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INFORMATION COMMUNICATION TECHNOLOGY COMPETENCIES FOR LEARNING: PRESERVICE SCIENCE TEACHERS' PERCEPTIONS AT NNAMDI AZIKIWE UNIVERSITY, AWKA

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ABSTRACT

Integrating Information and Communication Technology (ICT) into the learning process is becoming increasingly crucial due to its potential to personalize and enhance learning engagement and experiences. This study investigated preservice science teachers' (PST) perceptions of ICT competencies for learning at Nnamdi Azikiwe University, Awka. Three research questions and two hypotheses guided the study. A descriptive survey approach was used in the study with a population of 1,328 and a sample of 281 PSTs, respectively. The data for this study were collected electronically using an online-based ICT Competencies Questionnaire (Google form) adapted from de Guadalupe Arras-Vota and Muñoz-Repiso (2011). Using Cronbach's alpha reliability technique, the questionnaire demonstrated an overall high-reliability coefficient of 0.90, with subscale reliability coefficients of 0.74, 0.76, and 0.89 for basic, application, and ethical competencies, respectively. The study's questions were addressed using weighted average mean and standard deviation, and the hypotheses were tested at a 0.05 significant level using one-way ANOVA. The study's findings showed a mixed picture of ICT competencies perceptions among the investigated PSTs. Additionally, the findings revealed no gender disparities in PSTs' perceptions of ICT competencies for learning. However, significant differences emerged across academic levels, with third and fourth-year PSTs exhibiting significantly higher perceptions of basic and application ICT competencies than first-year PSTs. Based on the findings, it was recommended that the Faculty of Education at Nnamdi Azikiwe University, Awka, should integrate structured ethical ICT training into the curriculum.

Keywords: *Information Communication Technology (ICT), Preservice Science Teachers (PSTS), Basic ICT Competency, Application ICT Competency, Ethical ICT Competency*

INTRODUCTION

Teaching is a complex and multifaceted process that facilitates students' learning, knowledge acquisition, and skill development. As Hattie (2021) defines it, teaching is "the act of making learning visible" (p.18). This perspective emphasizes the teacher's role in conveying information, ensuring students' active engagement with and internalizing new concepts. In describing effective teaching, Darling-Hammond (2017) posited that it creates "the conditions under which students can learn powerfully" (p.3). This view of teaching encompasses the importance of the classroom environment, instructional strategies, and student motivation in the teaching process. According to Ogieva and Izuhiuwa (2024), the teaching profession is responsible for cultivating talent across all fields, with the axiom that no nation can surpass the quality of its educators. This means that those engaged in teaching

should possess a robust repertoire of knowledge and skills acquired through rigorous and comprehensive training (Darling-Hammond, 2012). This training is essential to meet the ever-evolving expectations and demands of various stakeholders in the educational ecosystem. Teachers still undergoing this training in teachers' training institutions are called preservice teachers.

Zeichner and Conklin (2008, p.270) defined preservice teachers as "individuals who are in the process of acquiring the knowledge, skills, and dispositions required for effective teaching practice, typically through a combination of coursework and fieldwork experiences". Specifically, the teachers in training in science coursework and fieldwork experiences to become science teachers are termed "preservice science teachers (PSTs)". Nwune et al. (2023, p.1009) defined PSTs as "those undergoing training in any of the science fields to become professional instructors in the specific scientific field of their choice". These future teachers usually enrol in science education programs at universities or colleges to acquire the knowledge, abilities, and attitudes needed for successful science instruction. There, they are exposed to a carefully chosen combination of theoretical information and real-world experiences contained in the curriculum.

According to Wells et al. (2019), the curriculum for PSTs often includes a strong foundation in the content knowledge of various scientific disciplines, such as Biology, Chemistry, Physics, and Earth Science. Additionally, these programs provide instruction in effective teaching strategies, classroom management techniques, assessment methods, and technology integration into the science classroom.

An important aspect of preparing PSTs is ensuring they develop the necessary competencies in utilizing Information and Communication Technology (ICT) for teaching and learning. This development builds upon the foundational knowledge and skills that PSTs acquire in their teacher education programs. The United Nations Educational, Scientific and Cultural Organization (UNESCO, 2011) defines ICT as a "diverse set of technological tools and resources used to communicate, and to create, disseminate, store, and manage information" (p. 1). In the educational sphere, ICT encompasses numerous digital technologies used to support teaching and learning processes. ICT integration is essential for PSTs to improve learning engagement, pedagogical methods, and student readiness for a technologically advanced world. According to Ala-Mutka (2011), ICT competency is the ability to utilize ICT critically and confidently for communication, work, and leisure. It encompasses a range of skills, knowledge, and attitudes that enable effective integration of digital tools and resources into the science classroom.

