

Knowledge, Utilization and Perception of Emergent Digital Technologies In Pedagogy by Pre-Service Science Teachers in Nigeria

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ABSTRACT The COVID-19 pandemic, globalization and development in ICTs have institutionalized the use of digital technologies in education, bringing innovations into teaching and learning and giving teachers new roles in pedagogy. Therefore, today's classroom requires a new set of teachers with digital knowledge, competence, and mindset to support the teaching process thereby, making the classroom more engaging, compelling, and interesting. Consequently, this study examined knowledge, utilisation, and perception of emergent digital technologies in pedagogy by pre-service science teachers in Akwa Ibom State. A descriptive survey design was adopted, and 300 pre-service science teachers were randomly sampled for the study. "Knowledge, Utilization and Perception of Emergent Digital Technologies in Pedagogy Questionnaire was used for data collection. The validated instrument had a reliability coefficient of 0.88. Mean and standard deviation answered the research questions, while independent t-test was used to test the hypotheses formulated at a 0.05 significance level. The findings of the study showed a moderate extent of pre-service science teachers' knowledge, a high extent of pre-service science teachers' utilization, and a high extent of pre-service science teachers' perception of emerging digital technologies in pedagogy. There also exists a significant difference in male and female pre-service science teachers' knowledge and utilization of emerging digital technologies in pedagogy. No significant difference in the perception of male and female pre-service teachers on emerging digital technologies in pedagogy was found. Based on the findings, it was recommended among others that pedagogical practices should be made to embrace the use of digital technologies so that teacher trainees have the appropriate knowledge and skills to meet with increasing needs of students.

KEYWORDS: Emergent Digital Technologies, Pedagogy, Perception, Pre-Service Science Teachers

I. INTRODUCTION

The Education in the 21st century has changed likewise the pattern of teaching and learning, which bloomed in 2020. The outbreak of coronavirus disease (COVID-19) led to the unexpected closure of schools worldwide, forcing teachers and students to work from home. Nigeria like every other country was hit by the pandemic and closure of schools. A report by Education in Emergency Working Group (2020), showed that 25% of Nigeria's total population about 4 million students were affected by the schools' closure. To ensure that learning was not halted, the transition to online learning was the only option during the period for teachers and students. The crisis ushered in increasing access to new emerging technologies for teaching and learning. In cognizance of the sharp changes in education delivery, methodology, and the curriculum teachers should be exposed and opened to innovations. Since no education system may rise above the quality of its teachers, in the provision of quality education in our nation, the Federal Government of Nigeria (2021) advocated that teacher education programmes be structured to equip teachers for the effective performance of their duties, as well as incorporation of information technology training into the teacher training programme. The 21st century classroom therefore requires a new set of teachers with ICT knowledge, competence, and mindset to support teaching and learning. In tandem with the above, the successful adoption and usage of emergent digital devices in education is fundamental to the shift in pedagogy. Knowledge refers to one familiarity, understanding or awareness of a particular subject, topic, or concept. It implies the possession of information, skills or expertise related to a particular area of knowledge, in this context, it refers

to understanding and expertise in the latest and cutting-edge digital advancements. Being familiar with new and evolving digital tools, platforms and methods that are emerging in digital technology. On the other hand, utilization refers to the act of using something effectively, having the ability and how to effectively apply digital tools in practical scenarios for various purposes such as communication, automation, problem-solving

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and many more. Perception of emergent technologies refers to the attitude, and beliefs, that teachers and students have about new or developing technologies. These include their views on the integration of technologies into teaching and learning, their impact on teaching and learning, as well as the opportunities and challenges technologies bring into teaching and learning.

