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Lived Experiences of Digital Inequality in Access to AI-Supported Learning Tools in STEM Education: A Phenomenological Study in Ondo North, Nigeria

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ABSTRACT

Digital inequality remains a significant challenge to the equitable integration of emerging technologies into STEM education, particularly where access to digital resources, infrastructure, and teacher capacity is uneven. This study explored the lived experiences of secondary-school students and STEM teachers regarding digital inequality and access to artificial intelligence (AI)-supported learning in Nigerian secondary education. This study adopted a Husserlian descriptive phenomenological approach to examine how participants experienced, interpreted, and responded to digital exclusion within their educational contexts. Data were obtained through semi-structured interviews and analysed using Colaizzi's phenomenological method. Five interconnected themes emerged: unequal access to digital learning resources; limited exposure to AI tools; structural and institutional barriers; emotional experiences of digital exclusion; and coping, adaptation, and grassroots resilience. Findings indicate that digital inequality extends beyond the physical availability of computers and internet connectivity to include restricted opportunities for practical digital engagement, unreliable electricity and connectivity, inadequate equipment maintenance, limited teacher preparation, and institutional resource constraints. These conditions were associated with frustration, perceived educational disadvantage, and concerns about future competitiveness. The study concludes that digital inequality constrains equitable participation in AI-supported STEM education and that individual coping strategies cannot substitute for sustainable institutional provision. It recommends increased investment in reliable digital infrastructure, continuous teacher professional development, curriculum integration of AI, and equitable digital policies that promote meaningful student access and guided engagement with AI technologies. The study underscores the need for context-responsive interventions that address the material, pedagogical, and experiential dimensions of digital inequality in Nigerian secondary-school STEM education.

INTRODUCTION

Artificial intelligence (AI) is increasingly becoming part of the educational landscape, creating new possibilities for how students learn and how teachers design and support instruction. Generative AI, intelligent tutoring systems, adaptive learning applications, and other AI-supported technologies can provide learners with new forms of information access, personalised support, feedback, and interaction. These developments are particularly relevant to Science, Technology, Engineering, and Mathematics (STEM) education, where digital technologies can support visualisation, problem-solving, simulation, experimentation, and access to diverse learning resources. However, the expansion of AI in education also raises important questions about equity and participation. UNESCO (2025) cautions that although digital technologies and AI may expand educational opportunities, existing inequalities in digital access can contribute to an emerging AI divide, particularly for rural and other underserved populations. The concern is not simply whether AI technologies are available, but whether learners and teachers have meaningful opportunities to access and use them for educational purposes. Digital inequality is multidimensional and may involve differences

in access to appropriate devices, internet connectivity, electricity, digital competencies, quality of use, and the capacity to derive educational benefits from digital technologies. In the context of AI-supported education, these dimensions become increasingly important because awareness of an AI tool does not necessarily provide an opportunity to use it meaningfully. A student may know about ChatGPT or another generative AI application but lack a suitable device, reliable internet connection, electricity, or institutional permission to use it for learning. Similarly, a teacher may recognise the potential of AI but lack the competencies, infrastructure, or institutional support required to integrate it into classroom practice. UNESCO's AI Competency Framework for Students emphasises that learners require more than exposure to AI; they need competencies that enable them to use AI safely, meaningfully, creatively, and responsibly (Miao *et al.*, 2024). Similarly, the AI Competency Framework for Teachers identifies the knowledge and skills educators require to use AI appropriately in teaching and learning (Miao & Cukurova, 2024). These frameworks suggest that meaningful participation in AI-supported education depends on a combination of technological access, human capacity, pedagogical preparation, and

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supportive educational environments. Consequently, inequalities in these conditions may influence who is positioned to participate in emerging AI-enabled learning opportunities and who remains largely excluded from them. The issue is particularly significant in STEM education. STEM learning frequently involves practical activities, visual representations, experimentation, data interpretation, simulation, and problem-solving. AI-supported technologies can potentially complement these processes by providing interactive resources, personalised assistance, simulations, and opportunities for students to explore concepts beyond the immediate classroom environment. Nevertheless, the educational possibilities associated with AI cannot be separated from the material and institutional conditions in which learning takes place. In their review of emerging AI trends in Nigerian education, Bali *et al.* (2024) identified infrastructural and technological challenges as key constraints on the country's ability to fully harness AI for education. Thus, the growing availability of AI technologies at the global level does not necessarily mean that students and teachers in all educational contexts have comparable opportunities to experience their potential.

Recent evidence from Nigeria demonstrates both the potential of AI-supported learning and the importance of the conditions surrounding its use. De Simone *et al.* (2025) evaluated a structured, teacher-supported generative AI programme involving senior secondary students in Nigeria. The programme used Microsoft Copilot as a virtual tutoring tool over six weeks and reported significant improvements in an assessment covering English-language content, AI knowledge, and digital skills. This evidence is important because it demonstrates that AI-supported learning can be implemented in a Nigerian secondary-school context when students are provided with structured instructional support and access to the necessary technological environment. At the same time, such evidence raises an important equity question: if meaningful AI-supported learning requires devices, connectivity, trained teachers, structured support, and suitable learning environments, do students and teachers in less digitally resourced schools have comparable opportunities to participate? The broader Nigerian digital environment makes this question particularly important. UNICEF Nigeria (2025) reported continuing challenges involving digital infrastructure and access, noting that only 36% of the population was using the internet, 78% of young people lacked digital-literacy skills, and only 47% of teachers had basic ICT skills. The organisation also identified limited and unaffordable electricity and broadband coverage, particularly in rural areas, as continuing barriers to digital learning. Although substantial efforts are being made to expand digital learning through initiatives such as the Nigeria Learning Passport, these conditions indicate that opportunities for meaningful digital participation remain uneven (UNICEF Nigeria, 2025).

At the international level, the implications of these

inequalities are becoming increasingly important as AI becomes more deeply embedded in education. UNESCO (2025) reported that approximately 2.6 billion people remained without internet access in 2024 and warned that existing digital inequalities could contribute to an emerging AI divide. This concern is particularly relevant for rural populations and other groups that experience persistent barriers to digital access. If AI-supported learning becomes increasingly important within education while the underlying conditions for access remain uneven, technological innovation may create new opportunities for some learners without being equally accessible to others. The central issue therefore becomes one of equitable participation in AI-supported education, rather than simply technological adoption. Within Nigeria, this concern warrants examination at the level of everyday educational experience. National statistics and policy reports can demonstrate differences in connectivity, infrastructure, and digital skills, but they cannot fully explain what these inequalities mean to students and teachers who encounter them in their daily educational activities. A student who knows that AI-supported learning tools exist but cannot use them at school may experience digital inequality differently from a student who regularly uses such tools. Similarly, a teacher who is aware of AI's potential but lacks reliable electricity, internet connectivity, appropriate devices, or professional preparation may develop particular ways of interpreting and responding to these limitations. These experiences cannot be adequately captured through measures of device ownership or connectivity alone.

This distinction provides an important rationale for examining digital inequality as a lived experience. The phenomenon involves not only the distribution of technological resources but also how individuals perceive access and non-access, interpret technological differences, experience opportunities and constraints, and respond to conditions that shape their participation. The present study therefore does not assume that digital inequality automatically causes particular academic or motivational outcomes. Instead, it seeks to understand how students and teachers describe and make meaning of unequal opportunities to engage with digital and AI-supported learning technologies within their educational environments.

The phenomenological approach adopted in this study is appropriate to this purpose because it enables attention to participants' lived experiences and the meanings they attach to those experiences. A descriptive Husserlian orientation is particularly relevant where the objective is to describe the phenomenon as experienced by participants while attempting to bracket the researcher's preconceptions. In the present context, this means attending closely to students' and teachers' accounts of access, limited access, non-access, technological constraints, opportunities, perceptions, emotions, and responses surrounding AI-supported learning rather than imposing predetermined assumptions about the

effects of technology. The need for such an inquiry is reinforced by the nature of the existing evidence. Current research and policy literature provide important information about AI's potential in education, digital infrastructure, teacher competencies, and the challenges associated with technology integration (Bali *et al.*, 2024; Miao & Cukurova, 2024; Miao *et al.*, 2024). However, less attention has been given to the lived experiences of secondary-school students and teachers who encounter unequal opportunities to access AI-supported learning within STEM education in specific Nigerian contexts. In particular, there is a need to understand how participants experience the intersection of digital inequality and emerging AI-supported educational opportunities, including how they interpret limited access and how they respond to the conditions surrounding their teaching and learning.

Ondo North Senatorial District provides a relevant context for examining this phenomenon. The study focuses on selected secondary schools within the district, where students and teachers encounter educational environments with differing levels of technological resources and infrastructural support. The original study identifies the district as comprising rural and semi-urban communities and considers variation in digital infrastructure and educational resources relevant to examining disparities in access to AI-supported learning tools. The study therefore uses the local context not to make unsupported generalisations about all Nigerian schools, but to investigate how digital inequality and AI access are experienced by participants within the specific educational settings under study. Against this background, the present study explores the lived experiences of digital inequality in access to AI-supported learning tools in STEM education among secondary-school students and teachers in Ondo North, Nigeria. By foregrounding participants' experiences rather than treating digital inequality solely as an infrastructural or technological deficit, the study seeks to illuminate how unequal opportunities for AI-supported learning are encountered, interpreted, and negotiated in everyday educational settings. The study consequently contributes an experience-based perspective to the broader discussion of equity, digital transformation, and meaningful participation in AI-supported STEM education. Recent empirical evidence from Ondo State further underscores both the potential and the emerging relevance of artificial intelligence in secondary-school education. Alabi, Adelekan, and Olotu (2025) found that secondary-school students exposed to an artificial intelligence-based intelligent tutoring system demonstrated significantly higher academic performance than their counterparts who received conventional instruction. This evidence suggests that AI-supported learning can provide meaningful educational benefits within the Nigerian secondary-school context. However, the demonstrated potential of AI does not necessarily imply equitable access to such opportunities. Students' ability to benefit from AI-supported learning may depend

on the availability of digital devices, reliable electricity and internet connectivity, affordable data, appropriate learning resources, and teachers with the knowledge and skills required to integrate AI effectively into classroom practice. Consequently, a critical issue remains insufficiently understood: how students and teachers themselves experience the inequalities that shape access to and participation in AI-supported STEM education within secondary schools in Nigeria, particularly in contexts where digital resources and institutional support are unevenly distributed. While existing studies have largely examined AI awareness, perceptions, adoption, instructional effectiveness, or learning outcomes, limited attention has been given to the lived experiences of those who encounter digital inequality in their everyday educational environments. This gap provides the rationale for the present Husserlian descriptive phenomenological study, which seeks to explore and describe how secondary-school students and STEM teachers experience, interpret, and respond to digital inequality and access to AI-supported STEM education in Ondo North Senatorial District, Nigeria.

Statement of the Problem

The increasing integration of artificial intelligence (AI) into education has created new possibilities for teaching and learning, particularly through generative AI, intelligent tutoring systems, adaptive learning technologies, and other AI-supported educational applications. In STEM education, these technologies may provide opportunities for personalised support, feedback, simulation, visualisation, information access, and problem-solving. However, the educational benefits associated with AI are unlikely to be experienced equally when learners and teachers differ substantially in their access to digital devices, connectivity, electricity, digital competencies, teacher preparation, and institutional support (Miao & Cukurova, 2024; Miao *et al.*, 2024; UNESCO, 2025). The problem is becoming increasingly important because AI is developing faster than the conditions required for equitable participation in AI-supported education. UNESCO (2025) has warned that existing digital inequalities may contribute to an emerging AI divide. This concern is particularly relevant in contexts where access to reliable internet, electricity, appropriate devices, and digital skills remains uneven. In such circumstances, the introduction of AI into education may create opportunities for students and teachers who are adequately equipped while leaving others with limited or no meaningful opportunity to participate.

Nigeria presents an important context in which to examine this problem. Recent evidence indicates continuing inequalities in digital access and preparedness. UNICEF Nigeria (2025) reported substantial limitations in internet use, digital literacy, teacher ICT competence, electricity, and broadband access. These challenges are relevant to AI-supported education because meaningful engagement with AI requires more than the existence of an application.

Students and teachers need the technological, human, and institutional conditions necessary to access, understand, and use such tools for educational purposes. At the same time, evidence from Nigeria demonstrates that AI-supported learning can produce educational benefits when appropriate conditions are provided. De Simone *et al.* (2025), for example, found positive learning-related effects from a structured generative-AI intervention involving senior secondary students in Nigeria. This creates an important equity problem. If structured access to AI-supported learning can provide educational opportunities, differences in students' and teachers' ability to access such technologies may become increasingly consequential. The issue is therefore not whether AI has potential value in education, but whether that potential is meaningfully accessible to students and teachers across different educational environments. The problem is further complicated by the difference between awareness, nominal access, and meaningful access. A student may have heard about generative AI without having a suitable device or reliable connectivity with which to use it for learning. A teacher may recognise the instructional possibilities of AI but lack the training, infrastructure, time, or institutional support required to integrate it into teaching. Consequently, conventional indicators such as device ownership or internet availability may not adequately capture the lived reality of digital inequality. What remains important is understanding how students and teachers themselves experience these differences in opportunity. This represents a significant gap in knowledge. Existing research and policy literature provide increasingly valuable evidence about AI's educational potential, digital infrastructure, AI competencies, and barriers to technology integration (Bali *et al.*, 2024; Miao & Cukurova, 2024; Miao *et al.*, 2024). However, comparatively less is known about how secondary-school students and teachers experience unequal opportunities to access AI-supported learning tools within their everyday STEM educational environments. In particular, there is insufficient context-specific phenomenological evidence concerning how students and teachers interpret access and non-access, how they experience technological constraints, what meanings they attach to unequal opportunities, and how they respond to those conditions. This gap is particularly relevant in Ondo North Senatorial District of Ondo State, Nigeria. The district includes secondary schools serving communities with differing educational and infrastructural circumstances. Yet general national statistics cannot adequately explain how digital inequality is actually experienced within these schools. Nor can the mere presence or absence of digital facilities establish what AI-supported learning means to students and teachers who encounter different levels of technological opportunity. There is therefore a need to investigate the phenomenon from the perspectives of those directly involved in teaching and learning. The specific problem addressed by this study is consequently the limited understanding of the lived experiences of

digital inequality in access to AI-supported learning tools among secondary-school students and teachers in STEM education in Ondo North, Nigeria. Without an understanding of these lived experiences, efforts to expand AI-supported education may focus primarily on technological provision while giving insufficient attention to the human, infrastructural, pedagogical, and institutional conditions that shape meaningful participation. The present phenomenological study therefore seeks to understand how secondary-school students and STEM teachers experience access, limited access, and non-access to AI-supported learning tools; how they interpret these experiences; and how they respond to the opportunities and constraints surrounding AI-supported STEM education. By foregrounding participants' experiences, the study seeks to provide context-specific evidence that can inform more equitable approaches to the integration of AI-supported learning technologies in Nigerian secondary education.

