria. The project arose from the recognition that

ICT has the potential to revolutionize physics education by making abstract concepts more engaging and fostering a deeper understanding. However, literature evidence suggested limited ICT integration in physics classrooms. The study employed semistructured interviews to gather rich data from physics teachers. These data were meticulously analyzed to identify the key challenges teachers faced in utilizing ICT effectively. These challenges encompassed limited access to technology, inadequate training in using ICT for physics education, and a lack of support structures.

The white paper synthesized the research findings and translated them into actionable recommendations for policymakers and educational stakeholders within the southwestern state. This project highlights the prospective benefits of ICT integration in enhancing student learning outcomes in physics, clearly outlines the challenges faced by teachers in implementing ICT-based teaching methods, and recommends practical strategies to address these challenges, such as providing teachers with professional development opportunities on using ICT for physics instruction, ensuring equitable access to technology in schools, and establishing strong infrastructural support for teachers. With an anticipated positive impact on student engagement and learning outcomes in secondary school physics classrooms, this white paper has the potential to be a catalyst for positive change within the southwestern Nigerian state.

Leadership and Change

My doctoral journey in the field of education has been a catalyst for immense personal and professional growth. It has not only propelled me from a middle-level leader to a supervisor role, but also equipped me with the skills and confidence to become a true leader of change within my school. Prior to embarking on this program, I was one of the teaching staff in my school. The critical thinking and research skills I gained through my EdD experience facilitated my ascent to the position of a supervisor. The program instilled in me a commitment to unbiased, reflective, and purposeful leadership**.** I learned to leverage research methodologies and data analysis techniques, skills that I have actively applied in my current role as the head of my school's professional development team. In this capacity, I spearhead initiatives to integrate ICT into teaching and learning practices, directly impacting the educational experience of students. Furthermore, my doctoral research focused on a pressing issue within the district. This project study, culminating in a white paper, served as a testament to my commitment to evidence-based solutions and continuous improvement. It not only informed my evaluation as a change agent, but also fostered stakeholder buy-in for innovative approaches to address district-wide challenges.

Beyond ascending as a supervisor, my doctoral journey has transformed me into a change agent at other levels of my school leadership team. My newfound confidence and expertise have secured me positions on crucial committees like the educational technology team and the school policies planning group. I also developed into a master trainer of the All India Educators' Forum, building a deeper understanding of teacher experiences for effective ICT integration in enhancing students' learning outcomes. Here, I contribute by setting data-driven goals, proposing impactful initiatives, and ensuring rigorous evaluation processes—all skills honed during my doctoral research.

Additionally, I now recognize the importance of research in informing decisions that positively impact the functioning of our school community.

Reflection on Importance of Work

Having completed my postgraduate studies over two decades prior, I embarked on this doctoral program in March 2021 with minimal research experience. My primary motivators were a strong passion for education and the desire to contribute to the field through a doctoral degree. However, the program's impact transcended these initial goals, fostering significant personal and professional development, molding me into a proficient research scholar.

One of the most transformative aspects of the program was the cultivation of critical reflection skills and empathy for diverse perspectives. Previously, my focus may have been primarily on my own viewpoints. However, the program equipped me to become a more active listener, carefully considering the experiences and perspectives of interviewees and teacher-participants. This newfound ability to engage with diverse viewpoints has proven invaluable in my research endeavors.

Just a few months into the doctoral program, I faced a personal tragedy with the loss of my husband. This unexpected event presented the most significant challenge I have ever encountered. In the wake of the loss, balancing the demands of work, motherhood, and doctoral studies required exceptional willpower and meticulous time management. Through sheer determination, unwavering support from my family and colleagues, I persevered. Although subsequent phases of the doctoral program presented their own challenges following this immense loss, these experiences ultimately yielded valuable insights and transformative learning opportunities.

The doctoral program remarkably refined my writing skills, particularly in the area of using research to support ideas. Initially, the process of writing a literature review felt overwhelming. However, through guidance and practice, I learned to conduct thorough searches using academic databases and credible online resources. This involved developing effective search terms, critically evaluating sources for relevance and credibility, and synthesizing findings from diverse studies. The resulting comprehensive literature review provided a strong foundation for my research project, situating it within the broader context of existing scholarship on physics education and ICT integration.