Preservice teachers are individuals or students enrolled in colleges of education, National Teachers Institute and University Faculty of Education, who are in the process of completing their education and training to become certified teachers. These are teachers who will graduate to train pupils and students who from birth are digital natives, who speak the language of digitization, computers, video games, high-speed internet, smartphones, and online-based platforms (Orji & Torunarigha, 2019). Teachers are key players in technology initiatives in the classroom, therefore they need to know of and be at ease with using new technologies that are rapidly emerging and have the understanding to effectively integrate digital technology into pedagogy. Given the above, teachers' knowledge, and proficiency in the use of technology are of great necessity as they are required for successful research, collaboration, publications, and online curriculum delivery (Emelogu, Nwafor, Chighu, Okoyeukwu & Eze (2022). Since today's classroom depends greatly on digital technologies and the teachers, it is pertinent that teacher training in the 21st century should be addressed based on the competency and usability of digital technologies (Akpan, et al., 2024). This study focused on the theory of technological pedagogical content knowledge framework established by Lee Shulman (1986) and Mishra and Koehler (2006). The theory describes the types of knowledge that a teacher needs to be successful in a technology-enhanced learning environment. Mishra and Koehler extended Lee Shulman's pedagogical content knowledge construct by including technology as a modelling element, thereby addressing subject knowledge, pedagogical knowledge and technological knowledge offers a foundation for integrating technology into teaching and learning (Emelogu, et al, 2022). The emergent digital technologies considered in this study are Web 2.0, Web4.0, industry 4.0, AI – ChatGPT, google search engine, YouTube, and Zoom technology.

In the era when delivery of instruction was done with talk and chalk, face-to-face, physical contact in traditional mode is becoming obsolete the world over. Several research have observed this method of teaching is becoming more ineffective in meeting the educational demands of the learners in this technology-driven generation. ICTs and emergent technologies have permeated every facet of human endeavours with no exceptions to pedagogy (instructional delivery). Despite the numerous digital technologies abounding, it has been observed sadly that teaching and learning in schools still rely very much on the obsolete method of delivering instructions to learners. The effectiveness of digital learning platforms is not debatable, as digital platforms have made students learn effectively. Research has proven that students are ready to embrace technology-driven sustainable learning and development, however, they need guidance from their teachers to enhance their digital skills, as well as increase their employability. The quality of teachers' technology experience is important to enhance the digital skills of students and future employment. Teachers' knowledge and competency in the use of emerging technologies is of great necessity as there cannot be any successful research, collaboration, or online curriculum delivery without adequate content and pedagogical knowledge of utilizing emergent technologies in teaching and learning. To become a professional teacher, one is required to have the competence and ability to transfer knowledge efficiently and effectively by integrating new technologies into teaching and learning. It is because of the above that this research; knowledge, utilization, and perception of emergent digital technologies in pedagogy by preservice science teachers in Nigeria was carried out. Specifically, the study sought to.

- a) Examine pre-service science teachers' knowledge of emerging digital technologies in pedagogy.
- b) Assess pre-service teachers' utilization of emerging digital technologies in pedagogy.
- c) Investigate pre-service teachers' perception of emerging digital technologies in pedagogy.

II. RELATED WORKS

A. EMERGENT DIGITAL TECHNOLOGIES

The teaching environment has changed from ‘talk and chalk’ in the classroom to a digital technology approach, where all topics can be assessed through technological tools. According to Akpan et al (2022), digital technology is changing the narratives in the teaching and learning process and the integration of these technological devices adds value to traditional methods. Digital technologies help in imparting and sharing knowledge through various electronic devices like smartphones, and applications connected to the internet to enhance communication between the teachers and the students. Emerging digital technologies are new digital tools that have emanated from previously existing technology and human achievements (Oliveira, et al. 2019).

They include social media, online games/applications, multimedia, cloud computing, interoperable systems, and mobile devices (Olaitan, 2020), as well as platforms such as Microsoft Teams, Google Hangout, Google Classroom, skype.com, GoTo.meeting.com, Easyclas.com, YouTube, zoom, WhatsApp and many more (Kennedy, et al, 2022). Included are Vimeo, movable wiki, WebEx, blog, Facebook, Instagram, email, and Twitter (Emelogu & Chigbu, 2021). Included are backend technologies such as computational thinking, simulations, dynamic visualizations, virtual labs, and computational technology-mediated play (Oliveira et al, 2019).