Purpose of the Study

The purpose of this study is to explore and describe the lived experiences of secondary-school students and STEM teachers regarding digital inequality and access to AI-supported learning tools in STEM education in selected secondary schools in Ondo North Senatorial District of Ondo State, Nigeria. Specifically, the study seeks to understand how students experience access, limited access, or non-access to AI-supported learning tools; how teachers experience opportunities and constraints associated with integrating AI into STEM instruction; how participants experience the influence of digitally unequal conditions on their teaching and learning experiences; and the meanings they attach to these experiences. Specifically, the study seeks to:

1. explore students' lived experiences of access, limited access, and non-access to AI-supported learning tools in STEM education;
2. describe teachers' lived experiences of using or attempting to integrate AI-supported tools into STEM instruction within their educational environments;
3. explore how students experience participation and engagement in STEM learning under conditions of unequal digital access; and
4. understand the meanings that students and teachers attach to their experiences of access, limited access, or non-access to AI-supported learning tools in STEM education.

Research Questions

The following research questions will guide the study:

1. How do secondary-school students and teachers experience and describe digital inequality in STEM education across selected school contexts in Ondo North Senatorial District, Nigeria?
2. How do teachers experience the opportunities and barriers associated with integrating AI-supported tools into STEM teaching?

3. How does digital inequality affect students' engagement and learning experiences in STEM education?
4. What meanings do students and teachers attach to access to, or exclusion from, AI-supported educational technologies?

Significance of the Study

The significance of this study lies primarily in its contribution to understanding digital inequality and AI-supported learning from the perspectives of those directly involved in secondary-school STEM education. Rather than treating digital inequality only as a difference in the distribution of devices, connectivity, or technological facilities, the study focuses on how students and teachers experience and interpret unequal opportunities to access and engage with AI-supported learning tools. The study contributes to scholarship on digital inequality, AI in education, and STEM education by providing a phenomenological account of participants' lived experiences. Its contribution is particularly relevant to understanding the distinction between technological availability and meaningful educational access. By documenting how students and teachers experience access, limited access, non-access, technological constraints, and opportunities for AI-supported learning, the study provides an experience-based perspective that can complement quantitative evidence on digital inequality. The findings may provide useful contextual evidence for education policymakers and planners concerned with digital transformation and equitable access to emerging technologies. Understanding the experiences of students and teachers may help policymakers consider not only the provision of digital devices and connectivity but also the conditions necessary for meaningful participation, including teacher preparation, digital competencies, electricity, technical support, and appropriate institutional arrangements.

The findings may assist school administrators and STEM teachers in understanding the practical realities surrounding the use of AI-supported learning tools in their schools. Participants' experiences may highlight specific opportunities and constraints that need to be considered when introducing or expanding AI-supported instructional practices. The findings may also inform discussions about teacher professional development, school-level support, and the responsible integration of AI into STEM teaching. The study gives students an opportunity to articulate their experiences of digital access and non-access within STEM learning. By foregrounding students' voices, the study may draw attention to barriers that are not adequately represented by conventional measures of technological provision. The findings may therefore contribute to efforts to create more inclusive learning environments in which students have meaningful opportunities to participate in digitally supported STEM education. The study contributes context-specific evidence from Nigerian secondary schools to the broader international discussion

concerning equity and participation in AI-supported education. Its focus on Ondo North Senatorial District provides a localized perspective through which the relationship between digital inequality and emerging AI-supported learning opportunities can be understood. The findings may also provide a basis for future comparative, qualitative, mixed-methods, or policy-oriented studies examining digital inequality and AI-supported education in other Nigerian or comparable educational contexts. The study may serve as a reference for researchers investigating digital inequality, AI-supported learning, STEM education, and lived educational experiences. Its phenomenological focus may provide a foundation for subsequent studies that compare different geographical contexts, school types, educational levels, or groups of learners and teachers.

Theoretical Review

The present study is primarily grounded in Husserlian descriptive phenomenology, supported by Digital Divide Theory and complemented by constructivist theory. The combination is appropriate because the study addresses two interconnected dimensions of the phenomenon under investigation. First, it seeks to understand how students and teachers experience and make meaning of digital inequality and access to AI-supported learning tools in their everyday educational environments. Second, it situates those experiences within the broader inequalities associated with access to digital technologies, digital skills, patterns of use, and the benefits derived from technology. Husserlian phenomenology therefore provides the principal philosophical and methodological orientation for understanding participants' lived experiences, while Digital Divide Theory provides a conceptual lens for understanding the structural and technological conditions surrounding those experiences.

Husserlian Descriptive Phenomenology

Phenomenology is concerned with the study of experience as it is lived and with the meanings individuals attach to what they experience. Its philosophical foundations are strongly associated with Edmund Husserl, whose phenomenological project sought to examine phenomena as they are experienced in consciousness rather than beginning with external theoretical explanations. In educational research, a phenomenological approach is particularly appropriate when the purpose is to understand first-hand experiences of learning and teaching from the perspectives of those who experience them (Creely, 2018). A central principle of Husserlian phenomenology is the attempt to return to the phenomenon itself and describe experience as faithfully as possible. This orientation requires the researcher to attend closely to participants' accounts rather than imposing predetermined explanations on their experiences. The methodological practice of epoché, or bracketing, is therefore important. Through bracketing, the researcher attempts to identify and suspend, as far as

possible, pre-existing assumptions and judgments about the phenomenon so that participants' descriptions can be examined with greater openness (Oluka, 2025). This principle is particularly relevant to the present study because digital inequality and AI-supported education are subjects that can easily attract assumptions. For example, it may be tempting to assume that access to AI necessarily improves learning, that lack of access necessarily produces poor learning experiences, or that teachers who do not use AI are technologically unprepared. A phenomenological approach requires these assumptions to be held in suspension while attention is directed toward what students and teachers actually describe about their experiences. The present study consequently treats lived experience as the central object of inquiry. Students' experiences of having, lacking, or having limited opportunities to use AI-supported learning tools are examined in their own terms. Similarly, teachers' experiences of awareness, access, attempted use, non-use, training, infrastructure, and institutional support are considered as experiences that require description and interpretation rather than being reduced immediately to predetermined categories. The phenomenological perspective also draws attention to the meanings that individuals attach to their experiences. Two participants may encounter similar technological circumstances but interpret those circumstances differently. One student may regard limited access to AI as an ordinary feature of school life, while another may experience it as exclusion from opportunities available to students elsewhere. Likewise, one teacher may regard the absence of AI facilities as a temporary technological limitation, whereas another may experience it as a significant constraint on instructional possibilities. Such differences in meaning are central to phenomenological inquiry. For this study, Husserlian phenomenology therefore provides the principal lens through which the experiences of students and teachers are approached. It supports an inquiry into not merely whether AI access exists, but how access, limited access, and non-access are experienced and what meanings participants attach to those experiences. This orientation is consistent with the study's purpose of describing the lived experiences of digital inequality in access to AI-supported learning tools within STEM education.

Digital Divide Theory

Digital Divide Theory provides the principal supporting framework for understanding the unequal technological conditions within which participants' experiences occur. Early discussions of the digital divide tended to emphasise the distinction between individuals and groups that possessed access to computers and internet technologies and those that did not. Contemporary scholarship, however, recognises that digital inequality extends beyond physical access. Van Dijk (2020) presents the digital divide as a continuing form of inequality

involving access to digital technologies and the skills and opportunities required to use them. The evolution of digital-divide research has similarly distinguished between differences in access, differences in skills and use, and differences in the outcomes or benefits derived from technology use (Scheerder *et al.*, 2017). This broader conception is particularly relevant to the present study. A student may have access to a smartphone but lack reliable internet connectivity. Another may have internet access but lack the digital or AI competencies necessary to use available tools effectively. A third may possess both a suitable device and connectivity but have little opportunity to use AI-supported learning applications because such technologies are not incorporated into the school's instructional environment. These situations represent different dimensions of inequality and demonstrate why digital inequality cannot be adequately understood through device ownership alone.

The access dimension of digital inequality concerns the availability of the technological resources necessary for participation. Within the present study, this includes access to appropriate digital devices, electricity, internet connectivity, and AI-supported learning tools. These material conditions determine whether students and teachers have the basic opportunity to encounter and use digital technologies in educational settings. The skills and use dimension concerns what individuals are able and enabled to do with available technologies. Digital access does not automatically imply effective or meaningful use. Differences in digital competence, AI literacy, teacher preparedness, confidence, and opportunities for practice may influence the ways in which students and teachers engage with AI-supported learning tools. This dimension is especially relevant to teachers because awareness of AI does not necessarily mean that teachers possess the pedagogical and technical capacity required to incorporate AI into STEM instruction. The outcome dimension extends the analysis beyond access and use to the benefits that individuals are able to derive from technology. Scheerder *et al.* (2017) distinguish this third level of digital inequality from the earlier focus on access and skills. In the present study, this dimension is approached cautiously. The study does not attempt to measure the causal educational effects of AI access. Rather, it considers participants' descriptions of the opportunities, limitations, perceived benefits, and disadvantages associated with their access or non-access to AI-supported learning tools. Digital Divide Theory is therefore useful for situating individual experiences within broader structural conditions. Students and teachers do not experience digital inequality in isolation from their schools, communities, infrastructure, socioeconomic circumstances, and institutional arrangements. Their experiences of AI access are embedded within these conditions. The theory consequently helps the study recognise that what may appear to be an individual experience of technological limitation can also reflect wider inequalities in educational resources and

opportunities.

Constructivist Learning Theory

The study is also informed by Constructivist Learning Theory, which views learning as an active process through which learners construct knowledge through interaction with learning resources, teachers, peers, and their learning environments. In the context of AI-supported STEM education, access to digital devices, connectivity, AI-supported learning tools, and opportunities for interaction may shape the conditions under which students engage in knowledge construction. Thus, while Digital Divide Theory provides a lens for understanding inequalities in access to digital and AI-supported resources, Constructivist Learning Theory helps explain the implications of such inequalities for students' opportunities to participate in interactive and resource-mediated learning experiences. This perspective complements the phenomenological orientation of the study by providing a learning-theoretical lens through which participants' experiences of access, exclusion, adaptation, and engagement can be understood.

Integration of the Theoretical Perspectives

The study therefore draws on three complementary perspectives. Husserlian descriptive phenomenology provides the primary orientation for examining participants' lived experiences; Digital Divide Theory provides a framework for understanding inequalities in access to digital and AI-supported learning resources; and Constructivist Learning Theory provides a learning-oriented perspective for understanding how differences in access may shape opportunities for interaction, participation, and knowledge construction in STEM learning. Together, these perspectives provide complementary lenses for interpreting the experiences of students and teachers in contexts of unequal access to AI-supported learning tools

Relationship Between the Two Frameworks

The two frameworks serve different but complementary purposes in the present study. Husserlian phenomenology provides the primary lens for understanding the experience of the phenomenon, whereas Digital Divide Theory provides a supporting framework for understanding the conditions associated with unequal digital access. Phenomenology directs attention inward toward participants' experiences and meanings. It asks: What is it like for students and teachers to experience access, limited access, or non-access to AI-supported learning tools? What meanings do they attach to those experiences? Digital Divide Theory directs attention toward the conditions surrounding those experiences. It asks: What forms of access, skills, use, and opportunity differentiate participants' digital experiences? The integration can therefore be represented conceptually as follows:

Digital conditions and inequalities

- access to devices, electricity, connectivity and AI tools,

- digital/AI skills and opportunities for use,
- opportunities for meaningful educational participation,
- participants' lived experiences,
- perceptions, feelings, interpretations and meanings.

The framework does not assume that digital inequality automatically causes particular educational outcomes. Instead, it provides a basis for examining how structural conditions are encountered and experienced by students and teachers. This distinction is important because the present study is phenomenological rather than experimental or correlational.