The program went beyond literature review, equipping me with the skills to effectively present and analyze data from my own research project. This involved mastering various data analysis techniques tailored to the qualitative semistructured interviews I conducted. For example, I learned methods for coding data, identifying emergent themes, and utilizing qualitative data analysis software to organize and synthesize findings. Ultimately, the program transformed me from a consumer of research to a researcher capable of collecting, analyzing, and presenting data in a rigorous and meaningful way.

Previously, I prided myself on independent problem-solving. However, the doctoral program emphasized the importance of collaboration. I learned to leverage the expertise of my doctoral committee, student advisors, and colleagues, leading to more informed decisions. The unwavering support of my doctoral committee proved invaluable during the capstone phase of my program. Their prompt and insightful feedback provided a source of encouragement and direction. This positive and constructive guidance fostered a productive learning environment, enabling me to refine my research and approach the capstone project with confidence. As a result, the capstone phase became not only a culmination of my doctoral journey but also a period of significant intellectual and professional growth.

The doctoral journey also solidified my role as a change agent. I actively sought solutions to improve educational experiences for students and staff in my school. Leveraging my research findings, I designed and facilitated professional development sessions for science teachers. These workshops focused on practical strategies for ICT integration, addressing the specific needs identified in my research, such as effective use of online simulations and data analysis tools. The spirit of change agency extended into my classrooms as well. Presently, I strive to instill a growth mindset in my students, encouraging them to embrace challenges, learn from mistakes, and actively seek solutions to problems they encounter. We regularly engage in discussions about their educational experiences, and I encourage them to be vocal advocates for their own learning needs. This approach empowers them to take ownership of their education and become active participants in their educational journey. The journey to gain my doctoral degree has transformed me into a leader driven by a passion for positive change and committed to improving educational experiences transcending classroom walls.

Implications, Applications, and Directions for Future Research

My research delves into the critical challenges faced by secondary school physics teachers when integrating ICT into their classrooms. By identifying these challenges, my research serves as a valuable tool for physics teachers across the district and state, and even teachers nationally may benefit from this research. Understanding these common hurdles will equip them to advocate for essential resources and support structures needed for successful ICT integration. My research findings can be used by schools within the district and beyond to develop targeted professional development programs that address the specific needs of physics teachers. This can empower them to leverage ICT effectively, ultimately enhancing student learning experiences.

By presenting a clear picture of the hardships faced by the state's physics teachers, my research can inform policymakers at the district and state levels. This data can guide the allocation of resources towards initiatives that bridge the gap between available technology and its effective application in physics education. The prospective impact extends beyond immediate geographical boundaries. Sharing my research findings at conferences and through publications can contribute to a national conversation on the importance of supporting ICT integration in physics classrooms. This, in turn, can lead to the development of best practices and resources that benefit teachers and students across the country. Ultimately, by shedding light on the challenges faced by physics teachers, my research aims to pave the way for a more effective and engaging learning environment for students of physics. This will prepare them with the technological literacy and skills necessary to thrive in an increasingly technology-driven world.

My research on the challenges faced by secondary school physics teachers in integrating ICT into their classrooms in Nigeria holds high probability for future exploration. Comparative research may be conducted to understand how the challenges faced by Nigerian physics teachers differ from or align with those experienced by teachers in other countries, particularly those with similar educational contexts. The research findings may reveal whether certain challenges are universal across different contexts, regardless of specific educational systems. This could point towards broader issues in ICT integration for physics education that require solutions with wider applicability. Understanding the specific challenges faced by Nigerian physics teachers compared to those in other contexts may also allow for the development of more targeted interventions. Furthermore, comparative research may strengthen arguments for increased resource allocation to address ICT integration challenges in Nigeria.

Investigating the long-term sustainability of interventions aimed at supporting ICT integration in physics education may be taken up for future research. By tracking the implementation of interventions over time, researchers may identify the factors that contribute to their long-term success or failure. This knowledge may inform the development of more sustainable interventions in the future. Longitudinal studies can be carried out to reveal unforeseen challenges that arise during the implementation of interventions. Early identification of these challenges may allow for adjustments and improvements, ensuring the interventions remain effective over long term. Longitudinal studies can also be utilized to assess whether interventions remain cost-effective over time, taking into account ongoing maintenance of technology devices, teachers' training needs, and resource allocation for ICT infrastructure. Findings of such studies can inform the development of evaluation frameworks for ICT integration initiatives. These frameworks can be applied to track key metrics over time, allowing educators to assess the ongoing effectiveness of their efforts.