In teaching and learning, these emerging technologies allow communication and virtual interactions at all levels. They often supplement classroom instructions by creating an enabling environment for teachers to use multimedia tools in active learners’ engagements and help facilitate the creation, uploading and exchange or sharing of content files (Emelogu, et al, 2022). Emerging technologies have provided various means through which teachers and learners receive, analyse, and use information, which has brought a paradigm shift in the way teachers teach and learners learn. Making education easily accessible, anywhere, anytime and collaborative. Despite the numerous benefits of digital technologies, there are challenges which include poor access to digital tools and the digital divide between males and females. Olowokere (2022) found that as of 2018, only 21.3% had access to computers in schools. Acquiring digital tools like laptops, smartphones, accessories and even data is expensive. Power generation is abysmally low and erratic (Adeoye, et al, 2020). Other challenges are that teachers lack the skills and competencies needed to use ICTs in their practices, therefore students are not motivated and encouraged (Akpan, et al, 2023) and personal factors such as motivation, boredom, and sheer laziness. Olowokere (2022) reported that some students and teachers did not accept technological innovations of online learning and preferred the conventional method of physical classroom learning, showing the groups’ slow acceptance of technological innovations.

B. EMERGENT TECHNOLOGY IN PEDAGOGY

Pedagogy is the method and practice of teaching, it encompasses the strategies, techniques and approaches used by the teacher to facilitate learning and promote the development of knowledge, skills and understanding in students. It involves the design, and implementation of instructional activities and the assessment of learning outcomes. It is the act or method of teaching with confidence using techniques, strategies, and technologies. Technologies have transformed teaching and learning by providing new ways to deliver content, engage students and support learning. Integrating digital technologies into pedagogy enhances interactive learning amongst students, gives immediate feedback, encourages personalized learning collaboration and communication, as well as access to information, resources, and remote learning (Samuel, et al, 2020). Basargekar & Singhavi (2017) emphasized that the application of ICTs in pedagogy involves the use of computers and other digital technologies as learning aids and complementary roles in the classroom, and if effectively deployed can provide better access to educational resources, improve the quality of learning and teachers’ productivity. The central role of digital technologies in pedagogy has made its adoption imperative for teachers. However, Etiubon & Akpan (2017) opined that despite the benefits derived from the use of ICTs in teaching and learning, their usage especially by schools is still low as teachers and school authorities are yet to embrace and utilize them for instructional purposes. According to Fakeye (2010), ICT development and utilization are low and not well-established in Nigerian schools, especially secondary schools due to teachers’ poor pedagogical knowledge of the use of ICTs.

Expanding the discussion further, Basargekar & Singhavi (2017) opined that inadequate digital resources, low teacher confidence, lack of motivation, lack of competence and teachers' attitudes towards the utilization of modern technologies for effective teaching and learning are major barriers experienced by schoolteachers in facilitating successful integration of ICT for teaching purpose. Pre-service teachers go on practicum in secondary school where they are supervised by experienced teachers, Obielodan et al (2020) noted that secondary school teachers had low pedagogical knowledge of using ICT tools for teaching, in that case, how then can technology knowledge be imparted to the student teachers. Amuchie (2015) established that most teachers were not utilizing ICT tools because they were not available, on the other hand, Obielodan (2020) noted that ICT tools are available, but not adequately utilized in schools by teachers due to low pedagogical knowledge of ICT tools for teaching.

Knowledge and Utilization of Emergent Digital Technologies in Pedagogy

Adebayo (2015) study on awareness and utilization of ICT tools by mathematics lecturers, and students found that 80% of the lecturers knew ICT tools but did not use them due to inadequate skills in how to use the tools. Samuel, et al. (2020) findings on the perception of Nigerian Open and Distance Learning students on the use of instructional technologies for pedagogic experience, revealed that students displayed a good level of interest in experiential learning using the available instructional technologies due to a high perception of the usefulness of instructional technologies for learning. It was also found that instructional technologies were not sufficiently available and accessible to the students for the acquisition of pedagogic experiences.

Web 2.0 technology is an interactive web-based technology that allows users to make and create information themselves (Mamman, 2019). Okuonghae, et al (2019) revealed that undergraduates' knowledge and utilization of web 2.0 technologies for collaborative learning in universities is high, while Itighise et al (2023) found no significant difference in the perception of male and female science teacher trainees on their awareness and utilization of web 2.0 technology. Industry or Education 4.0 is a technology-based teaching and learning inspired by the fourth industrial evolution. The aim of Industry 4.0 is to improve digital competencies across all levels, as well as to enhance the use of digital technologies for teaching and learning (Legg-Jack, 2021). Halili and Sulaiman (2021) worked on students' perceptions of integrating education 4.0 into science programmes and found that students had positive perceptions and were ready to embrace industry 4.0 use in their science programmes.

