Tech-Enhanced Teacher Training: Evaluating Pre-Service Early Childhood Teachers' Experiences and Perceptions

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Abstract. This qualitative case study explored the experiences of pre-service early childhood educators with technology integration during their teacher preparation programmes in Nigeria. Through semi-structured interviews with five final-year students, this study examined the influence of technology use on the development of technological pedagogical content knowledge and attitudes toward educational technology among pre-service teachers. Thematic analysis identified the authors' principal themes: the duality of technology integration, disparities and institutional infrastructure support, professional development needs, and pedagogical adaptation and professional identity. The findings reveal significant discrepancies between theoretical training and practical application of technology in early childhood settings. Pre-service teachers expressed ambivalence toward technology, acknowledging its potential while contending with its challenges in implementation. Inequalities and insufficient support systems emerged as the primary obstacles. Participants highlighted the necessity of comprehensive, ongoing professional development and mentoring to facilitate effective technology integration. This study underscores the complex nature of technology integration in early childhood teacher preparation, emphasising the need for more structured approaches that address allocation, institutional support, and identity development. Recommendations include enhancing infrastructure, revising curricula to better align theory and practice, and establishing partnerships between teacher preparation programmes and early childhood centres to provide authentic technology integration experiences.

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1. Introduction

As teacher educators specialising in early childhood education, the authors have observed the evolving landscape of technology integration in teacher training institutions. Their experience in preparing future early childhood teachers reveals a critical intersection between traditional pedagogy and technological advancement, necessitating careful consideration of teacher preparation. While educational technologies have transformed teaching practices, their implementation in early childhood settings presents unique challenges that require specialised preparation. At a high-tech university, the authors faced difficulties integrating advanced technologies such as interactive whiteboards into early childhood teacher preparation. This highlights a gap: while teachers are expected to create technology-rich environments, their training often lacks adequate preparation for age-appropriate technology integration. Recent meta-analyses show that while early childhood centres invest in technology, developing pre-service teachers' capacity to use these tools effectively often falls short (Park et al., 2023; Starkey, 2019).

As researchers in early childhood pedagogy, we observed that traditional technology integration approaches in teacher education may be insufficient. Studies indicate gaps between theoretical knowledge and practical challenges in implementing developmentally appropriate technology-enhanced learning strategies (Uerz et al., 2018). This disconnect is evident in early childhood settings, where teachers must balance technical competence, developmental appropriateness, play-based learning, and social and emotional needs. The implications of this study extend beyond teacher education to influence educational policy, curriculum design, and practice. As early learning environments worldwide face the challenge of preparing teachers for technology-dependent settings, understanding pre-service teachers' perceptions of technology during their preparation is crucial. This understanding is vital for identifying intervention points that enhance technological pedagogical content knowledge while maintaining developmentally appropriate practice. Building on these observations, this study aims to explore the following research questions and objectives.

1.1 Research Questions

1. What are the experiences of pre-service early childhood teachers in technology-enhanced training programmes?
2. How do they perceive the effectiveness of technology integration in their training to be?
3. What challenges do they face in utilising technology during training?
4. How does technology-enhanced training influence their readiness for classroom teaching?

1.2 Research Objectives
1. To explore and analyse the experiences of pre-service early childhood teachers in technology-enhanced training programmes.
2. To examine their perceptions regarding the effectiveness of technology integration in their training.
3. To identify and evaluate the challenges pre-service early childhood teachers face in utilising technology during training.
4. To assess the influence of technology-enhanced training on pre-service early childhood teachers' readiness for future roles.

2. Literature Review

This literature review explores technology-enhanced teacher training through key themes: the historical evolution of technology in teacher preparation programmes, current trends, challenges and opportunities, and theoretical frameworks guiding its implementation, among others. It synthesises recent research findings and identifies gaps in the phenomenon that this study aims to address

2.1 Historical Evolution of Technology in Teacher Preparation Programmes
Technology integration in early childhood teacher preparation has evolved significantly, reflecting changing views on the role of technology in early learning. In the 1980s and the early 1990s, the focus was on basic computer literacy, with limited pedagogical applications for young children (McClanahan, 2017; Molenda, 2021). Teachers were trained to use computers mainly for administrative tasks, reflecting uncertainties about technology in early learning environments.

The late 1990s and the early 2000s marked a shift towards more integrated approaches. This era saw the introduction of specialised courses to help future teachers integrate technology in developmentally appropriate ways (Lim, 2023). The focus has expanded to include how technology can support play-based learning and early literacy. However, many programmes struggled to fully integrate technology, often treating it as an add-on.

The mid-2000s to the early 2010s were transformative, with Web 2.0 technologies and social media introducing new possibilities for collaborative learning (McClanahan, 2017; Molenda, 2021). Education programmes have begun incorporating these tools, recognising their potential for fostering engagement and constructivist learning. The rise of mobile technologies and cloud computing has led to more flexible learning opportunities, changing how technology is used in teacher preparation (Park et al., 2023).