According to UNESCO's (2008) framework, ICT competencies can be categorized into three main areas. First, basic competencies that involve basic classroom ICT use, including utilizing digital tools for presentations, accessing information, and using online resources. Second, application competencies encompass more advanced skills like managing complex projects, solving real-world problems, collaborating, and leveraging information and expert networks. Finally, ethical competencies focus on the responsible, legal, and ethical use of ICTs. These categories are crucial for effective technology integration in science education, with basic competencies providing foundational skills, application competencies enabling enhanced learning experiences, and ethical competencies ensuring responsible use. For PSTs, Oviawe (2018) noted that developing these competencies is essential to meet stakeholders' educational expectations. Mastering these ICT competencies equips future science educators to integrate technology effectively and enhance learning outcomes. Technology integration in science education has altered learning and teaching practices, challenged conventional teaching strategies, and spawned new teaching approaches. ICT has become a vital component of educational reform initiatives, perceived as an essential aspect of the curriculum because of the opportunities and possibilities it provides. (Alemu, 2015).

Research indicates that PSTs and even in-service teachers tend to use ICTs for purposes such as communication and basic research (Amosun et al., 2015; Baydas & Yilmaz, 2018; Chukwuemeka et al., 2019; Dogo et al., 2021; Etokeren & Abosede, 2021; Fagbohun et al., 2018; Mirzajani et al., 2015; Yeung et al., 2014), but less for improving their actual learning of specific subject content. While PSTs strive to develop essential ICT competencies, their usage patterns and proficiency levels often vary based on factors like gender and academic levels. Gender disparities in ICT competencies among PSTs

remain persistent, reflecting broader societal stereotypes and inequalities in technology fields. Male PSTs often demonstrate higher levels of ICT self-efficacy and more frequent technology use than their female counterparts (Tondeur et al., 2012), stemming from deeply ingrained societal norms and expectations that shape attitudes towards technology from an early age. As Vekiri (2013) posits, gender stereotypes about technology use and ability are enshrined earlier in girls, influencing their interest and confidence in using computers. These disparities can have far-reaching consequences, as teachers' ICT competencies significantly impact their future integration of technology in classrooms (Teo, 2009). The underrepresentation of women in technology-related fields perpetuates a cycle where female students lack visible role models, further discouraging their participation (UNESCO, 2017). Addressing this issue requires targeted interventions in teacher education programs to boost female PSTs' confidence and skills in ICT and broader efforts to challenge gender stereotypes in technology (Siddiq & Scherer, 2019). However, recent studies like Cabezas-González et al. (2021) have shown that the gap between male and female students' knowledge and utilization of technology is beginning to close.

Interestingly, academic levels play a significant role in shaping students' ICT competencies for learning, with higher levels of education generally correlating with greater exposure to and proficiency in technology. Studies by Zhao et al. (2021) and Eger et al. (2018) confirm that as students progress through their academics, their competency in ICT increases, particularly in areas like information literacy, problem-solving, and digital content creation. According to Zhao et al., fourth-year students viewed themselves as having more digital competency than first-year students, particularly in more complex areas like digital communication and data management. Similarly, Eger et al. (2018) observed that master's level students demonstrated significantly better ICT skills than their first-year counterparts, particularly in software use and problem-solving, which are often essential for conducting research and completing academic projects at advanced levels. This information aligns with the findings of Danner and Pessu (2013), who reported that students with more formal computer training—typically acquired through higher education—exhibited higher levels of ICT competency. As Tondeur et al. (2017) additionally suggest, the pedagogical strategies employed at higher educational levels often integrate ICT tools more extensively, facilitating not only the acquisition of technical skills but also their application in real-world scenarios. Koyuncuoğlu (2022) also supports this, noting that students at lower academic levels may demonstrate higher competencies in ethical and responsible digital behaviour, but students at more advanced levels show greater proficiency in professional digital production and functional ICT skills. Therefore, as PSTs progress through their studies, their ICT skills may improve, enabling them to better engage with digital learning environments and incorporate technology into their teaching practices.

Despite ICT education's incorporation into teacher training programs, a persistent gap remains between theoretical knowledge and practical application in classrooms. Research consistently shows that many teachers, including preservice educators, struggle to effectively integrate ICT into learning (Ertmer et al., 2012; Kay, 2006). This struggle can be attributed to their lack of competency in effectively utilizing ICTs for their learning and their inability to apply what is learned during their training programs. The situation is particularly concerning, given the critical role of ICT in modern education and its potential to enhance learning outcomes. As Liu (2012) points out, there is often a lack of mentorship in applying computer skills in learning. This disconnect underscores the urgent need for teacher education programs to close the gap between ICT theory and practice, ensuring that future educators are fully prepared to leverage technology in their classrooms to develop scientific literacy and to prepare their prospective students to meet the demands of the 21st-century knowledge society. Therefore, viewing the dearth of research on PSTs' perceptions of ICT competencies for learning at Nnamdi Azikiwe University, Awka, this study sought to bridge this gap by assessing;

1. PSTs' perceptions of basic ICT competencies for learning at Nnamdi Azikiwe University, Awka.
2. PSTs' perceptions of application ICT competencies for learning at Nnamdi Azikiwe University, Awka.
3. PSTs' perceptions of ethical ICT competencies for learning at Nnamdi Azikiwe University, Awka.
4. The gender differences in PSTs' perceptions of ICT competencies for learning at Nnamdi Azikiwe University, Awka.