Artificial Intelligence (AI) is a field of computer science that refers to the theory and development of computer systems capable of performing tasks that mimic human cognitive processes. One of the most prominent examples of AI is ChatGPT as it has become one of the fastest-growing consumer applications in history with an estimated one hundred million monthly users (Akpan, et al, 2024). Woonhee-Sung, et al (2023) exploring college students' awareness of AI and ChatGPT observed that students had good knowledge of ChatGPT, there was a significant difference by gender in the knowledge of AI-ChatGPT and that lecturers were not utilizing the capabilities of AI and ChatGPT to the fullest potentials.

According to Kangiwa et al, (2024) academic perception towards the use of Zoom technologies, found that students' perception of using Zoom technology was low compared to instructional videos because instructional videos provided a flexible learning environment, unlike Zoom which needed real-time participation during learning. In a similar study, Bashir and Muslim (2022) found that students' perception of Zoom technology was moderate and independent of students' gender. Teachers' perception of the use of YouTube for teaching learning activities in Nigerian Schools was high, as it enhances effectiveness in finding relevant information about concepts and increases their productivity in the classroom within the shortest time frame (Ogirima, et al., 2021). As observed by Olumorin, et al (2022), students' perception of the use of Google Search was moderate and there was no significant difference between male and female students' perceptions towards the utilization of Google Classroom.

C. PERCEPTION OF EMERGENT DIGITAL TECHNOLOGIES IN PEDAGOGY

Several studies have been conducted on teachers' perceptions of the use of digital technology for instructional delivery. Otemuyiwa & Attah (2021) reported that teachers have negative perceptions of the use of ICTs for instructional delivery and concluded that it was one of the factors confronting its adoption in Nigerian schools.

Sinbada, Mapenduka & Furusa (2016) observed that teachers perceived the use of laptops for lesson preparation and interactive boards for delivering lessons as very necessary and that teachers communicate through emails among others. Samuel et al (2020) findings revealed that students displayed a good level of interest in exponential learning using the available instructional technologies due to a high perception of the usefulness of instructional technologies for learning. It was also perceived that instructional technologies were not sufficiently available and accessible to the students for the acquisition of pedagogic experiences. Akpan & Itighise (2017) also noted that there was a low perception of knowledge and utilization of innovative technologies in instructional delivery by lecturers. Baltaci-Goktalay & Ozdilek (2010) reported that pre-service teachers have both positive attitudes and a high perception level of using Web 2.0 technologies in support of their course work. Itighise, et al. (2023) observed no significance in the perception of male and female science teacher trainees on their awareness and utilization of Web 2.0 technologies. Ogirima et al. (2021) in future teachers' perception towards the use of YouTube, found a high perception level. Okuonghae, et al. (2019) findings revealed that the level of undergraduates' perception towards the use of technology for collaborative learning in universities is high. Atabang and Babayemi (2024) found no significant difference in the perception of lecturers towards the integration of the Zoom platform into pedagogy.

D. GENDER AND EMERGENT DIGITAL TECHNOLOGIES IN PEDAGOGY

Gender refers to culturally and socially defined perceptions of male and female entities that differ from one society to another. It is culturally specific and not global, but it transcends into the educational performance of students and their use of digital technology. Akpan et al (2024), Itighise, et al, (2023), and Etiubon and Akpan, (2017) have shown that there is a great gender gap in computer proficiency and other technological devices with males being more proficient than females. On gender differences in teachers' knowledge, utilization, and perception of emergent digital technologies for pedagogy, Otemuyiwa & Attah (2021), and Akpan, et al (2023) studies in recent times reveal that there is no significant gender difference between teachers concerning the application of electronic technologies and skills in teaching and learning. Atabang and Babayemi (2024) found a significant difference in the integration of the Zoom platform into pedagogy for teaching by male and female lecturers. The gap in gender perception could be because of cultural barriers and stereotypes faced by women, this automatically causes a setback for women in knowledge and skills. According to the OECD (2019), cultural barriers and stereotypes are major factors preventing women from accessing, using, or affording digital tools.