2.2 Technology in Early Childhood Settings: Current Trends and Practices
In the authors' exploration of technology integration in early childhood settings, they have witnessed remarkable transformations in the approach to digital tools in early years education. The authors' experience visiting various early childhood centres across Nigeria has revealed diverse approaches to technology implementation. One of the authors recalls walking into a preschool classroom in

Lagos where a teacher used an interactive whiteboard to engage three-year-olds in a collaborative storytelling session. This experience contrasts with observations in rural areas, where limited resources often necessitate more creative approaches to technology integration (Ottenbreit-Leftwich & Kimmons, 2018). The authors' research and personal observations have revealed a significant shift in how technology is viewed in early childhood settings. When the authors began their careers in early childhood education twenty-three years ago, there was considerable resistance to introducing technology in early years classrooms. However, recent experiences suggest growing acceptance, considering developmental appropriateness. One author recalls a conversation with a veteran educator who said, *"It is not about whether we should use technology anymore, but how we can use it meaningfully."*

This study revealed varying levels of technology integration across different settings. In urban early childhood centres, teachers have been observed using tablets for documentation and assessment, digital cameras for children's project work, and interactive displays for group activities. The most successful implementations always maintain a balance with traditional, hands-on experiences. The authors recall observing a lesson in which a teacher combined digital documentation with nature exploration, allowing children to photograph and record their discoveries during outdoor play. One teacher's innovative approach stood out: creating virtual morning circles that maintained social-emotional connections crucial for young children's development during COVID-19.

Research across different socioeconomic contexts has shown that access to technology varies significantly, creating a 'digital opportunity gap' in early childhood education. Visits to Nigeria's private and public early childhood centres have demonstrated how resource disparities affect technology integration. They remember visiting a well-funded private preschool with smart boards in every classroom, while a public centre just kilometres away struggled to access basic digital resources. These observations, which pose a challenge to early childhood, have influenced the authors' perspective on the need for equitable access to technology in early childhood settings.

2.3 Challenges and Opportunities in Digital Early Childhood Teacher Education
Anecdotal observations in early childhood teacher education show that digital transformation presents unique challenges and opportunities specific to the preparation of early years teachers. One pressing challenge is the rapid evolution of technology, which often outpaces the ability of preparation programmes to adapt (Foulger et al., 2017). In their observation, early childhood teachers struggled to maintain current technological knowledge while aligning it with developmentally appropriate practices for young children.

The authors' experiences revealed a significant disconnect between the technology available during teacher preparation and what pre-service teachers encounter in early-year practicum placements. As Tondeur et al. (2019) noted, this theory-practice gap is particularly evident in early childhood contexts, where

resources and technological infrastructure vary dramatically between settings. Digital transformation has opened new doors for enhancing early childhood teacher education. The authors witnessed how open educational resources enabled pre-service early childhood teachers to access diverse learning materials on developmentally appropriate technology integration (Fessl et al., 2022). Digital technologies have allowed the creation of more personalised learning experiences for pre-service teachers, helping them understand how to adapt technology for different early childhood age groups (Romero-Hall, 2021).

2.4 Understanding Pre-Service Early Childhood Teachers' Digital Literacy Needs

Research on pre-service early childhood teachers shows that their digital literacy needs have evolved significantly. Beyond basic technology skills, teachers require a complex understanding of digital literacy, including developmentally appropriate practices, information literacy, and digital citizenship (Lo et al., 2024). Classroom observations revealed varying digital literacy levels among incoming teachers, which posed unique challenges. Hence, the need for innovative frameworks which include (1) comprehensive assessment frameworks for evaluating digital literacy needs, (2) contextual digital literacy training tailored to age groups, (3) partnerships to address infrastructure challenges, (4) integration with pedagogical practices focusing on developmentally appropriate technology use, and (5) evolving curricula encompassing appropriate practices, information literacy, and digital citizenship (Han & Kwak, 2024).

The assessments revealed interesting patterns. As Instefjord and Munthe (2017) found, many students overestimate their digital competencies. While they are comfortable with personal technology, they struggle with developmentally appropriate integration for young children. This has led to the development of comprehensive assessment frameworks for early childhood contexts. Digital literacy needs are highly contextual in nature. As Lo et al. (2024) suggest, pre-service teachers need different skills depending on the age group they work with, such as toddlers and kindergarteners. This understanding influences the integration of technology into teacher preparation programmes. Moreover, infrastructure challenges in early childhood settings are significant and require urgent attention. Visits to learning centres showed disparities in technology access, aligning with the findings of Liu et al. (2023) and Molenda (2021) on budget constraints affecting resource provision.

This study highlights the importance of digital literacy in pedagogical practices. Successful technology integration requires an understanding of child development and play-based learning principles. As Falloon (2020) suggests, digital literacy extends beyond technical skills to include critical thinking about technology use and the evaluation of digital resources for young children.