Conclusion

This doctoral journey has transformed me from an educator into a scholar with a passion for research and a commitment to effecting positive change within the educational system. Working to secure my Ed. D. degree has instilled in me immense perseverance and resilience, propelling me forward towards future endeavors. The program has fostered my confidence in expressing my ideas and presenting research findings with clarity and purpose. The experience of defending my project study and engaging in academic discourse has significantly strengthened my communication skills. These qualities such as confidence, communication skills, and research expertise which I have cultivated will shape my future work as a leader, researcher, and advocate for innovative teaching practices in physics education.

The prospective impact of this project study and the resulting white paper go beyond academic boundaries. By advocating for teachers' professional development and efficacious teachers' training, this research recommends empowerment of teachers to utilize technology effectively, leading to increased job satisfaction and professional growth. By addressing challenges to ICT access within state schools, this research can contribute to closing the digital divide and equipping students with essential 21st-century technological skills. The proposed recommendations, if implemented, could significantly enhance the integration of ICT in physics education across schools in the studied state, yielding positive student outcomes.

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Appendix A: Project

Recommendations to Support ICT Integration in Physics Education

By

Hemamalini Srinivasan

Introduction

Nigerian national education policy emphasizes the importance of information and communication technology (ICT) for improving student outcomes. Despite calls for integrating technology and utilizing ICT tools to move away from teacher-centered approaches and embrace more modern educational methods, Nigerian public senior secondary schools are still struggling to achieve this goal. Researchers have attributed this struggle to lack of necessary technological expertise among secondary teachers and inadequate technology infrastructure in schools (Ifinedo & Kankaanranta, 2021; Opeyemi et al., 2019). Such inadequacy in training and infrastructure poses challenges to teachers in ICT integration and forces them to often resort to traditional teaching methods, limiting the impact of ICT on the secondary school curriculum (Jimoh et al., 2020).

Through this project study, I endeavored to explore secondary school physics teachers' perceptions of factors that challenge ICT integration in a southwestern state in Nigeria. Data was gathered through semistructured interviews with 12 secondary school physics teachers from one of the districts of the studied state. The perceptions and lived experiences of the teacher-participants were analyzed to answer the following research questions:

RQ1: What are Nigerian secondary teachers' perceptions about integrating ICT into the physics curriculum?

RQ2: What are secondary physics teachers' perceptions of the facilitating conditions that challenge ICT integration in the state under study in Nigeria?

RQ3: What are secondary physics teachers' perceptions of the resources needed for ICT integration in the state under study in Nigeria?

The Local Problem

Students' have developed a strong interest in technology due to the growing availability of digital tools, yet technology adoption remains low creating disconnect between student enthusiasm for technology and its actual use in secondary school physics classrooms in the target state. Nigerian education policy actively promotes the integration of technology into teaching practices. The Federal Ministry of Education's 2013 policy and 2019 directives (Federal Ministry of Education, 2013, 2019) emphasize the value of ICT pedagogy for improving student learning outcomes. However, this research identified a significant gap between policy pronouncements and the realities experienced by schools in the target state.

Despite ministerial support for ICT integration, many schools within the state struggle to fully embrace this approach. This limited adoption restricts the impact of initiatives aimed at incorporating ICT into the secondary school curriculum. Several infrastructural challenges impede effective ICT integration. Many school buildings lack essential resources, such as strong technology infrastructure, consistent electricity, and reliable internet connectivity. Furthermore, high student-teacher ratios, reaching up to 80:1 in public senior secondary schools, create significant challenges for teachers. These large class sizes make it difficult for teachers to implement traditional, teacher-centered pedagogy, let alone incorporate more technology-intensive methods.

The consequence of these challenges is a struggle for Nigerian secondary school students to achieve desired learning outcomes, particularly in physics. Limited ICT integration hinders the development of skills crucial for success in an increasingly ICT-dependent world. This is further evidenced by Nigerian students' consistent lower performance in physics compared to international benchmarks (UNESCO, 2020).