Relevance of the Theoretical Framework to the Present Study

The theoretical framework is relevant to the study in four principal ways. First, Husserlian phenomenology aligns directly with the study's focus on lived experience and meaning. Second, it provides a methodological orientation that encourages careful attention to participants' descriptions rather than premature causal interpretation. Third, Digital Divide Theory provides a vocabulary for understanding differences in technological access, skills, use, and benefits. Fourth, the combination allows the study to connect individual experiences with the broader digital conditions within which those experiences occur without reducing lived experiences to structural indicators alone. The framework is particularly appropriate for the study of AI-supported STEM education because AI represents a rapidly developing form of educational technology whose benefits may depend upon the availability of appropriate technological and human resources. By combining a phenomenological focus on lived experience with a multidimensional understanding of digital inequality, the study can examine the phenomenon at both the experiential and contextual levels. Accordingly, the study adopts Husserlian descriptive phenomenology as its primary theoretical and methodological orientation and Digital Divide Theory as its supporting theoretical framework. This combination provides a coherent basis for investigating how secondary-school students and STEM teachers in Ondo North, Nigeria, experience unequal opportunities to access AI-supported learning tools and how they interpret the significance of those experiences within their educational environments.

Conceptual Review

Digital Inequality in Education

Digital inequality refers to systematic differences in people's opportunities to access, use, and benefit from digital technologies. Earlier understandings of the digital divide often focused primarily on whether individuals possessed computers or had internet connectivity. Contemporary scholarship, however, increasingly recognises that digital inequality is more complex and involves differences in the quality of access, digital competencies, patterns of use, and the benefits individuals derive from digital technologies (Mirazchiyski, 2025). Recent reviews of educational research indicate that the concept remains multidimensional and that limiting digital inequality to

technology possession can obscure important differences in how learners actually experience digital participation (Meng *et al.*, 2024; Mirazchiyski, 2025). In educational settings, digital inequality may therefore occur when students or teachers differ in their access to suitable devices, reliable connectivity, electricity, digital resources, digital skills, technical support, and opportunities to use technology for meaningful educational purposes. These differences may exist between schools, communities, households, or individuals. Importantly, access to a digital device does not necessarily translate into equitable educational participation. A learner may possess a smartphone but have insufficient data, unreliable electricity, limited digital skills, or no opportunity to use the device for school-related learning. Similarly, teachers may have access to digital devices but lack the professional preparation or institutional support required to integrate emerging technologies into instruction.

Recent research has increasingly distinguished between different levels of digital inequality. The first concerns differences in physical or material access; the second concerns differences in skills and patterns of use; and the third concerns differences in the benefits or outcomes obtained from digital participation (Deng & El Hag, 2024; Mirazchiyski, 2025). This multidimensional understanding is particularly relevant to education because two students with nominally similar access to a smartphone or internet connection may nevertheless experience substantially different educational opportunities. The concept of digital inequality is particularly important in the context of AI-supported education. As AI becomes increasingly integrated into learning environments, inequalities in basic digital access may be accompanied by inequalities in access to AI applications, AI literacy, opportunities for experimentation, and the capacity to evaluate and use AI outputs critically. UNESCO (2025) has therefore drawn attention to the possibility that existing digital inequalities may contribute to an emerging AI divide. The issue is not simply whether AI tools exist, but whether learners and teachers have the conditions necessary to participate meaningfully in AI-supported education. For the present study, digital inequality is understood as unequal opportunities among students and teachers to obtain, access, use, and benefit meaningfully from digital and AI-supported technologies for educational purposes. This definition incorporates both material and human dimensions of access and provides an appropriate conceptual basis for examining participants' lived experiences.

Access, Limited Access, and Meaningful Access

Access is a central concept in understanding digital inequality, but access should not be treated as synonymous with mere availability. Meaningful access involves the practical conditions that allow individuals to use technology effectively for purposes that are relevant to their lives and educational needs. These conditions may include appropriate devices, affordable

and reliable connectivity, electricity, digital competence, technical support, and opportunities to use technologies in supportive environments. Recent literature on digital equality in education emphasises that equality cannot be reduced to the distribution of technological resources alone. Luo and Liu (2025), in a systematic review of conceptualisations of digital equality in education, demonstrate that digital equality can be understood through multiple dimensions rather than through a simple binary distinction between those who have technology and those who do not. Similarly, Mirazchiyski (2025) argues that contemporary educational research needs more precise definitions of the digital divide because access and possession alone do not adequately capture the complexity of digital participation.

This distinction is particularly important for the present study because students and teachers may experience different levels of access even when they attend schools that possess some digital facilities. For example, a school may have internet connectivity, but the connection may be unreliable or available only to administrative staff. Students may possess smartphones but be unable to afford sufficient data for sustained educational use. Teachers may have personal access to generative AI but lack permission, training, or institutional support to incorporate it into classroom instruction. Such circumstances represent different forms of limited or constrained access. The present study consequently distinguishes among access, limited access, and non-access. Access refers to a practical opportunity to use relevant digital or AI-supported learning tools. Limited access refers to circumstances in which technological opportunities exist but are restricted by factors such as inadequate devices, unreliable connectivity, cost, electricity, insufficient skills, limited institutional support, or restricted opportunities for educational use. Non-access refers to the absence of a practical opportunity to use relevant AI-supported learning tools for educational purposes.

The concept of meaningful access is especially important because AI-supported learning requires more than a device and an internet connection. UNESCO's AI Competency Framework for Students identifies competencies related to understanding, applying, and creating with AI, while also emphasising human-centred and ethical dimensions of AI use (Miao *et al.*, 2024). Similarly, the AI Competency Framework for Teachers highlights the knowledge, skills, and values required for teachers to use AI appropriately in education (Miao & Cukurova, 2024). Thus, meaningful access involves not only technological availability but also the human capacity and educational conditions required for effective and responsible participation.

Artificial Intelligence in Education

Artificial intelligence refers broadly to computational systems capable of performing functions associated with aspects of human intelligence, including pattern recognition, prediction, language processing, generation

of content, decision support, and problem-solving. In education, AI encompasses a diverse range of applications rather than a single technology. These include intelligent tutoring systems, adaptive learning systems, automated assessment, learning analytics, recommendation systems, conversational agents, generative AI, and other AI-enabled educational applications (Wang *et al.*, 2024). The rapid development of generative AI has expanded the educational applications of artificial intelligence. Generative AI systems can produce text, explanations, examples, questions, summaries, images, and other forms of content in response to user prompts. Such capabilities have created opportunities for new forms of interaction between learners, teachers, and digital systems. However, the educational value of these technologies depends substantially on how they are introduced, accessed, interpreted, and used.

Miao *et al.* (2024) emphasises that students need competencies that enable them to engage with AI safely, critically, creatively, and responsibly. The framework identifies competencies across four broad dimensions: a human-centred mindset, ethics of AI, AI techniques and applications, and AI system design (Miao *et al.*, 2024). These dimensions reinforce the idea that educational AI use should not be reduced to technical access. Students require opportunities to understand AI, evaluate its outputs, use it appropriately, and recognise its limitations. The same consideration applies to teachers. The integration of AI changes the relationship among teachers, students, and technological systems and consequently requires teachers to develop new forms of knowledge and competence (Miao & Cukurova, 2024). Teachers may need to understand how AI systems function, evaluate the reliability of AI-generated content, protect student data, design appropriate learning activities, and determine when AI use is pedagogically appropriate.

Recent empirical evidence also demonstrates that AI-supported learning can be implemented in Nigerian secondary education under structured conditions. De Simone *et al.* (2025) evaluated a programme using Microsoft Copilot as a virtual tutoring tool with senior secondary students in Nigeria and reported significant improvements in an assessment covering English-language content, AI knowledge, and digital skills. This evidence is important for the present study because it demonstrates the educational potential of AI within a Nigerian secondary-school context while also highlighting the importance of the conditions under which AI-supported learning is made available. The present study, however, is not primarily concerned with measuring the effectiveness of AI applications. Instead, it conceptualises AI-supported learning tools as educational technologies whose availability, accessibility, usability, and educational relevance are experienced differently by students and teachers. This distinction keeps the conceptual discussion aligned with the phenomenological purpose of the study.

AI-Supported Learning Tools

AI-supported learning tools are digital applications or systems that employ artificial intelligence to facilitate or support educational activities. They may provide personalised explanations, automated feedback, tutoring, content generation, adaptive learning, recommendations, simulations, assessment support, or conversational interaction. A recent systematic review of AI in education identified a broad range of AI applications and research directions, confirming that AI-supported education encompasses multiple technologies and educational functions rather than a single category of tool (Wang *et al.*, 2024). For the purposes of this study, the concept includes generative AI applications, intelligent tutoring systems, adaptive learning applications, AI-supported simulations, and other AI-enabled digital resources that can potentially support STEM teaching and learning. The definition is intentionally functional rather than tied exclusively to particular commercial platforms because AI technologies develop rapidly and specific applications may change over time. The concept also includes potential access, not merely actual use. This distinction is important because a student or teacher may be aware of an AI-supported tool without having an opportunity to use it in school. Similarly, a teacher may have experimented with an AI application outside the school environment but have no practical opportunity to integrate it into classroom instruction. The study therefore examines participants' experiences of access, limited access, non-access, awareness, attempted use, and opportunities for meaningful educational use.

Artificial Intelligence and STEM Education

STEM education provides an important context for examining AI-supported learning because AI technologies can be applied to activities involving mathematical reasoning, scientific inquiry, data analysis, modelling, simulation, problem-solving, and technological design. A recent systematic review specifically examining AI research in high-school STEM education identified growing scholarly attention to the use of AI in secondary STEM contexts and highlighted the evolving role of AI in teaching and learning (Akhmetova *et al.*, 2025). AI-supported tools may potentially support STEM learning by providing students with explanations, examples, problem-solving assistance, simulations, feedback, and opportunities to explore concepts interactively. Teachers may also use AI tools to generate instructional resources, formulate questions, differentiate learning materials, and support lesson preparation. However, the availability of such opportunities depends on the technological and human conditions within which STEM education occurs. This creates an important intersection between AI-supported learning and digital inequality. Students who have reliable devices, connectivity, digital skills, and opportunities to interact with AI-supported tools may encounter STEM learning differently from students whose access is restricted. Teachers who have access to professional development and technological support

may likewise experience AI integration differently from teachers who have limited exposure or inadequate infrastructure. The present study does not assume that greater AI access automatically produces superior STEM learning outcomes. Instead, it examines how students and teachers experience the opportunities and constraints associated with AI-supported STEM education. This distinction is consistent with the phenomenological orientation of the study and prevents the conceptual framework from imposing causal assumptions that the research design is not intended to test.

Digital Inequality and AI Access in Nigerian Education

The Nigerian educational context is particularly relevant to the study of digital inequality and AI-supported learning because digital transformation is occurring alongside continuing challenges in technological infrastructure and digital competence. UNICEF Nigeria (2025) reported that only 36% of the population was using the internet, while 78% of young people lacked digital-literacy skills and only 47% of teachers possessed basic ICT skills. These conditions indicate that access to the technological and human resources required for digital learning remains uneven. The emerging AI environment therefore introduces an additional dimension to existing digital inequalities. Students and teachers may encounter differences not only in internet connectivity and device availability but also in their exposure to AI, knowledge of AI applications, confidence in using AI, opportunities for guided use, and access to educational environments that support responsible AI engagement. UNESCO (2025) similarly warns that unequal digital conditions can contribute to an AI divide as artificial intelligence becomes increasingly embedded in education. At the same time, the Nigerian context should not be represented simply as one of technological deficiency. Evidence from the World Bank demonstrates that structured AI-supported learning can be implemented with Nigerian secondary students and can produce measurable educational benefits when appropriate instructional conditions are provided (De Simone *et al.*, 2025). The conceptual issue is therefore one of unequal opportunity, rather than a binary distinction between technologically advanced and technologically deprived schools. This distinction is particularly relevant to the present study. The investigation is not based on the assumption that all schools in Ondo North lack AI technologies or that all students have unequal access in the same way. Rather, it seeks to understand the different experiences through which students and teachers encounter digital and AI-supported learning opportunities within their specific educational environments.

Digital Inequality, AI Access, and Lived Experience

The concepts discussed above converge around the central phenomenon of the present study: the lived experience of digital inequality in access to AI-supported learning tools. Digital inequality provides the broader

context of unequal technological opportunity; access and meaningful access specify the conditions under which participation becomes possible; AI-supported learning tools represent the emerging technologies through which new educational opportunities are created; and STEM education provides the disciplinary context in which these experiences are examined. The conceptual relationship can therefore be expressed as follows:

Digital conditions

- availability of devices, electricity and connectivity
- Digital competencies and AI competencies
- opportunities for access and use
- meaningful or constrained access to AI-supported learning tools
- participants' experiences of participation, non-participation, opportunity and constraint
- meanings attached to those experiences.

This conceptualisation does not imply a deterministic relationship in which digital inequality automatically produces a particular educational outcome. Rather, it recognises that technological conditions constitute part of the environment in which students and teachers experience teaching and learning. The phenomenological inquiry then focuses on how participants encounter these conditions, how they perceive them, and what meanings they attach to them. The distinction is important because the same technological condition may be experienced differently by different individuals. A lack of school-based access to AI may be interpreted by one participant as an ordinary limitation of the school environment and by another as a missed educational opportunity. Similarly, access to a smartphone may provide one student with meaningful opportunities for AI-supported learning while providing another with little educational benefit because of data costs, connectivity problems, lack of guidance, or limited AI competence. Consequently, the present study conceptualises digital inequality not merely as a gap in technological possession, but as a difference in opportunities for meaningful educational participation through digital and AI-supported technologies. This conceptualisation is consistent with recent scholarship calling for more multidimensional understandings of digital inequality in education (Luo & Liu, 2025; Mirazchiyski, 2025) and with UNESCO's emphasis on inclusive and meaningful engagement with AI (Miao *et al.*, 2024; UNESCO, 2025).