2.5 Factors Influencing Technology Adoption Among Pre-Service Early Childhood Teachers

A unique combination of personal, institutional, and environmental factors influences the adoption of educational technology by pre-service early childhood teachers. Tondeur et al. (2019) identified self-efficacy as crucial in settings where

teachers balance technological integration with developmentally appropriate practices. Teachers who are confident in selecting age-appropriate technology are more likely to integrate it meaningfully. Prior experience with child-centred technology applications shapes attitudes toward technology adoption. Studies have shown that positive experiences with early childhood-specific technology during teacher preparation increase the likelihood of future integration (Naida et al., 2024).

Institutional support and infrastructure are critical components. Liu et al. (2023) emphasise that access to age-appropriate technology resources, technical support, and professional development opportunities for early years settings significantly influences teachers' willingness to adopt new technologies. The quality of technology integration modelling is crucial, especially in demonstrating how technology can enhance hands-on learning. Alignment between technology training and practical teaching experiences during practicum placements is critical for sustainable technology adoption (Instefjord &Munthe, 2017).

Barriers to technology adoption present unique challenges to the industry. Although first-order barriers, such as a lack of resources or support, are significant, second-order barriers are more challenging. These include beliefs about development, attitudes toward screen time, and perceived value of technology in play-based learning (Gath et al., 2025). Research highlights the importance of addressing these barriers through support systems that combine technical training with pedagogical guidance.

2.6 Pre-Service Early Childhood Teachers' Attitudes Towards Educational Technology

Pre-service early childhood teachers' attitudes toward educational technology are shaped by their understanding of child development and play-based learning principles. These attitudes are influenced by perceived developmental appropriateness, ease of implementation, and relevance to early childhood teaching (Naida et al., 2024). Throughout preparation programmes, attitudes evolve as pre-service teachers discover how technology can enhance their hands-on learning experiences.

The development of attitudes toward educational technology in early childhood settings is linked to practical experience. Successful integration during practicum placement can improve attitudes, particularly when technology supports traditional learning approaches (Naida et al., 2024). Research emphasises the need for structured support to help pre-service teachers balance technology use with young children's developmental needs.

Social influences are crucial in shaping early childhood pre-service teachers' attitudes. Vongkulluksn et al. (2018) noted that perspectives of experienced teachers, centre policies, and societal concerns about screen time influence attitude formation. The study revealed that an emphasis on digital literacy in early years education creates tension between traditional practices and technological integration.

2.7 Building Digital Confidence in Pre-Service Early Childhood Teachers
Developing digital confidence in pre-service early childhood teachers requires a focus on developmental appropriateness and play-based learning. Galindo-Domínguez and Bezanilla (2021) showed that those exposed to age-appropriate technology in play-based settings have higher digital confidence. This research highlights the importance of supportive environments for exploring technology within the principles of early childhood development.

Digital confidence is linked to understanding child development and age-appropriate practices. Pre-service teachers' beliefs about effective technology integration are shaped by their preparation experiences (Gath et al., 2025; Vongkulluksn et al., 2018). Confidence building includes peer modelling of appropriate technology use and challenges aligned with early childhood pedagogy. Emotional factors are crucial during early childhood. Main and Prestridge (2020) noted that anxiety about screen time and technology's impact can affect teachers' willingness to use educational technology. Effective programmes address these issues through support strategies, mentoring along with experienced teachers, and reflection opportunities on the role of technology in early learning (Diab & Green, 2024).

2.8 Assessment of Technology Competency in Early Childhood Teacher Education
Assessing technology competency in early childhood teacher education requires specialised frameworks that consider technical skills and pedagogical applications. Redecker and Punie (2017) supported multidimensional approaches that examine the knowledge, skills, and attitudes related to technology integration in early learning settings. Authentic tasks reflecting real-world scenarios are essential, requiring pre-service teachers to make informed technology-use decisions while maintaining developmentally appropriate practice. Research indicates that effective strategies should include formative and summative components to support ongoing competency development in early years settings. Performance-based approaches are valuable in early childhood education. Tasks requiring pre-service teachers to demonstrate technology integration in authentic situations provide more accurate competency measures than do traditional assessments (Redecker & Punie, 2017). Researchers have highlighted the use of specialised rubrics to evaluate technical proficiency, developmental appropriateness, and impact on learning. Incorporating peer and self-assessment to promote reflection on technology use is emphasised. Digital portfolios and continuous assessments are crucial for evaluating competency. Lokollo and Arman. (2021) demonstrated the effectiveness of portfolio-based approaches, allowing pre-service teachers to document technology integration in play-based environments.