This white paper addresses the challenges faced by secondary school physics teachers in integrating ICT into their classrooms within the target state in Nigeria. By identifying these challenges and proposing recommendations, this research aims to inform stakeholders and provide the necessary support to empower teachers to integrate ICT effectively. This, in turn, has the potential to significantly enhance student learning outcomes in physics education.

Summary of the Study

Methodology

This qualitative study delved into the perspectives of secondary school physics teachers within a specific Nigerian state. The research focused on uncovering the challenges that hinder them from effectively integrating ICT into their physics classrooms. By identifying these challenges, the study aims to inform the development of practical recommendations. These recommendations can be used by stakeholders to support more effective ICT integration within physics education, ultimately leading to improved student learning outcomes. Following a comprehensive literature review that established the research gap, I chose a basic qualitative design for its suitability in exploring the lived experiences and perspectives of secondary school physics teachers

(Merriam & Tisdell, 2016). This approach allowed for in-depth examination of teachers' perceptions concerning barriers to ICT integration within the specific context of this study.

The unified theory of acceptance and use of technology (UTAUT) model, proposed by Venkatesh et al. (2003), provided the theoretical foundation for this study. This model was chosen due to its focus on understanding factors that influence the adoption and use of technology in various contexts. The UTAUT framework served as a guide for exploring the attitudes and beliefs of physics teachers related to ICT integration and its application in their classrooms.

A purposeful sampling strategy was employed to recruit participants who possessed specific characteristics relevant to the research questions (see Merriam & Tisdell, 2016). In this study, the teacher-participants comprised secondary school physics teachers within the chosen state. Collaboration with the physics teachers' association within the district under study facilitated participant recruitment. From the received responses, a sample of 12 physics teachers, representing various secondary schools within a specific administrative division, were selected for semistructured interviews.

The credibility of the research findings, which was paramount, was achieved by implementing several strategies. Following the interviews, transcripts were shared with each participant for review, verification and member checking, ensuring the accuracy of captured information and reflecting their true perspectives (see Muzari et al., 2022). Throughout the research process, I maintained a reflective journal to document personal biases and assumptions that could potentially influence the interpretation of data (see Phillippi & Lauderdale, 2018).

Geographical limitations necessitated the use of online interviews as the primary data collection method. With the informed consent of participants, interviews were conducted via Zoom, a video conferencing platform. This approach offered several advantages. Online interviews facilitated participation for geographically dispersed teachers, overcoming travel constraints. The video conferencing format enabled me to capture both verbal and non-verbal cues, leading to richer and more nuanced insights from participants (see Żadkowska et al., 2022). With participant permission, interviews were recorded and stored securely on a password-protected Zoom account, allowing for later review and transcription.

Following data collection, I employed a multilevel and iterative approach for data analysis. Audio recordings of the interviews were transcribed using NVivo software, a qualitative data analysis tool. A coding process was conducted on each transcript, involving initial coding, identification of patterns within the data, and the development of thematic categories that emerged from the teachers' perspectives (Saldaña, 2021). To enhance the credibility of the findings, triangulation was achieved by analyzing data from multiple sources, in this case, the interviews with a diverse group of physics teachers across different schools within the chosen administrative division. This multisource approach helped me to ensure that the identified themes were representative of the broader population of physics teachers within the study context.

Data Analysis Findings

By analyzing the data, I was able to gain a clearer picture of the factors challenging technology integration in schools within the chosen Nigerian state. This analysis also resulted in the discovery of three key themes related to each research question, providing a more nuanced understanding of the challenges faced.

Theme 1: Physics is a complex subject that requires effective instructional methodologies to elucidate and deliver it to students. Aligned with existing literature on physics education's abstract nature as a barrier to learning, teacher-participants shared their perceptions providing a richer understanding of the challenges faced by offering practical insights and diverse viewpoints. Their lived experiences highlighted the need for innovative pedagogical approaches to directly address physics' abstractness, promoting deeper student engagement and comprehension.

Theme 2: Technology integration in teaching simplifies and strengthens the understanding of abstract physics concepts. Building upon RQ1, this theme focused on the practical applications of ICT in overcoming the abstract nature of physics concepts. Although every participant acknowledged the potential of technology to enhance student understanding, concerns regarding the dominance of traditional pedagogy emerged. These concerns pointed towards the hardships faced by teachers in integrating technology effectively within their existing instructional practice.