III. MATERIALS AND METHODS

A. RESEARCH DESIGN

A descriptive survey design was used for the study to enable one to understand opinions on the subject matter. The population of the study comprised 3062 male and female pre-service teachers from government-owned universities offering Science Education courses in Akwa Ibom State (University of Uyo - 1739 and Akwa Ibom State University - 1323). A simple random sampling technique was used to select 150 students from each of the schools, thus a total of 300 (87 males and 213 females) pre-service science teachers were selected for the study. The instrument for the study was a 31 item-questionnaire on 'Knowledge, Utilization, and Perception of Emergent Digital Technologies in Pedagogy by Pre-Service Science Teachers Questionnaire (KUPEDTPPSTQ)' was used for data collection. The instrument was developed on a four-point Likert scale of Very High Extent (VHE), High Extent (HE), Moderate Extent (ME) and Low Extent (LE). The instrument underwent a series of validations by experts in Measurement and Evaluation, and Science Education to ascertain the face, content, and construct validation, this was to scrutinize the items with respect to relevance and clarity of questions. To ascertain the reliability of the questionnaire, the instrument was trial tested on 40 respondents who were not used in the study and a reliability coefficient of 0.88 was obtained using Cronbach Alpha coefficient.

Research Questions

- a) What is the extent of pre-service science teachers' knowledge of emerging digital technologies in pedagogy?

- b) What is the extent of pre-service teachers' utilization of emerging digital technologies in pedagogy?
- c) What is the extent of pre-service teachers' perception of emerging digital technologies in pedagogy?

Hypotheses

- a) No significant difference exists in pre-service science teachers' knowledge of emerging digital technologies in pedagogy by gender.
- b) There is no significant difference in the utilization of emerging digital technologies in pedagogy by male and female pre-service science teachers.
- c) There is no significant difference in the perception of male and female pre-service teachers on emerging digital technologies in pedagogy.

Hard copies of the instrument were distributed physically to respondents, while the soft or electronic copies, a Google form was developed, and the link was sent to the respondents during the Zoom class and WhatsApp class platforms. The responses obtained from both methods of distribution were analysed using mean, standard deviation, and independent t-test.

B. RESEARCH METHODOLOGY

Hard copies of the instrument were distributed physically to respondents who had no Android phones or computers and laptops, while the soft or electronic copy (a Google form) was developed, and the link was uploaded online and shared with the respondents during the Zoom session and on the students' WhatsApp platforms. There was a 100% response rate from the students. The responses obtained from both methods of questionnaire administration were analysed using mean, standard deviation, and independent t-test. To make decisions as regards research questions, whenever the cluster mean score falls between: 1.00-1.49, 1.50-2.49, 2.50-3.49 and 3.50-4.00, it was taken to indicate: Low Extent (LE), Moderate Extent (ME), High Extent (HE), Very High Extent (VHE). To test the hypotheses, whenever the probability value was less than the .05 level of significance, the null hypotheses were rejected and whenever the probability value was greater than the .05 level of significance, the null hypotheses were retained.

IV. RESULTS AND DISCUSSION

The results of the analysis carried out on data collected for the study are presented and discussed in this section. The presentation was done in line with the research questions and hypotheses guiding the study.

A. RESEARCH QUESTION ONE

What is the extent of pre-service science teachers' knowledge of emerging digital technologies in pedagogy?

Table 1: Mean and Standard Deviation of the Extent of Pre-Service Science Teachers' Knowledge of Emerging Digital Technologies in Pedagogy (n=300)

S/N	Knowledge of Emergent Digital Technology	\bar{x}	SD	Remarks
1	Web 2.0 technology	1.84	0.91	ME
2	Web 4.0 technology	1.72	0.77	ME
3	Industry 4.0 technology	1.69	0.82	ME
4	AI chat tools - chatgpt	2.70	1.04	HE
5	Google search engine	3.09	0.72	HE
6	YouTube.	3.00	0.66	HE