2.9 Supporting Pre-service Early Childhood Teachers' Technology Implementation
Adequate support for pre-service early childhood teachers' technology implementation requires a specialised approach that addresses technical aspects and pedagogical integration. Tondeur et al. (2019) identified the critical elements of successful support systems, including mentoring relationships with

experienced teachers, collaborative learning communities, and ongoing professional development specific to early learning environments. Scaffolded support that gradually increases teachers' autonomy in play-based learning contexts is thus crucial. Effective strategies should address individual needs, recognising that pre-service teachers enter programmes with diverse technology experiences and varying understandings of child development principles.

Mentoring is vital for supporting technology implementation. Liu et al. (2023) found that mentoring relationships focusing on developmentally appropriate technology can enhance pre-service teachers' confidence and competence with digital tools. This research highlights the pairing of pre-service teachers with mentors skilled in technology integration and early childhood development. Structured mentoring programmes with regular observation, co-planning, and reflection on technology-enhanced learning experiences are particularly valuable for this purpose.

Recent research has explored technology-mediated support systems for pre-service teachers. Instefjord and Munthe (2017) affirmed the effectiveness of online communities of practice and digital coaching platforms in supporting appropriate technology implementation in teacher education. These approaches offer flexible, on-demand support and facilitate peer learning. This research emphasises the design of systems that promote active engagement while addressing challenges in early learning environments. The findings suggest that combining face-to-face and digital support strategies may best meet the diverse needs of pre-service teachers developing skills in technology implementation.

2.10 Impact of Technology-Enhanced Early Childhood Teacher Training
Studies on technology-enhanced early childhood teacher training programmes offer crucial insights into preparing teachers for digital integration in early learning environments. Tondeur et al. (2019) conducted a systematic review highlighting the positive effects of integrated, developmentally appropriate technology training on pre-service early childhood teachers' attitudes, self-efficacy, and technology use. The study emphasises the importance of longitudinal research designs in tracking the impact of training programmes from graduation through early career experiences. Programmes that combine theoretical knowledge of child development with hands-on practice significantly impact teachers' technology integration practices.

Recent studies have focused on specific pedagogical approaches to technology-enhanced early childhood teacher training. According to Uerz (2018), programmes incorporating play-based learning, child-centred approaches, and developmentally appropriate design thinking show promising results in developing pre-service early childhood teachers' technology integration skills. These strategies enhance pre-service teachers' ability to apply technology to support young children's development and learning (Bueno-Alastuey & Villarreal, 2021). This research emphasises the importance of aligning technology training with early childhood educational theories to ensure coherence and relevance in teacher preparation programmes.

Studies examining the impact of technology-enhanced early childhood teacher training on young children's outcomes have gained prominence. Uerz et al. (2018) explored the relationship between early childhood teachers' technology preparation and their students' digital literacy development. The research shows that pre-service teachers receiving comprehensive, developmentally appropriate technology training are better equipped to foster age-appropriate digital skills among young learners. Their findings emphasise the need for rigorous impact studies to establish causal links between early childhood teacher training approaches and child outcomes in technology-enhanced environments.

2.11 Theoretical Frameworks for Early Childhood Technology Integration
Several theoretical frameworks guide technology integration in early childhood education teacher training programmes. The technological pedagogical content knowledge (TPACK) framework, developed by Mishra and Koehler, has been adapted for early childhood contexts (Kim & Lee, 2018). In early years education, TPACK emphasises the interplay between technology, developmentally appropriate pedagogy, and early childhood content knowledge. This framework has been widely adopted in early childhood teacher education programmes, informing curriculum design and assessment practices that are specific to the learning needs of young children (Kim & Lee, 2018). Critics argue that while TPACK provides a useful conceptual model, it may not adequately address the contextual factors unique to early childhood settings, such as play-based learning and developmental appropriateness (Naida et al., 2024).

The TPACK framework is a theoretical lens for teacher learning and development in the 21st century. Grounded in components, it captures teachers' dynamic knowledge by interacting with several bodies of knowledge teachers use. TPACK is situated within the context of modern classrooms through technology application. It is pivotal in preparing teachers to craft high-quality student learning experiences, support teachers in resolving teaching and learning challenges, and offer strategies for transforming learning principles into practice. The TPACK framework provides a foundation for research inquiries into teacher education programmes. This pedagogical framework was employed to examine the perceptions of pre-service teachers specialising in early childhood by integrating concepts of today's digital society, intertwined with areas of students' lives.

The TPACK model involves a comprehensive understanding of content and pedagogy incorporated in a context-specific means of instruction through a network of teachers' understanding. It encompasses three primary bodies of knowledge operating simultaneously: content knowledge, pedagogical knowledge, and technological pedagogical knowledge (TPK). TPK encompasses the capabilities necessary for teachers to effectively utilise technological tools as part of their pedagogical skill set. This amalgamation of knowledge is referred to as the TPACK framework. The focal position considered in a profession or area of expertise is where the common understanding of expertise in education is embedded.