Theme 3: Technology integration in teaching ensures enhanced student engagement in learning and improves student outcomes in physics. Supporting the research focus on student outcomes, this theme highlighted the perceived effectiveness of

ICT integration in fostering student engagement and academic achievement. Teachers emphasized the power of technology-driven approaches, such as simulations and virtual labs, to promote active learning, cultivate student interest in physics, and ultimately, lead to improved academic performance.

Theme 4: Secondary school physics teachers faced challenges when integrating technology in instructional methodology. All teacher-participants reported challenges related to unreliable electricity and internet connectivity, hindering adoption of ICT-integrated pedagogies in their classrooms. The limited availability of digital devices and inadequate school infrastructure were also identified as essential factors for the unsuccessful integration of technology in the teaching and learning practices.

Theme 5: Secondary school physics teachers believed their school administration expected regular use of technological instructional strategies. Linking to the social influence aspect of the UTAUT model, the fifth theme revealed a perceived expectation from school administration for regular ICT integration, despite limited resources. This theme also highlighted a potential disconnect between teachers and administrators regarding the level of support needed for effective ICT integration in physics education.

Theme 6: Secondary school physics teachers received very limited support from their administrative division. Examining the sixth theme, this study explored the nature and impact of hardware/software support provided by school administration on teacher practices, student engagement, and academic achievement. Analysis of the interview data revealed inconsistencies in support levels offered by school administration and their impact on ICT integration effectiveness within physics classrooms.

Theme 7: Secondary school physics teachers required strong support from the school administration and the local government for effective ICT integration. This theme highlighted every teacher-participant’s desire for comprehensive support for successful ICT integration in their teaching strategies. Teachers called for increased funding for hardware, software, and incentives, alongside the creation of educational resources and support structures for both teachers and students.

Theme 8: Secondary school physics teachers perceived professional training and development to support their use of ICT in classroom teaching practices. The eighth theme highlighted the need for professional development tailored to physics education, focusing on meaningful ICT integration beyond technical skills. Despite teacher desire for such training, concerns about limited resources and unreliable electricity emerged as potential barriers to applying these new skills effectively.

Theme 9: Secondary school physics teachers yearned to learn from training sessions to create classrooms that incorporated a fun-way of learning physics. Highlighting teacher ingenuity, this theme revealed teachers’ interest in professional development that not only benefits their own students but empowers them to share resources and create cost-effective digital learning materials for the wider physics education community. This vision calls attention to the teachers' commitment to finding creative solutions for improved student learning experiences.

Recommendations

Recommendation 1: Ensure Equitable Access to ICT

To achieve equitable access to ICT across the state, a comprehensive needs assessment is necessary. This assessment should evaluate the current state of internet connectivity, the availability and types of technology devices in schools, considering student-to-device ratios, and the alignment of existing software applications and educational technology tools with curriculum requirements and learning objectives. Probable funding limitations, particularly for infrastructure upgrades and new device purchases, can be addressed through the identification of sustainable funding sources. Prioritizing underserved schools in remote areas for infrastructure development and expansion is crucial. Additionally, exploring alternative power sources like solar panels and establishing partnerships with educational technology companies to provide discounted curriculum-aligned software and resources can further support this initiative. By implementing these strategies, all schools within the state will have the necessary resources to effectively integrate ICT into their classrooms, ultimately promoting equitable access to technology for all students.

Recommendation 2: Invest in Teacher Training and Support

The second recommendation is made to productively invest in teacher training and support. The existing professional development opportunities offered to teachers regarding technology integration needs to be analyzed. Teachers' current technology skills and confidence levels need to be evaluated through surveys or self-assessments. One of the potential barriers to following through with the second recommendation is time constraint. Teachers often face heavy workloads, making it difficult to dedicate time for training. Not only teachers, but district and school leadership teams require a significant time investment for the successful implementation of the professional development program to achieve effective ICT integration. School leaders are also expected to dedicate additional time to share the training and ICT in education implementation process with their faculty. Ensuring teachers and leaders have the necessary time and resources allocated for ICT integration is crucial for the success of the professional development programs. A multitiered professional development approach with options for various skill levels and technology needs can be developed. Ongoing technical support personnel may be provided within schools to assist teachers with troubleshooting issues and utilizing technology effectively. Teacher learning communities can be established, focused on sharing best practices and fostering collaboration in ICT integration.