Conceptual Synthesis

The conceptual review establishes four central propositions for the present study. First, digital inequality is multidimensional and extends beyond physical access to include skills, opportunities for use, and the benefits that users can derive from technology. Second, meaningful access to AI-supported learning requires more than awareness of AI or possession of a digital device; it depends on appropriate technological, human, and institutional conditions. Third, AI-supported learning

is increasingly relevant to STEM education but its educational possibilities are mediated by the conditions under which students and teachers encounter and use AI. Fourth, understanding these inequalities requires attention to participants' lived experiences and the meanings they attach to access, limited access, and non-access. These propositions provide the conceptual foundation for examining how secondary-school students and STEM teachers in Ondo North experience the emerging relationship between digital inequality and AI-supported learning. The conceptual review therefore complements the theoretical framework by defining the principal concepts of the study while leaving the interpretation of participants' experiences to the phenomenological inquiry.

Empirical Review

Digital Inequality and Educational Technology Access

Digital inequality provides an important empirical foundation for understanding unequal participation in technology-mediated education. Although access to digital technologies has expanded considerably, empirical evidence indicates that access is not distributed uniformly across learners, schools, and geographical locations. Moreover, digital inequality extends beyond the simple possession of a device to differences in prior experience, quality of access, connectivity, digital competence, and opportunities to use technology meaningfully. Abdulkareem and Lennon (2025) examined the impact of the digital divide on secondary-school students' performance in the computerised Unified Tertiary Matriculation Examination (UTME) in Osun State, Nigeria. Their study considered ICT-related individual differences, including computer familiarity and experience, computer-based-test anxiety, and attitudes toward computer-based testing, while also examining differences according to school type and location. The study demonstrated that digital inequalities were associated with differences in students' technological experiences and their performance in computerised assessment. The significance of this study for the present research is twofold. First, it provides direct empirical evidence that digital inequality exists among Nigerian secondary-school students. Second, it demonstrates that technological inequality may have educational consequences. However, the study focused primarily on computer experience and computer-based assessment rather than artificial intelligence. It therefore does not explain whether students have equitable opportunities to access AI-supported learning or how they experience such inequalities. The present study extends this line of inquiry from the conventional digital divide toward the emerging question of unequal access to AI-supported educational opportunities.

Artificial Intelligence Accessibility, Awareness and Utilisation

As AI becomes increasingly incorporated into educational practices, researchers have begun to investigate whether learners are aware of AI technologies, whether they can access them, and whether they actually use them for educational purposes. These dimensions are important because awareness does not necessarily imply access, and access does not necessarily result in meaningful educational utilisation. Ugwuanyi *et al.* (2025) investigated Chemistry students' awareness, accessibility, and utilisation of artificial intelligence in Colleges of Education in South-West Nigeria. The researchers used a descriptive survey design and selected 340 Chemistry students from three Colleges of Education. The findings indicated low levels of awareness, accessibility, and utilisation of AI resources among the participants, while gender did not significantly influence the three dimensions. The authors recommended increased sensitisation and capacity-building activities to facilitate AI integration in Chemistry learning. The study is particularly relevant because it treats awareness, accessibility, and utilisation as distinguishable dimensions of AI engagement. Nevertheless, its participants were students in Colleges of Education rather than secondary-school students, and the survey design provides limited insight into how learners experience restricted access in their everyday educational contexts. The study consequently establishes the importance of AI accessibility in the South-West Nigerian context without explaining its lived meaning for secondary-school learners.

Fasinro *et al.* (2024) examined the impact, accessibility, suitability, and challenges associated with artificial intelligence in learning assessment within a South-West Nigerian tertiary institution. The study provides additional evidence that AI-related educational opportunities are shaped by institutional and technological conditions. However, its focus on tertiary academic staff and AI-supported assessment limits its direct applicability to secondary-school STEM learning. Its value to the present study is therefore primarily contextual: it demonstrates that questions of accessibility and institutional capacity are already emerging within Nigerian AI-in-education research.

AI-Supported STEM and Secondary-School Learning

The potential of AI to support STEM and secondary-school learning has also been examined empirically. These studies are important because they demonstrate the educational opportunities that may become available to learners who can obtain meaningful access to AI-supported learning environments. De Simone *et al.* (2025) evaluated a generative-AI virtual tutoring programme for senior-secondary students in Nigeria using a randomised controlled trial. The programme used Microsoft Copilot, powered by GPT-4, within a six-week, curriculum-aligned intervention for first-year senior-secondary students. The study reported a statistically significant improvement of 0.31 standard deviations on an assessment covering

English-language content, AI knowledge, and digital skills. This study provides unusually strong empirical evidence concerning the potential of generative AI in Nigerian secondary education. However, its findings need to be interpreted within the conditions of the intervention. Students were provided with structured access and pedagogical support within an organised programme. Thus, the study primarily answers the question of what AI-supported learning can accomplish when the conditions for access and use are deliberately created. It does not establish whether students in ordinary secondary-school environments have equal opportunities to obtain devices, connectivity, AI tools, guidance, and sustained opportunities for use.

This distinction is central to the present study. Evidence of AI effectiveness does not establish equity of access. Indeed, the existence of educational benefits from AI may make unequal access more consequential because students who cannot participate in AI-supported learning may be excluded from opportunities that are increasingly available to better-resourced learners. Adegoke *et al.* (2026) examined secondary-school students' perceptions and attitudes toward generative-AI tools in Osun State, Nigeria, using a sequential explanatory mixed-methods design. The study involved 390 students who responded to a structured questionnaire, supplemented by interviews with teachers. The researchers reported that 71.8% of students demonstrated positive perceptions of generative AI, whereas only 27.43% demonstrated positive attitudes toward its academic use. The study also reported relationships between students' perceptions of AI, academic performance, and skill acquisition.

The study is particularly relevant to the present research because it concerns secondary-school students, generative AI, and the South-West Nigerian context. Its mixed-method design also moves beyond purely quantitative evidence. Nevertheless, its principal focus was perception, attitude, academic performance, and skill development rather than unequal access. It therefore contributes evidence about students' orientations toward AI while leaving the experiential dimension of unequal access insufficiently examined.

Teachers, STEM Education and AI Engagement

Teachers constitute another important dimension of AI-supported education because meaningful classroom use depends partly on teachers' technological knowledge, confidence, pedagogical competence, and willingness to engage with AI. Ayanwale *et al.* (2024) investigated STEM teachers' trust in AI-based educational technologies. Their findings indicate that teachers' engagement with AI cannot be reduced to the mere availability of technology. Factors associated with trust, perceived usefulness, confidence, and related teacher characteristics can influence willingness to engage with AI-supported educational technologies. This evidence is relevant because it demonstrates that AI access is multidimensional. A school may possess technological infrastructure while

teachers remain unable to exploit it effectively because of insufficient knowledge, confidence, or trust. However, quantitative studies of teacher acceptance or trust do not necessarily reveal how teachers experience these conditions within their actual schools, particularly where infrastructure, connectivity, electricity, professional development, and financial resources are uneven.

The distinction between technological availability and meaningful educational participation is reinforced by UNESCO's (2024) AI competency frameworks. The framework for students identifies competencies spanning a human-centred mindset, AI ethics, AI techniques and applications, and AI system design, while the framework for teachers includes competencies relating to AI foundations and applications, AI pedagogy, ethics, and professional learning. These frameworks indicate that meaningful participation in AI-supported education involves more than simply having access to an AI-enabled device or application. Competence, ethical understanding, pedagogical knowledge, and opportunities for appropriate use are also necessary.

Empirical Evidence from Ondo State

The literature emerging from Ondo State is particularly important because it provides evidence from the geographical context in which the present study is situated. Akinbuwa (2025) investigated teachers' and students' perceptions of AI tools for academic support in selected secondary schools in Ondo State. The study involved 350 students and 150 teachers and examined participants' perceptions of AI-supported academic assistance. The study provides direct evidence that AI has become an identifiable educational issue among teachers and students in Ondo State secondary schools. The relevance of this study to the present investigation lies in its inclusion of both major participant groups. However, its emphasis on perceptions means that it does not explain how students and teachers experience unequal access to AI-supported learning tools. A participant may perceive AI positively while simultaneously lacking reliable connectivity, an appropriate device, financial resources, or opportunities for guided use. Oloja and Daramola (2026) examined teachers' perceptions of the use of AI in teaching basic mathematical skills among secondary-school students in Ondo State. This study is particularly pertinent to the present investigation because it connects AI with mathematics education in the same geographical context. However, its focus on teachers' perceptions does not address the experiences of students or the broader phenomenon of unequal access to AI-supported STEM learning.

Previous Research by the Present Author

The present author has also contributed, with different co-authors, to the emerging empirical literature on AI integration in Ondo State secondary education. These studies provide important contextual evidence but do not duplicate the focus of the present investigation. Aduloju

et al. (2026a) examined teachers' readiness and perceptions of AI integration in public secondary schools in Ondo State. The study highlighted the importance of teacher preparedness and identified contextual conditions that may constrain AI integration. These findings suggest that positive perceptions of AI do not necessarily translate into practical readiness for sustained implementation. In a separate co-authored study, Aduloju *et al.* (2026b) investigated AI adoption in secondary education, including perceptions of opportunities, challenges, readiness, and ethical concerns among teachers and school administrators in Ondo State. The study drew attention to infrastructural, technical, institutional, and professional conditions affecting AI adoption.

These previous studies are important to the present research because they establish an emerging evidence base concerning AI readiness, perception, and adoption within Ondo State. However, they employed quantitative survey approaches and focused primarily on readiness, perceptions, adoption, and institutional conditions. They did not investigate the phenomenon of unequal AI access through a phenomenological examination of students' and STEM teachers' lived experiences. Thus, the present study should be understood as an extension rather than a repetition of this previous work. The earlier studies address questions concerning whether educators are ready, how they perceive AI, and what conditions influence adoption. The present investigation addresses a different question: how students and STEM teachers experience unequal opportunities to access and use AI-supported learning tools and what meanings they attach to those experiences.

Synthesis of Empirical Evidence

The empirical evidence reveals several interconnected patterns. First, digital inequality remains an important feature of Nigerian education. Evidence from secondary-school students in Osun State demonstrates differences in computer experience and technological familiarity associated with school type and location (Abdulkareem & Lennon, 2025). Second, AI is rapidly becoming part of Nigerian secondary and STEM education. The Nigerian randomised trial reported measurable learning benefits when generative AI was integrated into a structured, teacher-supported learning programme (De Simone *et al.*, 2025). Third, South-West Nigerian research indicates that awareness, accessibility, and utilisation of AI are not necessarily high or uniform. Ugwuanyi *et al.* (2025), for example, reported low levels across these dimensions among Chemistry students in Colleges of Education. Fourth, recent research in Osun and Ondo States demonstrates that secondary-school students and teachers are increasingly engaging with questions concerning AI perception, attitude, readiness, mathematics instruction, and academic support (Adegoke *et al.*, 2026; Akinbuwa, 2025; Oloja & Daramola, 2026). Finally, the literature indicates that access should not be conceptualised merely as physical availability. AI-supported educational

participation can also depend on digital competence, teacher preparedness, pedagogical support, connectivity, infrastructure, and opportunities for sustained and meaningful use.

Gap in the Empirical Literature

The foregoing evidence indicates that the Nigerian literature on AI in education is no longer an empty research field. Researchers have examined digital inequality, AI awareness, accessibility, utilisation, perception, attitude, teacher readiness, trust, institutional adoption, and the effects of AI-supported interventions.

The remaining gap is therefore more specific.

There is limited phenomenological evidence explaining how secondary-school students and STEM teachers experience unequal access to AI-supported learning opportunities in their everyday educational environments. Existing quantitative studies can establish levels of awareness, accessibility, readiness, perception, utilisation, or adoption, while intervention studies can demonstrate what AI can accomplish under structured conditions. However, these approaches provide less insight into how individuals experience the consequences of having reliable access, intermittent access, constrained access, or no meaningful access to AI-supported learning. The distinction between availability and meaningful access is especially important. A student may own or have occasional access to a smartphone without having sufficient data, electricity, connectivity, AI literacy, or educational guidance to use AI meaningfully. Similarly, a teacher may have access to an AI platform but lack the training, confidence, infrastructure, or institutional support required to integrate it into STEM instruction. Such differences cannot be adequately understood through access statistics alone.

The present study therefore addresses a specific intersection that remains insufficiently explored

digital inequality + AI-supported learning + STEM education + secondary schools + lived experience.

Its contribution is consequently not to establish whether AI exists in Nigerian schools or whether teachers and students generally perceive it positively. Rather, the study seeks to understand how unequal access to AI-supported learning is experienced, negotiated, and interpreted by students and STEM teachers within their actual educational environments. By adopting a phenomenological approach, the study complements existing survey, mixed-method, correlational, and experimental research. It moves the literature from measuring access, readiness, perception, utilisation, adoption, and educational outcomes toward understanding the meaning and lived reality of unequal AI access. This focus provides a more precise basis for examining whether the emerging AI transformation of STEM education is creating genuinely inclusive learning opportunities or reproducing existing patterns of digital inequality.

MATERIALS AND METHODS

Research Design

The study adopted a qualitative descriptive phenomenological research design to explore the lived experiences of secondary-school students and STEM teachers concerning digital inequality and access to artificial intelligence (AI)-supported learning tools in STEM education. A phenomenological design was considered appropriate because the study focused on participants' first-hand experiences of accessing, attempting to use, being excluded from, or adapting to AI-supported educational technologies within their everyday teaching and learning environments. The study was informed by a Husserlian descriptive phenomenological orientation, with particular attention to participants' descriptions of their experiences and the meanings they attached to those experiences. The purpose was not to measure the prevalence or statistical effect of digital inequality but to understand the experiential dimensions of unequal access, including participants' perceptions of opportunity, exclusion, barriers, emotional responses, and adaptive practices.