Information and Communication Technology has significant potential to enhance student learning and outcomes across all grade levels. Pre-service teachers can model the best practices for meaningful technology integration. Despite the theoretical appreciation of Information and Communication Technology integration in teacher training, a research gap exists regarding how pre-service teachers are prepared to use technology meaningfully after instructor support incorporates technology uniquely. Teacher preparatory programmes have adopted ICT to ensure that pre-service early childhood teachers have the necessary skills, attitudes, knowledge, and resources to prepare future students. While existing scholarship emphasises faculty integration of technology in pre-service teacher education, few studies have directly examined its impact on students.

2.12 Developing TPACK in Early Childhood Education
Developing TPACK is essential for preparing early childhood teachers for technology-rich environments. Naida et al. (2024) show that effective technology integration requires technological knowledge, pedagogical understanding, and content knowledge. TPACK emphasises reimagining learning through the appropriate use of technology. Developing TPACK involves designing learning experiences that integrate technology with play-based pedagogy. Kim and Lee (2018) suggest strategies like modelling by experienced teachers, hands-on activities, and reflection on technology and learning principles. Research stresses the importance of providing pre-service teachers with authentic experiences in early childhood settings (Scherer et al., 2020).

Recent studies have explored the dynamic nature of TPACK in early childhood contexts. Naida et al. (2024) highlight TPACK as an evolving construct needing ongoing professional development. Key factors in TPACK development include prior technology experience, beliefs about development, and integration contexts. Holistic models consider broader contextual factors. The TPACK in Practice model adapts to the early years, incorporating play-based learning and centre culture influences (Lim, 2023).

Research shows that this approach helps pre-service teachers develop context-sensitive strategies. The emphasis is on navigating the factors influencing technology integration in real-world settings. Technology-enhanced teacher education demands the investigation of appropriate practices. Effective integration requires an understanding of the connection between technology, pedagogy, and expertise (Bwalya et al., 2023; Galindo-Domínguez & Bezanilla, 2021). Evidence suggests that attitudes and competencies in technology affect experiences during preparation (Park et al., 2023).

3. Methodology
The authors used a qualitative case study approach to investigate pre-service teachers' experiences with technology-enhanced teacher training. Using Naeem et al. (2023) qualitative inquiry framework, which emphasises exploring complex phenomena within their contexts, enabled an exploration of participants' lived

experiences as they unfolded in their educational contexts. The research was conducted within Nigeria's specialised universities of education, particularly in the Faculty of Education, which offers a curriculum on early childhood education. This curriculum prepares educators to teach children aged 3–12 years, covering the pre-primary and primary education levels. Following the case study framework, the authors devised a purposive sampling technique to explore the experiences of the target demographic.

3.1 Sampling Approach
To explore pre-service early childhood teachers' experiences and perceptions, the study utilised a purposive sampling technique, using descriptive statistics to capture diverse perspectives. The inclusion criteria for participants were enrollment in early childhood education programmes, active participation in technology-enhanced training modules, and willingness to participate voluntarily. Five final-year students were selected: three females and two males, aged 22–28 years. This decision balanced the depth of exploration and practical feasibility. A rigorous sampling approach enhanced the validity and credibility of the study.

3.2 Validity and Credibility
Multiple validation techniques were employed to enhance the credibility and comprehensiveness of thematic analysis. An external qualitative researcher specialising in educational technology independently reviewed the coding process and the emergent themes. Discrepancies identified during the peer review were collaboratively addressed to ensure consistency and depth. Member checking was conducted by sharing summaries of the initial findings with the participants to confirm the interpretations. Incorporating participant feedback enhances the accuracy and reliability of the findings.

3.3 Data Collection
Hsu (2016) was instrumental in crafting a protocol for conducting the semi-structured interviews used in data collection. The open-ended questions were designed to elicit insights into technology integration practices, perceptions of institutional support, and evaluation of the effectiveness of training. Participants selected private and comfortable interview venues, which contributed to the richness of the data. All interviews were conducted with the participants' consent and were audio-recorded. Detailed field notes documented the nonverbal cues and environmental context. Upon completing the interviews, the authors amassed substantial data, recordings, and field notes, setting the stage for a thorough thematic analysis.

3.4 Data Analysis
The interviews underwent thematic analysis, employing the six-step framework established by Braun and Clarke (Naeem et al.,2023)
1. Familiarisation with Data: Pseudonyms were used for participants, and data were read repeatedly to become familiar with the participants' stories and understand the data.
2. Generating Initial Codes: The authors adopted a data-driven, indirect coding approach, with codes emerging from the data without being

constrained to predefined theoretical frameworks. Two researchers conducted independent manual coding to ensure reliability and reduce any potential bias.

3. Identifying themes: The initial codes were systematically reviewed, and preliminary themes were developed to identify similarities and patterns in the data.

4. Reviewing and Refinement of Themes: Authors conducted multiple iterations of the review to ensure internal consistency within themes and maintain distinctiveness between them, frequently revisiting original transcripts and initial codes.