7	zoom technology	2.79	0.72	HE
	Cluster Mean	2.40	0.81	ME

The result in Table 1 shows the mean range for the response of the pre-service science teachers on the extent of their knowledge of emerging digital technologies in pedagogy for items 1,2 and 3, which falls within 1.50 -2.49. This means that there is a moderate extent of pre-service science teachers' knowledge of web 2.0 technology, web 4.0 technology and industry 4.0 technology as emerging digital technologies in pedagogy. The result also showed that the mean range for the responses of the pre-service science teachers for items 4,5,6 and 7 falls within 2.50 - 3.49 which means that there is a high extent of pre-service science teachers' knowledge of AI chat tools - ChatGPT, Google search engine, YouTube and zoom technology as emerging digital technologies in pedagogy. The result in Table 1 also showed the standard deviation scores of the respondents which ranged from 0.66 to 1.04 and since the standard deviation scores are small, it means that the spread of the scores is not far apart. However, the cluster mean of 2.40 for all the items indicates that there is a moderate extent of pre-service science teachers' knowledge of emerging digital technologies in pedagogy.

B. RESEARCH QUESTION TWO

What is the extent of pre-service teachers' utilization of emerging digital technologies in pedagogy?

Table 2: Mean and standard deviation of the extent of pre-service teachers' utilization of emerging digital technologies in pedagogy (n=300)

S/N	Utilization of Emerging Digital Technologies in Pedagogy	\bar{x}	SD	Remarks
1)	Web 2.0 technology	2.12	0.87	ME
2)	Web 4.0 technology	1.88	0.86	ME
3)	Industry 4.0 technology	1.95	0.85	ME
4)	AI chat tools - chatgpt	2.74	1.07	HE
5)	Google search engine	3.19	0.79	HE
6)	YouTube.	3.05	0.79	HE
7)	Zoom technology	3.13	0.68	HE
8)	Cluster Mean	2.58	0.84	ME

The result in Table 2 shows the mean range for the response of the pre-service science teachers on the extent of their utilization of emerging digital technologies in pedagogy for items 8,9 and 10, which falls within 1.50 -2.49. This means that there is a moderate extent of pre-service science teachers' utilization of web 2.0 technology, web 4.0 technology and industry 4.0 technology as emerging digital technologies in pedagogy. The result also showed that the mean range for the responses of the pre-service science teachers for items 11,12,13 and 14 falls within 2.50 - 3.49 which means that there is a high extent of pre-service science teachers' utilization of AI chat tools - chatbot, ChatGPT, Google search engine, YouTube and zoom technology as emerging digital technologies in pedagogy. The result in Table 2 also showed the standard deviation scores of the respondents which ranged from 0.68 to 1.07 and since the standard deviation scores are small, it means that the spread of the scores is not far apart. However,

the cluster mean of 2.58 for all the items indicates that there is a high extent of pre-service science teachers' utilization of emerging digital technologies in pedagogy.

C. RESEARCH QUESTION THREE

What is the extent of pre-service teachers' perception of emerging digital technologies in pedagogy?

Table 3: Mean and Standard Deviation of the Extent of Pre-Service Teachers' Perception of Emerging Digital Technologies in Pedagogy (n=300)

S/N	Perception of Emerging Digital Technologies in Pedagogy	\bar{x}	SD	Remarks
1)	I enjoy classes because teachers use digital devices in teaching	2.77	0.80	ME
2)	Digital technologies are valuable tools that can be used to improve the quality of education	2.99	0.89	ME
3)	It is frustrating using digital devices	2.18	0.90	ME
4)	Working with digital devices makes me nervous	2.30	0.88	HE
5)	It is exciting when learning with digital devices	3.06	0.85	HE
6)	I would perform better in my studies if I could use digital devices	3.08	0.80	HE
7)	Teaching/Learning with innovative digital resources encourages individualized learning	3.14	0.84	HE
8)	Innovative digital devices encourage interactions among students	3.27	0.77	HE
9)	I would perform better in my studies if teachers use digital devices in teaching	2.84	0.79	HE
10)	I have the competence to use emergent innovative digital devices in teaching/learning.	2.71	0.64	HE
11)	I am open to adopting new pedagogical methods using digital technologies	2.75	0.81	HE
12)	My teachers are open to adopting new digital technologies in pedagogy.	1.96	0.82	ME
13)	I find it easy to use innovative digital devices	2.79	0.76	HE
14)	Using technology makes it easier to prepare my lesson notes and do my class work and assignments.	3.37	0.74	HE
15)	Using technology supports collaborative and problem-based activities.	3.37	0.61	HE
16)	I do use innovative devices in learning	2.21	0.97	HE
17)	It is important that teachers use emergent digital devices in teaching and learning.	3.46	0.73	HE
Cluster Mean		2.84	0.80	HE