Although the study was descriptively oriented, interpretation was undertaken at the level of the meanings emerging from participants' accounts. This was particularly relevant to the fourth research question, which examined the meanings students and teachers attached to access or lack of access to AI-supported learning tools. The researcher therefore maintained reflexivity throughout data collection and analysis and sought to keep interpretations grounded in participants' accounts.

Area of the Study

The study was conducted in Ondo North Senatorial District of Ondo State, Nigeria. The district comprises six Local Government Areas: Akoko North-East, Akoko North-West, Akoko South-East, Akoko South-West, Ose, and Owo. The area includes rural and semi-urban communities with variations in educational resources, digital infrastructure, connectivity, and socioeconomic conditions.

The study area was considered appropriate because secondary schools within the district operate under differing technological and infrastructural circumstances. Such variation provides an appropriate context for exploring how students and STEM teachers experience differences in access to digital and AI-supported learning resources.

Population of the Study

The population comprised SS II students offering STEM-related subjects and STEM teachers in selected secondary schools within Ondo North Senatorial District. The student population included learners offering subjects such as Mathematics, Biology, Chemistry, and Physics, while the teacher population comprised teachers responsible for STEM-related instruction. These participant groups

were selected because students are the direct recipients of learning opportunities while teachers are central to the integration of AI-supported technologies into classroom instruction. Including both groups therefore enabled the study to examine the phenomenon from complementary educational perspectives.

Participants and Sampling

The study involved 22 participants, comprising 12 SS II students (2 from each of the six local government areas of senatorial district, one from private school and one from public school) and 10 STEM teachers (2 from each of the six LGA of the northern senatorial district of the state 1 from public and 1 from private but 1 private and one public school teacher were later unable to participate reducing the number to 10). Participants were selected from public and private secondary schools located in urban and rural areas of Ondo North Senatorial District. Purposive sampling was used to select participants who could provide information-rich accounts relevant to the phenomenon under investigation. Selection sought variation in participant role, school type, geographical setting, and exposure to digital technologies and AI-supported learning resources. The purpose of the sampling was not statistical representation but the acquisition of sufficiently rich descriptions of participants' experiences. The inclusion of both students and teachers also provided an opportunity to compare experiences across participant groups and identify areas of convergence and divergence.

Instrument for Data Collection

Data were collected using a semi-structured phenomenological interview guide developed in line with the research questions. The guide was designed to elicit detailed descriptions of participants' experiences of digital inequality and access to AI-supported learning tools. The interview questions addressed participants' experiences of access to digital and AI-supported resources, opportunities and constraints associated with AI use, differences in access across schools and learners, infrastructural and institutional barriers, experiences of participation or exclusion, coping and adaptation, and the meanings participants attached to having or lacking access to AI-supported learning opportunities. The semi-structured format provided consistency across interviews while allowing the researcher to use probing and follow-up questions to clarify participants' accounts and obtain richer descriptions of their experiences.

Data Collection Procedure

Data were collected through in-depth, semi-structured interviews with the selected students and STEM teachers. Interviews were conducted individually and lasted approximately 30–60 minutes. With participants' consent, the interviews were audio-recorded. Field notes were also maintained to document relevant contextual information and observations arising during the interview process.

The interviews encouraged participants to describe their experiences in their own words rather than respond to predetermined interpretations. Probing questions were used where necessary to obtain concrete examples and clarify the circumstances surrounding participants' experiences of access, limited access, or lack of access to AI-supported learning resources.

Data Analysis

The interview data were analysed using Colaizzi's phenomenological method. This approach was selected because it provides a systematic procedure for moving from participants' descriptions to the essential meanings and structure of the phenomenon.

The analysis proceeded through the following stages. First, the interview recordings were transcribed verbatim and the transcripts were read repeatedly to obtain a comprehensive understanding of the participants' accounts. Second, significant statements directly related to digital inequality, AI access, STEM learning, teaching experiences, barriers, emotional responses, and coping practices were identified. Third, meanings were formulated from the significant statements while remaining closely grounded in the participants' descriptions. Fourth, formulated meanings were organised into clusters according to their conceptual and experiential similarities. Fifth, the clusters were developed into themes representing recurring dimensions of participants' experiences. Sixth, an exhaustive description of the phenomenon was developed by integrating the themes and supporting participant accounts. Seventh, the fundamental structure or essence of the phenomenon was identified from the exhaustive description.

Although the analysis involved articulating meanings emerging from participants' descriptions, the researcher remained focused on describing the phenomenon as experienced and on grounding all analytic interpretations in participants' accounts. This approach was consistent with the Husserlian descriptive orientation of the study, which emphasises faithful description of participants' lived experiences rather than imposing predetermined theoretical interpretations on their accounts. The analysis resulted in five major experiential themes: unequal access to digital learning resources; limited exposure to AI tools; structural and institutional barriers; emotional experiences of digital exclusion; and coping strategies and adaptation. The themes were subsequently examined in relation to the research questions and interpreted in a manner that remained grounded in participants' descriptions.

Trustworthiness of the Study

The study addressed trustworthiness through the four commonly recognised criteria of credibility, transferability, dependability, and confirmability.

Credibility was supported through the use of in-depth interviews, probing and follow-up questions, comparison of accounts from students and teachers, and the grounding of interpretations in participants' direct

statements. Member checking was conducted by providing participants with summaries of their accounts, given the opportunity to confirm the accuracy of summaries or interpretations of their accounts.

Transferability was addressed through detailed description of the study setting, participant characteristics, school contexts, and conditions surrounding digital and AI access. Such contextual information enables readers to determine the relevance of the findings to educational contexts with comparable characteristics.

Dependability was enhanced through systematic documentation of the research procedures, including participant selection, interview procedures, transcription, coding, development of meaning clusters, and theme development. An audit trail was maintained to document the analytical process.

Confirmability was addressed through reflexive engagement by the researcher and the grounding of interpretations in the interview data. The researcher documented assumptions and reflections concerning digital inequality and AI in education and repeatedly returned to the original participant accounts during analysis to minimise the possibility of interpretations becoming detached from the data.

Researcher Reflexivity

Because phenomenological research recognises the potential influence of the researcher on the interpretation of experiential accounts, the researcher engaged in reflexive practice throughout the study. Attention was given to pre-existing assumptions concerning digital inequality, AI access, STEM education, and technological readiness. Rather than claiming complete elimination of researcher influence, reflexivity was used to make such assumptions explicit and to encourage continuous examination of how they might affect questioning, interpretation, and theme development. Participant quotations and original interview accounts were used as important anchors for the interpretation of the findings.

Ethical Considerations

The study adhered to relevant ethical principles governing research involving human participants. Participation was voluntary, and participants were informed about the purpose and procedures of the study before data collection. Participants were informed of their right to decline participation or withdraw from the study without penalty. Because the study included SS II students who may be minors, appropriate parental or guardian consent and student assent were obtained and documented in accordance with the requirements of the relevant institutional ethics process. STEM teachers provided informed consent before participation. Confidentiality and anonymity were maintained by replacing participants' identifying information with codes or pseudonyms in transcripts and reporting. Audio recordings, transcripts, field notes, and related research materials were stored securely and used only for the stated research purposes.

Methodological Scope

The study was designed to provide contextually rich understanding rather than statistical generalisation. Consequently, the experiences reported by the 22 participants should not be interpreted as representative of all secondary-school students or STEM teachers in Ondo State or Nigeria. The contribution of the study lies instead in illuminating how digital inequality and unequal access to AI-supported learning are experienced and interpreted within a particular secondary-school context. The detailed contextualisation of participants' accounts enables readers and researchers to assess the potential transferability of the findings to comparable educational environments.

RESULTS AND DISCUSSION

Overview of Participants and Emergent Findings

The study explored the lived experiences of digital inequality and access to artificial intelligence (AI)-supported learning among secondary school students and STEM teachers in Nigerian secondary schools. The participants comprised 22 individuals: 12 SS II students and 10 STEM teachers, drawn from public and private secondary-school contexts within Ondo North Senatorial District. The study included participants from both urban and rural settings to capture variation in the technological and institutional environments in which STEM teaching and learning occurred. Following the phenomenological approach adopted for the study, participants' accounts were examined for recurring meanings and patterns of lived experience. The analysis generated five interconnected themes: (1) unequal access to digital learning resources, (2) limited exposure to AI tools, (3) structural and institutional barriers, (4) emotional experiences of digital exclusion, and (5) coping, adaptation, and grassroots resilience. The five themes were not treated as isolated categories. Rather, they represented interconnected dimensions of participants' experiences. Unequal access affected opportunities for practical engagement with digital technologies; limited access contributed to a gap between informal awareness of AI and its formal educational use; infrastructural and institutional barriers reinforced these limitations; prolonged exclusion acquired emotional meanings for some participants; and students and teachers developed individual and collective strategies to cope with the resulting constraints.

Research Question One: Experiences of Digital Inequality in STEM Education

RQ1: How do secondary-school students and teachers experience and describe digital inequality in STEM education across selected school contexts in Ondo North Senatorial District, Nigeria?

The findings indicate that participants experienced digital inequality primarily through unequal access to functional digital resources and unequal opportunities to engage

practically with technology-supported STEM learning. The experience was not restricted to the physical absence of computers or other devices. Participants also described inadequate numbers of available devices, limited opportunities for individual interaction, and differences in technological provision between school contexts.

Theme 1: Unequal Access to Digital Learning Resources

Absence of Practical Engagement and Device Deficits

Students described digital inequality as an immediate limitation on their ability to interact directly with technological resources. Student 04 stated: "In our school, we only read about computers in textbook diagrams. When we go to the laboratory, there are no systems for us to practice physics simulations or coding like students in other places do." This account illustrates the distinction between theoretical knowledge of technology and practical access to technology. The student may encounter digital technologies conceptually through instructional materials but has limited opportunity to manipulate or apply them directly in STEM learning. Student 12 similarly described the consequences of inadequate device availability: "Even on the rare days when a teacher brings a laptop to class, we have to crowd around it in groups of ten. By the time it reaches the back, the class is already over, and you haven't touched the keyboard yourself." The account demonstrates that the presence of a technological device does not automatically constitute meaningful access. Where one device is shared among many learners, opportunities for individual interaction may remain severely restricted. Digital inequality is therefore experienced not simply through whether a device exists, but through whether learners can meaningfully use it.

Structural Differentiation Across School Contexts

Teachers' accounts further indicated that technological opportunities differed across institutional contexts. Teacher 02 explained: "The disparity is glaring. While some private schools can boast of tablet carts or computer labs with intermittent service, public schools like ours struggle with basic desktop hardware that broke down years ago and has no budget for repair." This account situates students' experiences within wider institutional differences in technological provision. The participant's description suggests that access is affected not only by the initial acquisition of technological equipment but also by the capacity of schools to maintain and replace such resources. The finding therefore indicates that nominal technological provision and functional technological access are not equivalent. A school may possess computers or a designated computer laboratory while students continue to experience substantial digital exclusion if equipment is obsolete, insufficient, inaccessible, or poorly maintained.

Phenomenological Interpretation: The Spatial-

Material Divide

The experiences reported under Theme 1 reveal a spatial-material divide in STEM learning. For the students, technology is often encountered at a distance—through textbook representations, occasional exposure to a teacher’s device, or comparison with better-resourced educational settings—rather than through sustained personal interaction. The lived experience is consequently characterised by a separation between knowing about digital technologies and experiencing them as instruments of learning. The significance of this finding extends beyond equipment shortages. Participants’ accounts suggest that limited access changes the conditions under which STEM learning occurs by restricting opportunities for practical exploration, experimentation, simulation, and technology-mediated problem solving. The teacher’s account adds an institutional dimension to this experience. Unequal technological provision appears to be embedded within the different resource conditions of schools, making digital inequality simultaneously a classroom experience and an institutional experience.

Theme 2: Limited Exposure to AI Tools

A second dimension of RQ1 concerned participants’ exposure to AI technologies. The findings reveal a notable distinction between awareness of AI in the wider society and actual exposure to AI within formal STEM education.

Disconnect Between Informal Awareness and Classroom Reality

Students described encountering AI-related technologies outside the formal classroom through personal devices, family members’ devices, social media, television, and other informal sources. Student 06 explained:

“Sometimes on my brother’s phone, I see videos of apps that can solve complex chemistry equations or explain physics concepts instantly. But when we enter our science class, it is back to chalk, talk, and copying notes from a textbook that is ten years old.” Similarly, Student 11 stated: “We know artificial intelligence is changing the world because people talk about it online and on television. But inside the four walls of our school, nobody has ever shown us how to use an AI tool for our assignments or science projects. It feels like a different world entirely.” These accounts suggest that awareness does not necessarily translate into educational access or practical AI experience. Students may recognise the growing importance of AI and observe its capabilities outside school while having limited opportunities to use AI for academic purposes within their STEM classrooms. Phenomenological Interpretation: The Chasm Between Informal and Formal Realities

The students’ accounts reveal a chasm between informal technological awareness and formal educational experience. AI is visible in the wider technological environment, but its presence within participants’ formal STEM learning remains limited. Consequently, AI is

experienced less as a practical instrument for scientific inquiry and more as a technology observed from outside the classroom. This distinction is significant because meaningful AI literacy requires more than awareness that AI exists; it involves opportunities to understand, interact with, evaluate, and appropriately apply AI-supported tools.