5. Defining and Naming of Themes: Themes were clearly defined, and subthemes were identified as necessary to capture nuances in participants' experiences. For example, initial codes like "limited technical support," "limited access to resources", and "institutional support" were clustered under a broader theme of "Resource Disparities and Institutional Infrastructure Support Systems."

6. Reporting Findings: Final themes are presented clearly, with quotations from participants used to exemplify and support analytical interpretations. The analysis was enhanced by writing detailed analytical memos throughout the process, documenting decision-making, emergent interpretations, and reflections, and maximising the transparency and rigour of the qualitative inquiry.

3.5 Ethical Considerations

Multiple validation strategies were employed to establish trustworthiness, including data triangulation, member checking with participants, and peer reviews by experienced colleagues in educational technology. These measures helped ensure the credibility and reliability of the research outcomes. Ethical considerations were paramount throughout the study. The researchers obtained formal approval from the Faculty of Specialised Education at Alvan Ikoku Federal University of Education, with a FSE-EC 2024/54 research ethics code. All participants provided informed consent after receiving detailed information about the study's purpose and procedures. The researchers used pseudonymisation and secure data storage practices to protect confidentiality, with access restricted to the authors and supervisory team. Participants were assured of their right to withdraw from the study at any time.

4. Results and Discussion of Findings

Pre-service teachers' experiences with technology integration were critically analysed using participants' responses, current literature, and the researchers' interpretations. The analysis was thematically integrated to ensure an inclusive understanding of the complex dynamics of technology integration in early childhood education settings.

4.1 Theme 1: The Duality of Technology Integration
4.1.1 Sub-theme 1.1: Ambivalence Toward Technology Integration
The analysis revealed a significant pattern of uncertainty among the pre-service teachers regarding technology integration. This uncertainty manifested

particularly in their reflections on daily classroom implementation and the use of technology as perceived benefits versus challenges. Participant 3 noted:

> "I find it bothersome. The more technology you utilise in the classroom, the more difficult things become, and the more likely something will go wrong. Today, while creating an exercise, I considered making a slideshow to show the terms I wanted to utilise. But I concluded that I would need too much work, have a high risk of failure, and limit my capacity to merely execute the activity freely, such as adjusting the difficulty based on rapid feedback."

This uncertainty aligns with Tondeur et al.'s (2019) findings on the complex nature of technology adoption among pre-service teachers. Hu et al. (2021) similarly identified this tension between recognising technology's potential and the practical challenges of implementation. The participants' candid reflections reveal a deep-seated tension between technological innovation and practical implementation, highlighting the need for more concerted approaches to technology integration in teacher preparation programmes.

4.1.2 Sub-theme 1.2: Transformative Potential

Despite these challenges, other participants recognised the transformative potential of technology in education, particularly its ability to reshape traditional learning environments and approaches. Participant 2 acknowledged the following:

> "Technology has completely changed the game for education. It's no longer about textbooks and whiteboards; it's about smart tools, immersive experiences, and personalised learning journeys. The classroom is no longer confined to walls — it's wherever the learner is. Every learner is unique, and technology makes it possible to meet them where they are."

This viewpoint agrees with Bueno-Alastuey and Villarreal's (2021) research on the transformative potential of technology in education. Kim and Lee's (2018) work further supports this view, particularly regarding the role of technology in creating personalised learning experiences. The unambiguous contrast between these participants' perspectives highlights the complex nature of technological integration in early childhood education, suggesting the need for differentiated support systems.

4.2 Theme 2: Resource Disparities and Institutional Infrastructure Support Systems

The findings showed significant concerns about resource allocation and institutional support structures, particularly in public education settings. Participant 4 confirmed the challenges of equitable resource distribution and its impact on effective technology integration, as mentioned in the following excerpt:

> "Very unfortunately, the public community college where I teach has tended to invest limited resources in equipping a few classrooms with a lot of bells and whistles that most people don't know how to use, rather than just simple laptop projection with internet connection for every single classroom."

In affirmation of the views of participant 4, participant 1 stated, *"The disparity is stark. Some classrooms have everything, while others lack basic connectivity. It's not just about having fancy equipment; it's about having reliable, accessible technology that teachers can actually use effectively in their daily teaching."* This observation corroborates Liu et al.'s (2023) findings regarding the critical importance of equitable resource distribution. Bwalya et al. (2023) further emphasised how resource inequalities impact the effectiveness of technology integration. Moreover, McClanahan (2017) argued that uneven resource allocation can create "technology deserts" within educational institutions, leading to inequitable learning opportunities. The participants' responses revealed a significant disconnect between institutional technology investments and practical teaching needs. The findings revealed a concerning pattern where advanced technology was concentrated in select spaces, while basic technological needs remained unmet in others. This has created what the researchers term a "technological divide" within institutions.

Following the voice of participant 5, it is safe to say that institutions lack or inadequately provide support systems for technological infrastructure.