The result in Table 3 shows the mean range for the response of the pre-service science teachers on the extent of their perception of emerging digital technologies in pedagogy for items 15,16, 17 and 26 falls within 1.50 -2.49. This means that to a moderate extent, pre-service science teachers: enjoy classes because teachers use digital devices in teaching, digital technologies are valuable tools that can be used to improve the quality of education, it is frustrating using digital devices and their teachers are opened to adopting new digital technologies in pedagogy. The result also showed that the mean range for the responses of the pre-service science teachers' for items 18, 19, 20, 21, 22, 23, 24, 25, 27,28,29, 30 and 31 falls within 2.50 - 3.49 which means that to high extent, pre-service science teachers': working with digital devices makes me nervous, it is exciting when learning with digital devices, they would perform better in their studies if they could use digital devices, teaching/Learning with innovative

digital resources encourages individualized learning, innovative digital devices encourage interactions amongst students, they would perform better in their studies if teachers use digital devices in teaching, they have the competence to use emergent innovative digital devices in teaching/learning, they are opened to adopting new pedagogical methods using digital technologies, using technology makes it easier to prepare my lesson notes and do their class work and assignments, they find it easy using innovative digital devices, using technology support collaborative and problem-based activities, they do use innovative devices in learning and it is important that teachers use emergent digital devices in teaching and learning. The result in Table 3 also showed the standard deviation scores of the respondents which ranged from 0.64 to 0.97 and since the standard deviation scores are small, it means that the spread of the scores is not far apart. However, the cluster mean of 2.84 for all the items indicates that there is a high extent of pre-service science teachers' perception of emerging digital technologies in pedagogy.

A. Hypothesis One

There is no significant difference in male and female pre-service science teachers' knowledge of emerging digital technologies in pedagogy.

Table 4: Independent T-Test Analysis of the Difference in Male and Female Pre-Service Science Teachers' Knowledge of Emerging Digital Technologies in Pedagogy (n=300)

Gender	n	\bar{x}	SD	t-value	Sig.	Remarks
Male	87	2.54	0.57	2.74	0.01	Significant
Female	213	2.35	0.55			

The result in Table 4 showed the t-value of 2.74 and the corresponding probability level of significance of .01 alpha at 298 degrees of freedom. This level of significance is less than .05 on which the decision is based. With this result, the null hypothesis was rejected. This result implies that there is a significant difference in male and female preservice science teachers' knowledge of emerging digital technologies in pedagogy.

B. Hypothesis Two

There is no significant difference in the utilization of emerging digital technologies in pedagogy by male and female pre-service science teachers.

Table 5: Independent T-Test Analysis of the Difference in the Utilization of Emerging Digital Technologies in Pedagogy by Male and Female Pre-Service Science Teachers (n=300)

Gender	n	\bar{x}	SD	t-value	Sig.	Remarks
Male	87	2.74	0.66	2.98	0.00	Significant
Female	213	2.52	0.55			

The result in Table 5 showed the t-value of 2.98 and the corresponding probability level of significance of .00 alpha at 298 degrees of freedom. This level of significance is less than .05 on which the decision is based. With this result, the null hypothesis was rejected. This result implies that there is a significant difference in the utilization of emerging digital technologies in pedagogy by male and female pre-service science teachers.

C. Hypothesis Three

There is no significant difference in the perception of male and female pre-service teachers on emerging digital technologies in pedagogy.

Table 6: Independent T-Test Analysis of the Difference in the Perception of Male and Female Pre-Service Teachers on Emerging Digital Technologies in Pedagogy (n =300)

Gender	n	\bar{x}	SD	t-value	Sig.	Remarks
Male	87	3.07	0.35	1.65	0.10	Not significant
Female	213	3.00	0.33			

The result in Table 6 showed the t-value of 1.65 and the corresponding probability level of significance of 10 alpha at 298 degrees of freedom. This level of significance is greater than .05 on which the decision is based. With this result, the null hypothesis was retained. This result implies that there is no significant difference in the perception of male and female pre-service teachers on emerging digital technologies in pedagogy.