Synthesis of Findings for Research Question One

The findings for RQ1 indicate that participants experienced digital inequality through both material exclusion and experiential exclusion. Material exclusion involved inadequate or non-functional digital resources, while experiential exclusion involved limited opportunities to use those technologies in meaningful STEM learning. The findings also reveal a distinction between general awareness and educational participation. Some students were aware of AI and had observed its capabilities through informal digital exposure, yet this awareness rarely translated into formal classroom use. Taken together, Themes 1 and 2 indicate that the digital inequality experienced by participants is multidimensional. It involves not only unequal possession of technological resources but also unequal opportunities to interact with, learn through, and develop practical competence with emerging digital and AI-supported technologies. This finding provides the foundation for the subsequent themes. The next question therefore concerns the conditions that help explain why meaningful digital and AI-supported learning remains difficult within the participants’ educational environments.

Research Question Two: Teachers’ Experiences of AI Integration in STEM Education

RQ2: How do teachers experience the opportunities and barriers associated with integrating AI-supported tools into STEM teaching?

The findings indicate that teachers’ experiences of AI integration were shaped by a combination of limited technological exposure, infrastructural constraints, inadequate professional preparation, and individual efforts to compensate for institutional limitations. Teachers did not generally describe the challenge as a lack of recognition of the potential value of AI. Rather, their accounts pointed to a gap between the perceived usefulness of emerging technologies and the conditions available for incorporating them into everyday STEM instruction.

Theme 2: Limited Exposure to AI Tools—Teachers’ Perspective

Teachers’ accounts complemented the students’ descriptions of limited AI exposure. Teacher 05 explained: “Students talk about these modern AI tools because they see them on social media, but as teachers, our hands are tied. We have no computers, no stable electricity to power a lab if we had one, and no training on how to integrate AI into a syllabus that is already rigidly focused on passing

traditional paper exams.” The account identifies several interconnected constraints. First, teachers may encounter students who are already aware of AI through informal digital channels. However, teachers themselves may lack the equipment and professional preparation required to transform that awareness into structured classroom activities. Second, the participant links AI integration to broader curricular and assessment conditions in which conventional examination preparation remains a dominant instructional priority. The finding therefore suggests that teachers experience AI integration as a capacity and opportunity problem, rather than simply as a question of willingness to adopt a new technology.

Theme 3: Structural and Institutional Barriers

Infrastructural Deficits: Electricity and Connectivity

Teachers identified basic infrastructure as a fundamental prerequisite for digital and AI-supported instruction. Teacher 04 stated: “It is impossible to talk about digital learning or AI when we do not even have a stable power supply, let alone an internet router. Halfway through a lesson, the electricity cuts off, and whatever momentum we built is completely lost.” The account demonstrates how infrastructural instability can interrupt not only the operation of digital devices but also the continuity of planned instruction. The problem is therefore experienced at both the technical and pedagogical levels. A teacher may plan to incorporate digital resources into a lesson, but an unexpected power interruption can terminate the activity and require an immediate return to conventional instructional methods. The teacher’s experience suggests that AI integration depends upon foundational conditions that precede the technology itself. Without dependable electricity and connectivity, even motivated teachers have limited opportunity to sustain technology-mediated instructional practices.

Administrative Neglect and Resource Allocation

Teacher 07 further described the institutional dimension of the problem: “The administration treats computer literacy as an extracurricular luxury rather than a core part of STEM education. There is no budget allocated for software licenses, hardware maintenance, or teacher training workshops.” This account suggests that institutional support is experienced as an important determinant of teachers’ capacity to integrate digital technologies. The issue is not limited to the acquisition of computers. Teachers identify the continuing requirements of software, maintenance, professional development, and institutional prioritisation. From this perspective, AI integration is embedded within a wider institutional ecosystem. Where digital learning is not treated as a core component of STEM education, teachers may have limited access to the resources and professional support required to experiment with and sustain AI-supported approaches.

Phenomenological Interpretation: Systemic Constraints on Teacher Agency

Taken together, the teacher accounts indicate that educators experience AI integration within a context of constrained professional agency. Teachers recognise emerging technologies and encounter students who are increasingly aware of AI, yet their ability to respond pedagogically is restricted by equipment shortages, unreliable infrastructure, limited training, and institutional priorities. The experience is therefore not adequately described as simple teacher resistance to technology. Rather, the accounts suggest a distinction between willingness or recognition of technological value and practical capacity to implement technology-supported instruction. This distinction is important. When teachers lack functional devices, reliable electricity, connectivity, training, or institutional support, the decision not to use AI cannot automatically be interpreted as a negative attitude towards innovation. It may instead represent a rational response to conditions in which sustained implementation is difficult.

Theme 5: Teacher Resourcefulness and Personal Device Utilisation

Despite these constraints, teachers described efforts to create limited opportunities for digital learning through personal resources. Teacher 01 stated: “To teach anything related to digital concepts, I have to use my personal smartphone, download diagrams or short clips at home using my own data, and then bring it to class for students to cluster around. But it is a very poor substitute for a real computer lab.” This account demonstrates an important counterpoint to the structural barriers identified above. Teachers are not entirely passive in the face of technological scarcity. Instead, some attempt to mobilise personal devices, personal internet expenditure, and materials obtained outside school to sustain aspects of technology-supported instruction. However, the teacher simultaneously identifies the limitations of this strategy. Having several students gather around one personal smartphone provides exposure to digital content but does not reproduce the opportunities available in a properly equipped computer laboratory. The experience therefore represents adaptive resourcefulness under institutional constraint. Personal resources temporarily extend the technological capacity of the classroom, but they do not resolve the underlying infrastructural deficit.

Theme 5: Student Collaboration as a Complementary Response

Although students’ peer-support practices are principally addressed under the broader findings on coping and adaptation, they also provide evidence relevant to teachers’ experiences of AI and digital integration. Student 02 reported: “Since we do not have individual computers or steady internet, those of us who have phones with internet access download study notes and share them with others in school the next day so nobody is left completely behind.” Similarly, Student 07 explained: “We form small study groups after school where we discuss

science problems together. If one person managed to find a helpful textbook or a video on a parent's phone over the weekend, we all gather around to look at it." These accounts suggest that where teachers cannot consistently provide technology-mediated learning through formal school infrastructure, students sometimes construct informal support networks to extend their access. Such practices may help teachers sustain learning objectives indirectly, but they should not be mistaken for substitutes for institutional digital provision.

Synthesis of Findings for Research Question Two

The findings for RQ2 reveal a tension between teachers' recognition of the relevance of digital and AI-supported learning and the structural conditions within which they teach. Three interconnected experiences are particularly evident. First, teachers operate within classrooms where AI exposure is limited despite students' growing informal awareness. Second, infrastructural and institutional conditions—including electricity, connectivity, equipment, maintenance, professional development, and curricular or assessment pressures—constrain sustained implementation. Third, teachers respond through personal resourcefulness, including the use of personal smartphones, data, and downloaded materials. The findings therefore suggest that the experience of AI integration is characterised by constrained innovation rather than simple technological rejection. Teachers attempt to create opportunities for digital learning where possible, but these efforts remain dependent on personal resources and cannot fully compensate for inadequate institutional infrastructure. The teacher experience can consequently be understood as a movement between recognition, constraint, adaptation, and limitation: teachers recognise the relevance of emerging technologies, encounter structural barriers to their use, adapt through personal and informal resources, but remain aware that such adaptations cannot provide the sustained and equitable learning environment associated with fully supported digital STEM education.

Research Question Three: Digital Inequality and Students' STEM Engagement

RQ3: How does digital inequality affect students' engagement and learning experiences in STEM education? The findings indicate that digital inequality affected students' STEM experiences through several interconnected pathways. Limited access to functional digital resources reduced opportunities for practical engagement; infrastructural interruptions constrained continuity of technology-supported learning; and repeated experiences of technological exclusion were associated, in participants' accounts, with frustration, discouragement, and concerns about future educational competitiveness. These experiences suggest that the consequences of digital inequality extend beyond access itself to the quality of students' participation and their perceptions of what is possible within STEM education.

Theme 1: Unequal Access and Restricted Practical Engagement

The first dimension of students' STEM experience concerned their limited opportunities to engage directly with digital resources. Student 04 explained: "In our school, we only read about computers in textbook diagrams. When we go to the laboratory, there are no systems for us to practice physics simulations or coding like students in other places do." The participant's account suggests that limited technological access constrains the practical dimension of STEM learning. Rather than using digital tools to explore scientific concepts, conduct simulations, or develop computational skills, students may encounter such technologies primarily through theoretical descriptions. Student 12 similarly described the consequences of insufficient device availability: "Even on the rare days when a teacher brings a laptop to class, we have to crowd around it in groups of ten. By the time it reaches the back, the class is already over, and you haven't touched the keyboard yourself." This account indicates that even occasional availability of technology may not produce meaningful engagement when access is highly restricted. The opportunity to observe a device is different from the opportunity to interact with it. Thus, students' participation is shaped not only by whether technology is present but also by the quantity, accessibility, and usability of the resources available.

Theme 3: Infrastructural Disruption and the Continuity of STEM Learning

Students also experienced digital inequality through the infrastructural conditions surrounding technology use. Student 03 stated: "Even if someone manages to bring a laptop or a tablet to school, there is no light to charge it. Most times, the power goes off for days, so we cannot rely on any electronic device for our science practicals or assignments." The account reveals how unreliable electricity can undermine the continuity of digital learning. The problem is not simply that a particular activity cannot be completed. Rather, uncertainty about whether devices can be powered makes digital learning itself difficult to depend upon as a routine component of STEM instruction. The resulting learning experience is one of technological uncertainty. Students may recognise the usefulness of digital tools but cannot assume that those tools will be available or operational when needed.

Theme 4: Frustration and the Weight of Educational Disadvantage

The emotional dimension of this restricted participation emerged strongly in students' accounts. Student 05 explained: "Sometimes it makes you feel like you are running a race with your hands tied behind your back. When you see students in other countries or private schools using advanced tools to learn science, and you are struggling to even see a working computer, it brings down your morale." The metaphor of a race undertaken

with one's hands tied conveys the student's perception that unequal technological conditions place them at a disadvantage relative to other learners. The emotional response is therefore connected to a perceived inequality in educational opportunity. Student 10 similarly linked technological exclusion to concerns about future academic participation: "It is very frustrating because we know the world is moving fast toward technology. When we cannot access these things, you feel left behind even before you finish secondary school, wondering how you will compete with others in the university." Here, the consequences of digital inequality extend beyond the immediate classroom. The participant connects present technological limitations with anticipated challenges in higher education. Digital inequality is consequently experienced not only as a current learning constraint but also as a concern about future preparedness and competitiveness.

Phenomenological Interpretation: The Emotional Embodiment of Digital Inequality

The students' accounts indicate that digital inequality is experienced both materially and affectively. The absence or limited availability of digital resources becomes meaningful when students compare their circumstances with those of learners who appear to have greater technological opportunities. The resulting experience involves frustration, discouragement, and a perception of being left behind. Importantly, these emotions are not presented as independent psychological states; they are connected to the participants' interpretation of unequal educational conditions. Thus, the digital divide becomes embodied in the learner's experience of participation. Students are not merely aware that resources are unavailable. They experience the consequences of that unavailability in terms of what they can practise, what they can explore, and how prepared they believe themselves to be for increasingly technology-oriented educational environments.

Teacher Perspective: Witnessing the Consequences for Student Engagement

The emotional consequences described by students were also observed by teachers. Teacher 06 stated: "You can see the disappointment in the eyes of bright students when they ask practical questions about software or digital tools that we cannot demonstrate. Over time, that initial curiosity fades into resignation, and they stop aspiring to high-tech STEM careers because they feel systems are not built for them." This account provides an important complementary perspective. The teacher describes students as initially demonstrating curiosity about digital technologies but subsequently experiencing disappointment when their questions cannot be supported through practical classroom experiences. The participant's account suggests a possible movement from curiosity to disappointment and, for some students, resignation. However, this should be understood as the teacher's

observed experience rather than a universal outcome for all students. The evidence does not establish that digital inequality necessarily causes students to abandon STEM careers; rather, it indicates that persistent technological limitations may influence how some students perceive their future opportunities.

Integrative Findings for Research Question Three

The findings for RQ3 demonstrate that digital inequality affects students' STEM experiences through a combination of restricted practical engagement, disrupted learning opportunities, and emotional responses to perceived educational disadvantage. At the practical level, students have limited opportunities to manipulate digital technologies and participate in technology-mediated STEM activities. At the infrastructural level, unreliable electricity and other environmental constraints make technology-supported learning difficult to sustain. At the experiential level, repeated limitations can generate frustration and perceptions of being left behind. The findings therefore suggest that the consequences of digital inequality extend beyond the traditional question of whether students possess or can access technological devices. What matters experientially is whether students can reliably and meaningfully participate in technology-supported STEM learning. The accounts also reveal that participation is relational. Students evaluate their own opportunities partly by comparing them with what they observe among peers, in private-school environments, through media, and in the wider technological world. Such comparisons can make technological deprivation more salient and contribute to perceptions of educational disadvantage.

Overall, RQ3 reveals a progression from material restriction to constrained participation and then to emotional meaning. Limited access reduces opportunities for practical engagement; infrastructural instability makes those opportunities unreliable; and repeated exclusion may contribute to frustration and concerns about future preparedness. Digital inequality is therefore experienced not merely as a technological problem but as a condition that can shape how students participate in, interpret, and imagine their STEM education.

Research Question Four: Meanings Attached to AI Access, Exclusion, and Adaptation

RQ4: What meanings do students and teachers attach to access to, or exclusion from, AI-supported educational technologies?