> *"The author's institution provides the hardware but lacks the support structure. We have smart boards in every classroom, but when something goes wrong, we might wait days for technical support. What we really need is ongoing training and immediate technical assistance. It's not just about having the technology; it's about having the support system to use it effectively."*

These infrastructure challenges echo Starkey (2019) and Park et al. (2023), who, in their research, mentioned the importance of institutional readiness for technology integration. Starkey's (2019) study further stressed the importance of robust technical support systems in educational settings. The gap between technology provision and support infrastructure suggests the need for more comprehensive institutional planning, considering hardware requirements and ongoing support needs.

4.3 Theme 3: Professional Development, Support Needs and Student Learning

Considering that participants kept mentioning the need for comprehensive training and ongoing support for technology integration, professional development and support needs emerged as themes. In their responses, participant 5 revealed: *"Lack of training... teachers may not have the training or professional development to use technology effectively. Poor infrastructure, resistance to change and lack of motivation."* Participants showed concern about the impact of inadequate professional development and their need for support on learners; thus, participant 1 voiced:

> *"It has, in some ways, made my students' work more difficult. The ease of using Google wrecks their research skills, and it takes multiple years to break them off. Somewhat ironically, the scholarly sources are all now available in databases, and thus they should be equally as easy to search as Google is, but students have trouble making that leap."*

This observation correlates with Uerz et al.'s (2018) study on the challenges of developing critical research skills in technology-rich environments. Park et al. (2023) further emphasised the need for structured guidance in developing digital literacy skills. His findings support the importance of scaffolding students' transition from general internet searches to academic database utilisation. The participants' insights reveal a critical tautness between the user-friendliness of information and the development of robust research skills, suggesting the need for more structured approaches to teaching digital literacy and academic research methods. What can teachers do when they are not professionally developed in this area, considering that they are not digital natives?

4.4 Theme 4: Pedagogical Adaptation, Innovation and Professional Identity
This study shows a paradigm shift in pedagogical approaches, with teachers navigating technology in their teaching practices. This is traceable in how they accommodate technological tools while maintaining effectiveness. Participant 3 avowed:

> *"I've had to completely rethink my teaching approach. It's not just about using technology as a tool, but about redesigning learning experiences. Sometimes, I find myself creating hybrid approaches – combining traditional hands-on activities with digital elements. For example, during the author's nature study unit, students use tablets to document and research plants in school garden, then create physical artwork based on their digital observations."*

Zhang and Liu (2019) endorsed transformative pedagogy in hybrid learning environments for early childhood education. Additionally, as cited by Kim and Lee (2018), Mishra and Koehler's updated TPACK framework emphasises the importance of such integrated approaches to technology-enhanced teaching. The emergence of these pedagogical practices reflects an understanding of the role of technology in education, suggesting that successful integration requires technical competency and pedagogical innovation. When teachers adapt their pedagogical practices, it leads to professional identity, a situation in which they perceive themselves as more knowledgeable and equipped to perform their tasks. Participant 1 narrated:

> *"Initially, I saw myself as a traditional early childhood educator. Now, I'm learning to be both a tech facilitator and a teacher. It's challenging but exciting. Some days I feel like I'm pioneering new ways of teaching, other days I worry about losing the essential human connection that's so crucial in early childhood education."*

This professional identity transformation aligns with the research of Gertsog et al. (2017) on teacher identity in digital-age classrooms. Lee et al.'s (2022) work further supports the notion of evolving professional identities in technology-enhanced educational settings. The evolution of professional identity among early childhood educators reflects the broader transformation of education in the digital age, suggesting the need for professional development that addresses both technical skills and identity-related challenges in the digital age.

5. Recommendations

The research findings highlight critical areas requiring attention to enhance technological integration in early childhood teacher preparation programmes. The recommendations stem from an analysis of participant experiences and observed patterns, offering practical solutions to address the identified challenges.

Institutions must prioritise developing robust infrastructure and equitable resource distribution. The findings revealed disparities in technology access across learning spaces, creating "technology deserts" within institutions. To address this, the study recommends that university management implement a resource management system to ensure equal access to technological tools across all learning environments. This system should include regular maintenance schedules and dedicated technical support. One participant noted, "Having the technology isn't enough; we need reliable support systems to use it effectively." Establishing technology resource centres for early childhood education would provide spaces for pre-service teachers to experiment with educational technologies.

Professional development has emerged as a crucial area that requires enhancement. The research indicates that current training programmes often fail to meet pre-service teachers' practical needs. This study therefore recommends that the government, school managers, and education stakeholders develop comprehensive, ongoing professional development programmes beyond basic technology skills. These should emphasise age-appropriate technology integration strategies and provide hands-on experience with educational technology tools. Regular workshops on emerging technologies should complement mentoring programmes that pair experienced technology-using teachers with pre-service teachers.