Recommendation 3: Address Cost Considerations

The third recommendation is made to address cost considerations in implementing ICT in education. The current budget allocations for technology in schools needs to be analyzed. Existing funding streams such as federal grants or state technology initiatives have to be identified. As the cost of technology goes beyond initial infrastructure and device purchases, including software licenses, maintenance, and potential upgrades, ongoing costs stand as a potential barrier to this recommendation. Funding through grants, public-private partnerships, or budget allocations for technology acquisition needs are to be secured. High costs of ICT tools, software and their licenses, simulations and their subscriptions, necessitate a strategic approach to investments. This includes meticulous planning, exploring innovative funding models, and fostering collaboration and resource-sharing networks to maximize efficiency. Cost-saving strategies such as open-source software or bulk licensing agreements may be implemented. Collaboration between schools to share resources and expertise can be encouraged.

Recommendation 4: Implement a Phased Approach with Evaluation

The fourth and the last recommendation is made for the adoption of a phased approach with ongoing evaluation for successful integration of ICT within the educational system of the state being studied. This recommendation prioritizes a methodical and data-driven implementation process. The existing ICT initiatives within the state need to be analyzed. The past successes and areas of improvement in the implementation of ICT in education initiatives need to be identified. The potential barrier to this recommendation would be lack of a comprehensive implementation plan, leading to inefficiencies, wasted resources, and a lack of direction. It can also be challenging to assess the effectiveness of ICT integration in school without established evaluation tools. A detailed implementation plan outlining clear phases, with pilot programs strategically implemented in select schools based on their needs and readiness, is to be developed. Measurable goals and objectives for ICT integration has to be established. Clear metrics to track progress and assess the impact on student learning outcomes need to be defined. A robust evaluation system that utilizes data to identify challenges and areas for improvement in ICT integration within schools need to be implemented. A culture of data-driven decision making has to be fostered in schools, utilizing evaluation results to inform future ICT integration efforts.

Conclusion

This qualitative study explored teacher perspectives on ICT integration in secondary school physics education within a Nigerian state. 12 secondary school physics teachers participated in online interviews, revealing challenges and opportunities. The research identified the abstract nature of physics as a barrier to student understanding, highlighting the need for innovative pedagogical approaches. Teachers acknowledged the potential of ICT to enhance student engagement and learning, particularly through simulations and virtual labs. However, significant barriers were identified, including unreliable electricity, limited access to technology, and inadequate infrastructure. Additionally, a complete disconnect emerged between teachers and administration regarding support for ICT integration. Teachers desired professional development tailored to physics education and focusing on meaningful technology use beyond technical skills.

The analysis and findings in this study provide valuable insights into the current state of ICT integration within secondary school physics education in the target Nigerian state. Based on these findings, the study proposed four key recommendations, summarized and analysed in the white paper format. By prioritizing equitable access to ICT, investing in teacher training and support, adopting strategic cost-management practices, and implementing a phased approach with ongoing evaluation, the target state can establish a sustainable foundation for successful ICT integration within its physics education curriculum.

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Appendix B: Social Media Flyer

Seeking Physics Teachers to Participate in a Research Study

The purpose of this basic qualitative study is to explore secondary physics teachers' perceptions of the factors that challenge information and communication technology integration in their curriculum.

The research study is being conducted for a Walden University project study.

If you are willing to participate in this study, please contact me at hemamalini_srinivasan@waldenu.edu

Participant must be a:

- Secondary school physics teacher with 5 or more years of classroom teaching experience
- Teacher in a school setting located in Nigeria
- Teacher who has integrated or attempted to integrate information and communication technology in teaching and learning of physics

Participants expectations include:

- Consenting participants will be invited via email to participate in a 45 – 60 minute interview on the Zoom video conferencing platform.
- All participants need technology and access to internet through a laptop or a mobile device that will facilitate them to be interviewed online.
- Prior to the interview, an Informed Consent Form should be signed and returned to hemamalini_srinivasan@waldenu.edu

Appendix C: Participant Invitation Via Email

Subject Line:

Interviewing secondary school physics teachers for research study

Dear Invitee,

There is a new study about the challenges faced by teachers in integrating information and communication technology in secondary school physics classrooms. This study could benefit teachers to enhance student outcomes in physics learning. For this study, you are invited to describe your experiences integrating technology in physics teaching and learning.