The findings indicate that participants attached meanings to AI access that extended beyond the availability of technological devices. Access was associated with educational opportunity, preparedness, participation, and future competitiveness, whereas exclusion was experienced through frustration, perceived disadvantage, and uncertainty about future opportunities. At the same time, participants did not experience exclusion entirely passively. Teachers and students developed informal

strategies to negotiate technological scarcity and sustain learning.

Theme 4: Digital Exclusion as an Experience of Educational Disadvantage

Students' accounts indicate that exclusion from AI-supported and digitally mediated learning was interpreted as a form of educational disadvantage. Student 05 described this experience metaphorically: "Sometimes it makes you feel like you are running a race with your hands tied behind your back. When you see students in other countries or private schools using advanced tools to learn science, and you are struggling to even see a working computer, it brings down your morale." The meaning attached to exclusion is evident in the student's comparison between their own educational conditions and those of students perceived to have greater technological opportunities. The metaphor of being constrained in a race suggests that technological inequality is understood as affecting one's capacity to compete educationally. Student 10 similarly connected limited access with future preparedness: "It is very frustrating because we know the world is moving fast toward technology. When we cannot access these things, you feel left behind even before you finish secondary school, wondering how you will compete with others in the university." For this participant, access to technology carries a meaning that extends into the future. AI and digital competence are perceived as increasingly relevant to educational progression, making present exclusion meaningful in terms of anticipated future participation. These accounts suggest that participants attach an instrumental and aspirational meaning to AI access. Technology is valued not simply because it is modern, but because participants associate technological competence with opportunities to learn, participate, compete, and prepare for further education.

Theme 4: Erosion of Aspirational Horizons

The teacher perspective adds another dimension to the meaning of exclusion. Teacher 06 observed: "You can see the disappointment in the eyes of bright students when they ask practical questions about software or digital tools that we cannot demonstrate. Over time, that initial curiosity fades into resignation, and they stop aspiring to high-tech STEM careers because they feel systems are not built for them." This account suggests that prolonged technological exclusion may influence students' perceptions of what is attainable. The teacher describes an apparent progression from curiosity to disappointment and, in some cases, resignation. The finding should not be interpreted as establishing that exclusion necessarily causes students to abandon STEM careers. Rather, it indicates that the teacher perceives persistent technological limitations as capable of narrowing some students' perceived horizons of possibility. From a phenomenological perspective, the significance lies in how the structural absence of technology becomes meaningful at the level of personal

aspiration. A technological limitation external to the learner may gradually become interpreted as a limitation on what the learner can realistically pursue.

Theme 5: Coping as Agency Under Constraint

Despite the meanings associated with exclusion, participants also demonstrated agency through adaptive practices. Teachers used personal devices and resources to create limited opportunities for technology-supported learning. Teacher 01 stated: "To teach anything related to digital concepts, I have to use my personal smartphone, download diagrams or short clips at home using my own data, and then bring it to class for students to cluster around. But it is a very poor substitute for a real computer lab." This account reveals a meaning of professional responsibility and commitment. The teacher's use of personal resources indicates an attempt to prevent technological scarcity from completely halting digital-related learning. However, the participant's acknowledgement that the practice is "a very poor substitute" is equally important. It demonstrates awareness of the difference between coping access and equitable access. The teacher's resourcefulness creates a temporary opportunity but does not eliminate the structural deficit.

Theme 5: Student Collaboration and Collective Agency

Students similarly constructed informal systems of support. Student 02 explained: "Since we do not have individual computers or steady internet, those of us who have phones with internet access download study notes and share them with others in school the next day so nobody is left completely behind." Student 07 described another form of collective adaptation: "We form small study groups after school where we discuss science problems together. If one person managed to find a helpful textbook or a video on a parent's phone over the weekend, we all gather around to look at it." These accounts demonstrate that exclusion does not eliminate learner agency. Students actively redistribute scarce resources, share information, and organise collaborative learning opportunities. The meaning of access therefore becomes partly relational. A technological resource possessed by one student can become a shared resource within a peer network. Students consequently attempt to transform individually available resources into collective educational opportunities. Nevertheless, this adaptation has clear limits. Sharing a smartphone, downloaded material, or textbook cannot provide the same experience as having reliable individual or small-group access to functional digital infrastructure. The coping strategies therefore reveal both agency and continuing deprivation. Phenomenological Interpretation: Adaptation Without Resolution

The experiences represented in Theme 5 reveal a tension between human agency and structural constraint. Participants do not simply accept digital exclusion.

Teachers mobilise personal resources, while students mobilise peer networks and collective study practices. However, these adaptive practices do not resolve the underlying inequalities. Instead, they function as temporary or partial mechanisms for keeping learning active under constrained circumstances.

The lived experience can therefore be understood as adaptation without resolution. Participants demonstrate the capacity to improvise, collaborate, and persist, but their ability to do so remains dependent on resources that are themselves limited and unevenly distributed.

Overall Phenomenological Essence of the Findings

Across the four research questions and five themes, the findings reveal digital inequality as a layered lived experience rather than a simple absence of technological devices. At the material level, participants experience unequal access to functional digital resources and limited opportunities for practical interaction with technology. At the experiential level, students may be aware of AI through informal sources while encountering little opportunity to use it within formal STEM education. At the structural level, unreliable electricity, connectivity limitations, inadequate maintenance, insufficient professional preparation, and institutional priorities constrain sustained digital integration. These conditions acquire emotional and aspirational meanings. Students describe frustration and feelings of being left behind, while teachers report observing disappointment and, in some cases, declining expectations regarding technology-intensive STEM pathways. At the same time, participants demonstrate agency through personal resource use, peer collaboration, information sharing, and informal study networks.

The central essence of the lived experience is therefore one of technological possibility constrained by unequal educational conditions, producing a continuous tension between exclusion and adaptation. Participants are aware that digital and AI technologies can expand STEM learning possibilities, yet their educational environments do not consistently provide the resources and institutional conditions necessary to experience those possibilities directly. The findings further suggest that participants' responses to digital inequality are neither wholly passive nor sufficient to overcome the inequality. Teachers and students actively improvise around technological scarcity, but their coping strategies remain partial substitutes for reliable institutional provision. Thus, the lived experience of digital inequality may be characterised as a cycle of: unequal access → limited exposure → structural constraint → emotional and aspirational consequences → individual and collective adaptation. This cycle provides the interpretive foundation for the subsequent discussion of the findings in relation to digital-divide theory, phenomenological perspectives, constructivist learning theory, and contemporary empirical research on AI-supported education.

Discussion

Unequal Access as More Than a Device-Access Problem

The first major finding is that digital inequality among the participants was experienced as more than the simple absence or presence of computers and other digital devices. Participants described a deeper distinction between nominal access and meaningful educational access. Students reported encountering situations in which digital devices were absent, insufficient, shared among large numbers of learners, or unavailable for practical use. Teachers similarly described differences in the availability, functionality, and maintenance of technological resources across school contexts. This finding is consistent with the broader understanding of digital inequity as a multidimensional phenomenon. Recent scholarship argues that educational digital inequality cannot be adequately understood through physical access alone because inequalities also arise through differences in skills, usage opportunities, institutional support, and educational outcomes (Meng *et al.*, 2024).

The present findings extend this perspective by showing how these dimensions are experienced by students and teachers in their everyday STEM learning environments. Student 04's description of learning about computers primarily through textbook diagrams illustrates the difference between being exposed to knowledge about technology and having the opportunity to learn with technology. Similarly, Student 12's description of several students crowding around a single laptop demonstrates that the physical presence of a device does not automatically create equitable participation. This distinction is particularly important in STEM education because many contemporary STEM activities depend upon opportunities for exploration, simulation, visualisation, data analysis, coding, and problem solving. Where students cannot interact directly with digital tools, their technological learning may remain predominantly observational or theoretical. The finding therefore suggests that the relevant question is not simply "Does the school have computers?", but rather "To what extent can students reliably and meaningfully use digital technologies for learning?"

The Nigerian context makes this distinction particularly significant. Recent Nigerian scholarship on AI and STEM education identifies inadequate resources and expertise among the challenges affecting the integration of AI into STEM education (Okoye & Mante, 2024). Similarly, Adesina and Shotayo (2024) argue that AI has considerable potential for improving STEAM education in Nigeria while highlighting the importance of conditions that support effective integration. The present phenomenological evidence adds an experiential dimension to these observations. It demonstrates that resource inequality is not experienced by participants simply as a statistical difference in school equipment. It becomes a difference in what students are able to touch, practise, explore, and experience as part of their STEM

education.

The Gap Between AI Awareness and Educational Exposure

A second important finding concerns the gap between informal awareness of AI and formal educational exposure to AI. Several students indicated that they were aware of AI through social media, television, family members' devices, and other informal sources, yet reported little or no opportunity to use AI-supported tools for assignments, science projects, problem solving, or classroom learning. This finding is particularly significant because it challenges the assumption that young people's growing familiarity with digital technologies necessarily translates into AI literacy. Participants may encounter AI as part of everyday technological culture while remaining excluded from the educational practices through which they could develop critical and purposeful competence in using AI. The distinction is consistent with recent scholarship showing that AI adoption in education is strongly influenced by the surrounding technological, pedagogical, and institutional environment. A recent review of AI-enhanced pedagogies in the Global South found that persistent digital divides, infrastructure deficits, limited institutional support, and inadequate educator preparation remain major constraints on meaningful AI integration.

The present findings contribute to this literature by revealing the phenomenological meaning of the awareness–exposure gap. Student 11's description that AI seems to exist in “a different world” from the school classroom illustrates the separation between technological life outside school and formal educational experience inside school. This is an important form of inequality because awareness without opportunity may produce a paradoxical condition: students know that AI is becoming increasingly important but lack the educational environment required to develop informed, practical, and critical competence in using it. In this sense, the AI divide may begin before differences in advanced AI skills become visible; it can originate in differences in opportunities to encounter AI meaningfully within formal education.

Structural Infrastructure as a Precondition for AI Integration

The third major finding concerns the foundational role of electricity, connectivity, equipment maintenance, and institutional support. Participants repeatedly described unreliable electricity, inadequate connectivity, obsolete equipment, inaccessible computer laboratories, insufficient maintenance, and limited teacher training. This finding suggests that the challenge of AI integration in low-resource educational environments is partly pre-AI. Before a school can meaningfully integrate sophisticated AI applications, it must possess the basic

infrastructure that permits digital technologies to function consistently. This interpretation is strongly supported by recent international evidence. A 2025 review of AI-powered education and digital inequality identified infrastructure gaps, socioeconomic barriers, digital-literacy limitations, and policy constraints as major barriers to equitable AI-supported learning. More recent evidence concerning emerging economies similarly emphasises reliable electricity, internet connectivity, devices, and digital literacy as foundational requirements for countries seeking to benefit from AI. The Nigerian evidence is particularly relevant. Eke (2024), in a study of Nigerian teacher educators, found generally positive attitudes and readiness toward AI adoption while also examining barriers to adoption. This is important when interpreted alongside the present findings. The problem should not automatically be conceptualised as teachers being unwilling to embrace AI. Rather, there may be a substantial difference between positive disposition toward AI and the practical conditions necessary for implementation.

Teacher 05's account illustrates this distinction particularly clearly. The participant described students' awareness of AI while simultaneously identifying inadequate computers, unstable electricity, and insufficient teacher training. The resulting situation is one in which teachers may recognise the pedagogical relevance of AI but remain unable to translate that recognition into sustained classroom practice. This finding has an important theoretical implication for the digital-divide perspective. If digital inequality is treated only as a problem of individual access, interventions may focus excessively on distributing devices. The present findings indicate that device provision without electricity, connectivity, maintenance, teacher preparation, and institutional support may produce only nominal inclusion.

Digital Inequality as an Emotional and Aspirational Experience

The fourth major finding extends the digital-inequality discussion into the affective domain. Students described frustration, discouragement, and feelings of being left behind when comparing their learning conditions with those of students in better-resourced environments. Teacher 06 similarly described observing disappointment and declining enthusiasm among students who repeatedly encountered limitations when asking questions about digital technologies. This finding is significant because it demonstrates that digital inequality has consequences beyond technological participation. Students interpret unequal access in relation to their own educational identity and future prospects. Student 05's metaphor of “running a race with your hands tied behind your back” indicates that the participant does not perceive limited technology merely as an inconvenience. It is experienced as an unequal starting condition.

The finding is also consistent with the broader literature

on digital inequity, which increasingly treats inequalities in digital participation and outcomes as distinct from simple physical access (Meng *et al.*, 2024). The present study contributes something further by showing how this inequality is emotionally interpreted by learners themselves. Students' concern that they may be unable to compete effectively in university because of inadequate technological preparation indicates that the digital divide can become incorporated into expectations about the future. However, the findings should not be interpreted deterministically. The qualitative evidence does not establish that technological exclusion inevitably produces poor academic outcomes or abandonment of STEM careers. Rather, it demonstrates that participants perceive and experience technological inequality as capable of affecting morale, confidence, and perceptions of future opportunity. This distinction strengthens the phenomenological contribution of the study. The issue is not simply whether digital inequality produces a measurable reduction in achievement. It is also what it means to a learner to know that important educational technologies exist but to experience limited opportunities to use them.

Coping, Resourcefulness, and the Limits of Individual Adaptation

The fifth major finding concerns participants' adaptive responses to digital inequality. Teachers described using personal smartphones, personal internet data, and downloaded materials, while students described sharing devices and information and forming informal study groups. These practices demonstrate considerable agency. Participants are not passive recipients of structural disadvantage. They actively construct alternative pathways through which some learning can continue. At the same time, the findings reveal an important contradiction. Individual resourcefulness can mitigate digital inequality without necessarily resolving it. When teachers must use personal data and smartphones to compensate for institutional deficiencies, some of the responsibility for maintaining digital learning shifts from the institution to the individual educator. Similarly, when students depend on classmates' devices and informal peer networks, access becomes dependent upon the distribution of personal resources within the student community.