The alignment of the curriculum with practical needs requires attention. The findings suggest a gap between theoretical knowledge and practical application in teacher training programmes. The study recommends that the Ministry of Education revise the curricula to better integrate technology across all aspects of training. This revision should incorporate more hands-on technology experiences throughout the programmes. Specific modules on developmentally appropriate technology integration should be developed, with assessment methods for evaluating technical competency and pedagogical application. One participant emphasised, *"We need to move beyond teaching about technology to teaching with technology."*

Institutional support systems play a vital role in the successful integration of technology. The research indicates that clear policies and support networks are essential for pre-service teachers, particularly during practicum experiences. This study recommends that university management and policymakers establish comprehensive support frameworks with guidelines for technology integration in early childhood settings, feedback mechanisms, and partnerships with technology providers for sustainable resource access.

Additionally, the study recommends developing partnerships between teacher preparation institutions and early childhood centres to provide authentic experiences in technology-rich environments for pre-service teachers. These partnerships should facilitate exposure to real-world technology applications, allowing pre-service teachers to observe and practice effective integration strategies. One participant reflected, *"Seeing technology successfully integrated into actual classroom settings makes a significant difference in understanding its potential."* This study emphasises the need to create sustainable evaluation mechanisms to assess and improve technology integration. Regular assessments of pre-service teachers' needs and programme effectiveness should inform ongoing adjustments to support the systems and resource allocation. This ensures that technology integration strategies remain relevant and effective in preparing future early childhood educators for their evolving profession. However, this study has some limitations, as outlined below.

5.1 Limitations of the Study
1. Small sample size: Only five participants were included, limiting generalisability. A larger and more diverse sample would provide more robust insights.
2. Limited geographical scope: The study focused on pre-service teachers from a specific Nigerian region. Expanding to other regions or countries may reveal different perspectives.
3. Self-reported data: Relied on interviews and self-reported experiences, possibly biased or limited by participants' recall and articulation.
4. Lack of longitudinal data: Captured views at a single point in time. A longitudinal approach could show how perceptions change during teacher training programmes.
5. Focus on pre-service teachers only: Excluded perspectives from teacher educators, mentor teachers, or other stakeholders in technology integration efforts.

5.2 Directions for Future Research
1. Conduct large-scale studies with diverse samples across multiple regions and countries.
2. Implement mixed methods by combining qualitative insights with quantitative data on technology use and competencies.
3. Design longitudinal studies to track pre-service teachers' experiences and perceptions throughout their preparation and early teaching careers.
4. Investigate the perspectives of other stakeholders (e.g. teacher educators and mentor teachers) for a comprehensive view of technology integration.
5. The impact of specific technology integration interventions or training on pre-service teachers' competencies and attitudes was explored.

6. Conclusion
This study provides valuable insights into the experiences and perceptions of pre-service early childhood teachers regarding technology integration in their teacher preparation programmes. The findings reveal a complex landscape characterised

by opportunities and challenges in preparing future educators to leverage technology effectively in early childhood settings.

Several key themes emerged from the analysis, including the duality of technology integration, resource disparities and institutional support issues, professional development needs, and the evolution of pedagogical approaches and professional identities. Pre-service teachers demonstrated ambivalence toward technology, recognising its potential, while grappling with implementation challenges. Significant gaps between theoretical training and practical application were identified, highlighting the need for more authentic and context-specific learning experiences.

This study underscores the critical importance of robust institutional support systems, equitable resource allocation, and ongoing professional development opportunities in fostering successful technology integration. Partnerships between teacher preparation programmes and early childhood centres have emerged as a promising avenue for providing pre-service teachers with authentic technology integration experiences. These findings have important implications for designing and implementing early childhood teacher preparation programmes. Recommendations include revising curricula to better align theory and practice, enhancing infrastructure and support systems, and developing comprehensive, ongoing professional development initiatives focused on developmentally appropriate technology integration.

Future research should focus on developing and evaluating specific interventions based on these findings to enhance the effectiveness of technology-enhanced teacher training in early childhood education settings. By addressing the challenges and leveraging the opportunities identified in this study, teacher preparation programmes can better equip future early childhood educators with the knowledge, skills, and confidence needed to effectively integrate technology in support of young children's learning and development.

6.1 Declaration of AI in Scientific Writing
The authors acknowledge the use of Monica AI, an artificial intelligence language model, as a language enhancement tool in preparing this work. While Monica AI assisted with language refinement, clarity, and structural organisation, all ideas, research findings, analyses, and intellectual content presented in this study are the authors' original work.

6.2 Funding Details
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6.3 Ethical Approval
Approval to conduct the research was granted by the Faculty of Specialised Education at Alvan Ikoku Federal University of Education (FSE-EC 2024/54).

6.4 Disclosure Statement

The authors declare that there are no competing interests that could influence the research or its outcomes. Neither of us has any financial, professional, or personal relationships that could have inappropriately impacted or biased our work.

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