D. DISCUSSION OF FINDINGS

The findings of the extent of pre-service science teachers' knowledge of emerging digital technologies in pedagogy revealed that there is a moderate extent of pre-service science teachers' knowledge of emerging digital technologies in pedagogy. The result of the hypothesis revealed that there is a significant difference in male and female preservice science teachers' knowledge of emerging digital technologies in pedagogy. The finding is contrary to the observation of Obielodan et al (2020) who noted that secondary school teachers had low pedagogical knowledge of using ICT tools for teaching, in that case, how then can technology knowledge be imparted to the students? The finding lends credence to that of Woonhee-Sung, et al (2023) who observed that students had good knowledge of chatGPT and there was a significant difference by gender in the knowledge of AI-ChatGPT. The findings of the extent of pre-service science teachers' utilization of emerging digital technologies in pedagogy revealed that there is a high extent of pre-service science teachers' utilization of emerging digital technologies in pedagogy. The result of the hypothesis revealed that there is a significant difference in the utilization of emerging digital technologies in pedagogy by male and female pre-service science teachers. The finding is contrary to the observation of Etiubon & Akpan (2017) who reported that despite the benefits derived from the use of ICTs in teaching and learning, their usage especially by schools is still low as teachers and school authorities has yet to embrace and utilize them for instructional purpose. The finding aligns with that of Okuonghae, Ijeh, and Olorunyomi (2019) whose findings revealed the level of undergraduates' awareness and utilization of Web 2.0. Technologies for collaborative learning in universities are high and they have positive perceptions towards the use of the technology. The finding also aligns with that of Etiubon and Akpan, (2017) who found that there is a great gender gap in computer proficiency and other technological devices with the males being more proficient than females. The findings of the extent of pre-service science teachers' perception of emerging digital technologies in pedagogy revealed that there is a high extent of pre-service science teachers' perception of emerging digital technologies in pedagogy. The result of the hypothesis revealed that there is no significant difference in the perception of male and female pre-service teachers on emerging digital technologies in pedagogy. The finding is contrary to the observation of Baltaci-Goktalay & Ozdilek (2010) who reported that pre-service teachers have both positive attitudes and a high perception level of using Web 2. Technologies in support of their course work. The finding is also contrary to the observation of Otemuyiwa & Attah (2021) who reported that teachers have negative perceptions of the use of ICTs for instructional delivery and concluded that it was one of the factors confronting its adoption in Nigerian schools. The finding lends credence to that of Itighise, Akpan & Babayemi, (2023) who observed no significance in the perception of male and female science teacher trainees on their awareness and utilization of Web 2.0 technologies.

V. Conclusion and Recommendation

Over a century ago, John Dewey criticized the academics of his days on education's need to adopt new instructional approaches based on future societal needs and today's societal need is digital technologies. It took the unpleasant Covid-19 and lockdown to help unleash education potential and discover new, better, and more convenient ways of teaching and learning. From the findings of this study, It was therefore concluded that there is a moderate extent of knowledge, a high extent of utilization and a high extent of pre-service science teachers' perception of emerging digital technologies in pedagogy in Nigeria. It could be seen from the results that pre-service teachers are ready to embrace emergent digital technologies in pedagogy but face serious challenges in acquiring relevant skills because their teachers need more knowledge on the use of digital technologies for teaching and learning. Based on the findings and conclusion of the study, the following recommendations were made:

- a) Institutions should provide necessary digital facilities and should encourage the lecturers to work remotely, using digital resources.
- b) professional development programmes for lecturers (workshops, conferences,) should be encouraged and financially supported.
- c) the government should fund the tertiary institutions sufficiently, and non-governmental organizations and stakeholders should partner to provide interventions in emergent digital devices in the classrooms for teachers and students to use practically.
- d) The curriculum of teacher education programmes should be restructured to include digital literacy and skills.
- e) The teacher education curriculum should be restructured such that pedagogical practices embrace the use of digital technologies and provide opportunities for teachers to have appropriate knowledge and skills to meet the needs of their students.

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