About the study:

- One 45 – 60 minute online interview on Zoom video conferencing platform that will be video recorded
- You will receive a gift card (in local currency equivalent to $10) after completing the interview, as a gesture of thanks
- To protect your privacy, the published study will not share any names or details that identify you

Volunteers must meet these requirements:

- Secondary school physics teachers with 5 or more years of classroom teaching experience
- Teachers in a school setting located in south-western Nigeria
- Teachers who have integrated or attempted to integrate ICT in teaching and learning of physics.

This interview is part of the doctoral study for Hemamalini Srinivasan, an Ed. D. student at Walden University.

Please e-mail hemamalini_srinivasan@waldenu.edu to let the researcher know of your interest. You are welcome to forward it to others who might be interested.

Sincerely,

Hemamalini Srinivasan

Doctoral Student

Walden University.

Appendix D: Interview Guide

[To be read to the participant] Greetings for the day! I appreciate you consenting to participate in this project study and share your perceptions and experiences. The problem addressed in this study is that secondary school teachers are challenged to integrate information and communication technology in physics teaching and learning. The purpose of this project study is to explore secondary physics teachers' perceptions of the factors that challenge information and communication technology in their curriculum. The results of this project study will strongly emphasize the significance of teachers' opinions when designing technology integrated pedagogy in teaching and learning of secondary school physics. The information you provide today will be maintained confidentially and secured safely for a minimum period of five years or till the doctoral committee confirms the results of the study. This interview will last for 45 – 60 minutes. With your consent, the interview proceedings will be recorded. Do you agree? [Zoom recording will be turned on and the interview will begin].

Interviewee's Name:

Interview Date:

Appendix E: Interview Questions

Background Information/Demographics Prompt: [Kindly share your teaching background]		Responses
1	What course level or grade are you currently teaching?	
2	For how long you have been teaching physics?	
RQ1: What are Nigerian secondary teachers' perceptions about integrating ICT into the physics curriculum?		
3	How would you describe latest classroom technology integrated teaching of physics?	
4	How well does technology integration enhance the understanding of physics learning?	
5	How does integrating technology enhance student outcomes in physics? Sub-question: Could you provide an example of a specific instance where you observed enhanced student outcomes through technology integration?	
RQ2: What are secondary physics teachers' perceptions of the facilitating conditions that challenge ICT integration in the state under study in Nigeria?		
6	What challenges are you experiencing when you integrate technology in teaching physics?	

7	Tell me about the technology support provided by your administrative division.	
8	How do the Principal and other leaders of the school expect you as a teacher to use technology in teaching and learning of physics?	
9	How well does technology integration assist in planning lessons in complex concepts of physics?	
10	What type/s of hardware (Multimedia TV, WIFI with Access point, LCD Projector etc.), software (collecting Database integrated, YouTube, social media etc.) and on-time professional support does the administrative division provide for secondary school physics teachers?	
11	What makes technology integration effective for you?	
RQ3: What are secondary physics teachers' perceptions of the resources needed for ICT integration in the state under study in Nigeria?		
12	What support do you need to aid integration of information and communication technology (Google, ChatGPT, Twitter, Instagram, LinkedIn, etc.) in your classrooms?	
13	What would you like to learn about technology integration in the teaching of physics?	

<table>
<tr><td>14</td><td>How well can professional development support your technological skills?</td><td></td></tr>
<tr><td>15</td><td>What kind of professional development does your administrative division provide to strengthen teachers' technological skills?</td><td></td></tr>
<tr><td>16</td><td>What additional aid is required to support technology integration in physics curriculum?</td><td></td></tr>
<tr><td>17</td><td>Would you like to add anything else?</td><td></td></tr>
<tr><td colspan="2">Closing Statement: I appreciate your taking time to meet with me for this interview. You have provided me a deeper insight into your perceptions related to ICT integration in secondary school physics curriculum.</td><td></td></tr>
<tr><td colspan="2">Follow-up Statement: I will be transcribing this interview over the following several weeks, and after that, I will email you to finish the member-verification process and allow you to ask any clarifying questions up to a maximum of five. When I give you the follow-up email, you are welcome to add anything additional you may have thought of. Feel free to get in touch with me if you have any more questions. I genuinely appreciate you taking the time to speak with me today, being open to sharing, and letting me utilize your knowledge to help the field of education learn more ICT integration in physics classrooms.</td><td></td></tr>
</table>

Appendix F: SME Consent—Email Confirmation

Subject Line: Seeking feedback on Qualitative Research Interview Protocol

Dear Subject Matter Expert,

Hope this e-mail finds you in good health. I am Hemamalini Srinivasan, a doctoral student at Walden University. I am writing this mail to seek your consent to participate in my research project as a subject matter expert.