This finding is especially important in the context of AI. Recent discussions of AI equity increasingly emphasise the need for affordable, locally appropriate, and inclusive approaches rather than assuming that technological innovation alone will eliminate existing inequalities. The present findings therefore suggest that resilience should not be used to obscure structural deprivation. The fact that teachers and students find creative ways to continue learning is evidence of agency, but it is not evidence that institutional digital inequality has been solved. The distinction between adaptation and resolution is consequently central to understanding the participants' experiences. Their coping strategies keep educational

activity moving, but they cannot fully reproduce the opportunities associated with reliable electricity, functional computer laboratories, stable connectivity, adequate devices, professional training, and sustained institutional support.

An Integrated Interpretation: From Digital Divide to AI Opportunity Divide

Taken together, the five themes suggest that the phenomenon observed in this study extends beyond a conventional digital divide. The participants' experiences point toward an emerging AI opportunity divide. The distinction is important. A conventional digital divide asks whether learners have access to digital technologies and connectivity. The findings of this study suggest a further question: Who has meaningful opportunities to use emerging AI technologies for educational purposes, under supportive instructional and institutional conditions?

The five themes form a connected experiential sequence:

1. Unequal access to digital resources limits practical engagement;
2. limited AI exposure creates a gap between informal awareness and formal educational use;
3. structural and institutional barriers reproduce those limitations;
4. emotional consequences emerge through frustration and perceptions of disadvantage; and
5. coping, adaptation, and grassroots resilience provide partial responses without removing the underlying structural conditions.

This interpretation aligns with recent evidence that digital inequity is multidimensional and that AI integration in the Global South is constrained by infrastructure, institutional support, and educator capacity. The Nigerian context adds an important empirical dimension to this discussion. Recent Nigerian studies have begun to examine AI readiness, AI adoption, and the potential of AI for STEM education, but the present phenomenological findings shift attention toward how unequal AI opportunity is actually lived by secondary-school learners and teachers. The central contribution is therefore not simply the observation that Nigerian schools face technological challenges. Rather, the study demonstrates how material scarcity, institutional constraints, limited AI exposure, emotional experience, and adaptive agency interact to shape the lived meaning of digital inequality in STEM education. This integrated interpretation suggests that achieving educational equity in the age of AI requires a shift from a narrow device-distribution model toward an opportunity-and-participation model. Equitable AI-supported STEM education requires students and teachers to have not only devices, but also reliable infrastructure, meaningful opportunities for use, appropriate teacher preparation, institutional support, and educational practices that enable technology to become part of genuine learning rather than an occasional demonstration.

Theoretical Implications of the Findings

The findings have implications for the three theoretical perspectives underpinning the study: Digital Divide Theory, phenomenological interpretation, and Constructivist Learning Theory. Considered together, the findings suggest that digital inequality in STEM education is simultaneously a problem of access, lived experience, and opportunity for active knowledge construction.

Implications for Digital Divide Theory

The findings provide empirical support for a multidimensional interpretation of Digital Divide Theory. The participants' experiences demonstrate that inequality does not end with differences in the physical availability of digital devices. Rather, inequality operates through several interconnected levels: access to functional resources, opportunities for meaningful use, institutional conditions supporting use, and the educational meanings and consequences attached to that use. The experiences of Students 04 and 12 illustrate the first two dimensions particularly clearly. The absence of functional equipment and the need to crowd around a single laptop restrict opportunities for individual interaction. Similarly, the accounts of Teachers 02, 04, 05, and 07 demonstrate that access is conditioned by maintenance, electricity, connectivity, training, and institutional priorities. These findings therefore extend the interpretation of the digital divide from a simple "haves versus have-nots" distinction toward a more differentiated "quality and opportunity of access" perspective. Two schools may both possess digital equipment while providing substantially different opportunities for students to use those resources meaningfully.

More importantly, the findings suggest that an emerging AI opportunity divide may develop from existing digital inequalities. Students who lack reliable digital access may also have fewer opportunities to develop practical familiarity with AI-supported educational tools. Consequently, inequalities in conventional digital access can become the foundation upon which later inequalities in AI literacy, AI-supported learning, and technology-related educational opportunities are built. The theoretical implication is therefore that Digital Divide Theory remains highly relevant in the age of AI, but its analytical focus needs to move beyond device ownership toward meaningful participation in AI-mediated educational practices.

Implications for the Phenomenological Perspective

The phenomenological dimension of the study contributes a different but complementary understanding of digital inequality. Rather than treating inequality solely as an external structural condition, the findings demonstrate how it is experienced, interpreted, and given meaning by those living within the educational environment. For students, technological exclusion is experienced through the inability to practise with digital tools, frustration when comparing their circumstances with those of better-resourced learners, and uncertainty about their

preparedness for future education. For teachers, the experience involves a tension between recognising the relevance of emerging technologies and working within conditions that restrict their ability to implement them. The findings therefore demonstrate that the meaning of digital inequality is not exhausted by the absence of technological resources. A computer laboratory that remains locked, a laptop shared among many students, or a digital lesson interrupted by power failure acquires meaning through the lived experience of the participants. These situations communicate to learners what kinds of educational opportunities are available to them and what forms of participation are realistically possible.

The phenomenological interpretation consequently reveals a progression from structural condition to lived experience and then to meaning. Material inequality becomes experienced as restricted participation; restricted participation becomes interpreted as disadvantage; and prolonged disadvantage may acquire emotional and aspirational significance. This strengthens the value of a phenomenological approach for studying digital inequality because it makes visible dimensions that may remain hidden in purely quantitative measures of device ownership, internet availability, or technology adoption.

Implications for Constructivist Learning Theory

The findings also have implications for Constructivist Learning Theory because many of the opportunities associated with digital and AI-supported STEM education depend upon learners' active engagement with information, tools, problems, and collaborative environments. The students' accounts demonstrate that limited access to digital resources restricts some of the conditions through which active learning can occur. When students primarily encounter computers through textbook illustrations, or when ten learners must share a single device during a short lesson, their opportunities to explore, manipulate, test, and construct knowledge through digital environments are constrained. At the same time, the peer-support practices described by Students 02 and 07 demonstrate that learners attempt to create collaborative learning environments despite technological scarcity. Their sharing of materials, collective problem solving, and informal study groups illustrate learners' capacity to construct knowledge socially even under constrained conditions.

This finding provides an important qualification to a purely technology-centred interpretation of constructivist learning. Technology does not itself create constructivist learning. Rather, technology can provide affordances for exploration, interaction, collaboration, feedback, and knowledge construction when appropriate resources and pedagogical conditions are present. The findings therefore suggest that unequal digital access can create unequal opportunities to participate in technology-mediated constructivist learning experiences. AI-supported STEM education should consequently be understood not simply as the introduction of a new technological tool, but as the

creation of learning environments in which students can actively engage with technology to investigate problems, construct understanding, collaborate, and reflect.

Contribution to Knowledge

The study contributes to existing knowledge in four principal ways. First, it provides phenomenological evidence of digital inequality at the secondary-school STEM level in Nigeria. Much discussion of digital inequality focuses on infrastructure, access statistics, technology adoption, or policy. The present study adds the lived perspectives of students and teachers, demonstrating how these structural conditions are experienced within everyday educational practice. Second, the study identifies a distinction between AI awareness and AI educational exposure. Participants may encounter AI in their everyday digital environment while remaining largely excluded from meaningful AI-supported learning within formal STEM education. This distinction suggests that awareness should not be treated as evidence of AI literacy or equitable AI participation. Third, the findings conceptualise digital inequality as a layered phenomenon comprising material access, practical participation, structural support, emotional experience, and adaptive response. This provides a more comprehensive account than a narrow focus on whether technological devices are physically available. Fourth, the study identifies the emerging possibility of an AI opportunity divide. Existing inequalities in digital infrastructure and meaningful technology use may translate into unequal opportunities to develop familiarity and competence with AI-supported educational technologies. This is particularly important as AI becomes increasingly relevant to STEM learning and future educational and occupational participation.

The study therefore shifts the analytical question from: “Who has access to digital technology?” toward: “Who has meaningful opportunities to learn with, through, and about emerging AI technologies, under conditions that support sustained participation?” This shift provides a useful conceptual contribution for research and policy concerned with educational equity in the transition from conventional digital learning to AI-supported education.

Implications for Educational Practice and Policy

The findings have implications for educational practice and policy in Nigeria. First, interventions designed to promote AI-supported STEM education should not focus exclusively on the procurement of devices. The evidence indicates that devices require supporting infrastructure, including reliable electricity, connectivity, maintenance, software, and appropriate technical support. Second, teacher professional development should accompany technological investment. The findings indicate that teachers may recognise the relevance of AI while lacking the training required to integrate it meaningfully into STEM instruction. Professional development should therefore move beyond general awareness of AI and include practical guidance

on pedagogical integration, responsible use, critical evaluation of AI-generated information, and alignment with curriculum objectives. Third, schools should create opportunities for students to engage directly with digital and AI-supported resources rather than limiting exposure to demonstrations or theoretical descriptions. Where resources are scarce, carefully structured small-group and rotational approaches may provide greater participation than simply displaying a device to an entire class. Fourth, policy responses should recognise the importance of equity of participation. Providing a computer laboratory is not sufficient if students cannot access it, equipment is obsolete, electricity is unreliable, or teachers lack the capacity to use the facility pedagogically. Finally, the resourcefulness demonstrated by teachers and students should be recognised as evidence of agency rather than treated as a substitute for institutional responsibility. Personal smartphones, personal data, peer sharing, and informal study groups can support learning under difficult conditions, but sustainable digital and AI equity requires institutional systems capable of providing reliable and equitable opportunities for participation.

CONCLUSION

This study examined the lived experiences of digital inequality and access to AI-supported learning among secondary school students and STEM teachers in Nigerian schools. The findings show that digital inequality extends beyond access to devices and internet connectivity to include meaningful opportunities to use, understand, and learn through digital and AI technologies. Participants reported unequal access to digital resources, limited AI exposure, institutional barriers, emotional experiences of exclusion, and adaptive responses. A key finding was the gap between AI awareness and meaningful educational exposure: although some students encountered AI through informal channels, opportunities for formal AI-supported STEM learning remained limited. Teachers similarly recognised AI’s potential but faced infrastructural, institutional, and professional constraints. Although participants demonstrated resilience through resource sharing, peer support, and the use of personal resources, these responses are adaptive rather than sustainable solutions. Equitable AI-supported STEM education therefore requires reliable infrastructure, teacher preparation, institutional support, and meaningful student participation. The study conceptualises this inequality as an emerging AI opportunity divide, reflecting differences not only in technological access but also in opportunities to meaningfully encounter, use, understand, and learn through AI-supported technologies.

Limitations of the Study

This phenomenological study involved a relatively small group of students and STEM teachers within selected Nigerian school contexts; therefore, the findings are not statistically generalisable to all Nigerian schools. The study relied primarily on participants’ accounts, which may be

influenced by memory and personal interpretation. The findings reflect lived experiences rather than independent assessments of school infrastructure. Contextual differences in geography, school type, resources, and teacher preparation may also affect transferability. Additionally, the study did not examine the causal effects of AI use on academic outcomes. Finally, because AI technologies, policies, and educational practices are rapidly evolving, participants' experiences reflect conditions during the period of data collection.

Recommendations

1. Improve digital infrastructure: Educational authorities should provide reliable electricity, internet connectivity, functional devices, maintenance, and technical support.

2. Strengthen teacher preparation: Continuous professional development should equip STEM teachers with practical skills in AI-supported pedagogy, responsible AI use, critical evaluation of AI outputs, privacy, and curriculum integration.

3. Promote meaningful student participation: Schools should provide structured opportunities for students to engage with AI-supported learning through collaborative, rotational, and offline approaches where resources are limited.

4. Institutionalise digital learning: Schools should include digital and AI-supported learning in planning and budgeting, with dedicated provision for connectivity, maintenance, software, training, and technical support.

5. Reduce dependence on personal resources: Teachers should not be expected to finance digital learning through personal devices, internet data, or privately acquired materials.

6. Adopt equity-oriented AI policies: Educational policies should assess equity through meaningful participation, accessibility, teacher preparedness, and educational use rather than device availability alone.

Implications For Future Research

Future research should examine the AI opportunity divide across diverse Nigerian contexts, including urban and rural schools and public and private institutions. Longitudinal studies could investigate how changing infrastructure, teacher preparation, and AI exposure influence students' experiences over time. Mixed-methods research should combine lived experiences with measures of infrastructure, teacher AI readiness, student AI literacy, and technology use. Intervention studies could further determine whether improvements in infrastructure, teacher preparation, and AI-supported pedagogy reduce inequalities and improve STEM engagement, achievement, retention, problem-solving, and AI literacy. Future qualitative studies should also examine responsible AI use, privacy, algorithmic bias, academic integrity, teacher agency, and critical AI literacy.

Final Contribution Of The Study

The central contribution of this study is its demonstration that equitable AI-supported STEM education involves more than technological availability. The findings reveal an interaction between material access, meaningful participation, institutional conditions, emotional experiences, and adaptive agency. The study therefore reframes digital inequality in the AI era as an opportunity problem—unequal access to the conditions necessary to meaningfully encounter and use AI for educational purposes. It contributes a phenomenological understanding of how digital inequality shapes AI-supported STEM learning experiences in the Nigerian context and highlights the need to shift from merely providing technology to creating the infrastructure, capabilities, pedagogical opportunities, and institutional conditions that make technology an effective educational resource.

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