Kindly read the following information carefully, and do not hesitate to ask any questions before making your decision.

Purpose of the Study:

The purpose of my research project is to explore secondary school physics teachers' perceptions of factors that challenge ICT integration in a southwestern state in Nigeria. I have designed an interview protocol as my qualitative data collection instrument consisting of an interview guide and interview questions. A panel of five subject matter experts has to be formed to review my interview protocol and provide their professional subjective judgment to ensure that the designed instrument is appropriate for data collection.

Your expertise in the subject matter is highly valued, and I would greatly appreciate your consent to provide feedback as an SME and enhance the quality of the data collection instrument.

Study Procedures:

After receiving consent from you to provide your viewpoints, I will provide you with a copy of the interview protocol. I kindly request you to review the document and provide feedback on the relevance, necessity, and comprehensiveness of the interview questions in the area of technology integration. You may also provide your viewpoints on the areas where improvement is possible.

Risks and Benefits:

There are no known risks associated with providing feedback on the interview protocol. However, your expertise will be invaluable in improving the research protocol, contributing to its quality and effectiveness.

SME's Consent:

If you agree to share your viewpoints on the relevance of the interview protocol for gathering relevant data, please indicate your consent by replying to this e-mail with the words "I consent."

Printed Name of the SME ________________________________

Date of Consent ________________________________

Appendix G: Peer Debriefer Consent-cum-Confidentiality Form

- I, ____, agree to assist as a peer debriefer in this project study.
- I am willing to commit to the debriefing process and be available on mutual agremment.
- I have enough knowledge in integrating technology in secondary school teaching practices to understand and critique the data and its analysis.
- My relationship with the researcher is based on honesty, trust, and communication.
- I have no stake in the outcome of this project study.
- I will strive to serve as both conscience and critic for the researcher's work.
- I will be careful and empathetic, and avoid discouragement during debriefing.
- I will provide constructive criticism for the debriefing to be effective.
- I assure to meet the disclosures of the researcher and the participants of this project study with discretion and diplomacy.
- I will maintain the confidentiality of the participants and their demographics.

____

Signature of the Peer Debriefer Date

____

Signature of the Researcher Date

Appendix H: Review and Approval of Transcribed Interviews—Confirmation Email

Dear [Interviewee's Name],

Thanks for signing up for this project study and taking out your time to participate in the interview during which we discussed about the factors that challenge the integration of ICT in secondary school physics classrooms.. It was a valuable conversation, and your insights have greatly contributed to my research. As a next step in the research process, I have transcribed our interview to ensure accuracy and clarity. I now request your cooperation in reviewing and approving the transcribed interview. Your approval is essential to maintain the integrity of the project study.

Please find attached the transcribed interview for your review and approval [Attachment – Transcribed interview].

Your feedback and approval are needed in the following aspects:

Accuracy: Please verify that the transcription accurately represents what was discussed during our interview. If you come across any discrepancies, kindly make the necessary corrections or provide clarifications.

Confidentiality: Please ensure that any confidential information or personally identifiable data you shared during the interview is appropriately redacted or anonymized.

Completeness: Please confirm that the entire conversation has been transcribed, and nothing crucial has been omitted.

Clarity: Notify us of any parts that may be unclear or require additional context.

To facilitate the review process, I kindly request you complete your review and approval by [deadline]. If you require more time, please let me know. I will do my best to accommodate your schedule.

You can provide your feedback and approval either by replying to this email with your comments and approval or make necessary corrections or comments directly on the downloaded document and return it via email.

Your feedback is highly valued, and I thank you once again for your participation and cooperation in this project study. If you need further assistance or have any questions, please do not hesitate to reach out to me.

Warm regards,

Hemamalini Srinivasan,

Doctoral Student,

Walden University.