5. The academic level differences in PSTs' perceptions of ICT competencies for learning at Nnamdi Azikiwe University, Awka.

METHODOLOGY

Design

The study utilised a descriptive survey research design. Creswell & Creswell (2018) posit that the descriptive survey research design examines a population sample to give a numerical or quantitative description of its trends, attitudes, or opinions. The design is appropriate for the current study as it aims to assess preservice science teachers' perceptions of Information and Communication Technology (ICT) competencies for learning at Nnamdi Azikiwe University, Awka.

Participants

The population of this study comprises 1328 preservice science teachers enrolled in the Science Education and Technical and Vocational Education departments in the Faculty of Education at Nnamdi Azikiwe University, Awka. The sample size for the study was 281 PSTs obtained using the multistage sampling procedure. The stages of selection are as follows: first, the simple random sampling technique was used in this study to select the Science Education department from the two departments in the Faculty of Education, training PSTs at Nnamdi Azikiwe University, Awka (Science Education and Technology and Vocational Education departments). Next, a stratified disproportionate sampling technique was employed to select PSTs across different academic levels (100, 200, 300, and 400 levels) within the Science Education department. The third stage involved using the accidental sampling technique to select the number of participants from each category. This selection was based on the accessibility of the respondents and the researchers' judgment, making up the 281 participants used in the present study.

Table 1. *Participants' Information*

Respondents (N=281)	Number of Participants	Percentage (%)
Gender		
▪ Male	129	45.9
▪ Female	152	54.1
Year of Study		
▪ 100 Level	62	22.1
▪ 200 Level	79	28.1
▪ 300 Level	83	29.5
▪ 400 Level	57	20.3

Measures

The instrument used to collect data for this study was an online-based ICT Competencies Questionnaire (Google Forms) adapted from the translated version of de Guadalupe Arras-Vota and Muñoz-Repiso (2011). It contained two sections – A and B. Section A assessed the sociodemographic information of the respondents. At the same time, Section B was designed to measure the basic, application, and ethical ICT competencies of preservice science teachers, which aligns with the specific research objectives outlined. The questionnaire consists of 14 items covering the three dimensions of ICT competency, and the 4-point Likert-scale response format (Strongly Disagree, Disagree, Agree, Strongly Agree) allows for quantitative assessment of the PSTs' self-reported competency levels. Cronbach Alpha reliability test conducted on the instrument yielded an overall reliability index of 0.90 and 0.74 for basic competency, 0.76 for application competency, and 0.89 for ethical competency subscales, indicating that the instrument is reliable.

Data Collection

Google Forms was used to collect data for this study electronically. The questionnaire was given to the respondents at Nnamdi Azikiwe University in Awka to complete, following the acquisition of the required approvals and informed consent from the relevant authorities and PSTs. The link to the questionnaire

was to the PSTs through their general class group WhatsApp platforms. The completed questionnaires were securely stored, and the data collection process was closely monitored to ensure a high response rate and complete data while maintaining the confidentiality and anonymity of the participants throughout the process by not collecting their email addresses as part of their responses.

Data Analysis

The collected data were analyzed using weighted average mean and standard deviation for research questions and One-way ANOVA for research hypotheses at a .05 significance level. Any item mean score equal to or greater than the weighted average mean represents PSTs' high perception of ICT competencies for learning, and an item mean score below the weighted average mean is taken to represent a low perception. For the hypothesis, the null hypotheses were rejected if the p-value was less than or equal to 0.05 ($p \leq 0.05$) and not rejected if the p-value was greater than 0.05 ($p \geq 0.05$).

FINDINGS

Research Question One: What are PSTs' perceptions of basic ICT competencies for learning at Nnamdi Azikiwe University, Awka?

Table 2. *PSTs' Perceptions of Basic ICT Competencies for Learning at Nnamdi Azikiwe University, Awka*

S/N	Items	N	Mean	Std. Deviation	Remark
1	I use the main computing and network resources for my learning.	281	3.12	.782	Low Perception
2	I utilize various online applications to support my learning.	281	3.24	.698	Low Perception
3	I apply digital tools to obtain information from diverse sources for my studies.	281	3.37	.643	High Perception
4	I employ models and simulations to explore complex topics in my field.	281	3.86	.891	High Perception
5	I interact and collaborate with my peers using a variety of digital resources.	281	3.19	.754	Low Perception
	Weighted Average		**3.36**	**0.754**	

Table 2 shows PSTs' perceptions of basic ICT competencies for learning at Nnamdi Azikiwe University, Awka. Based on the decision rule for answering the research questions posed in this study, items 1, 2, and 5, with mean scores of 3.12 (SD = 0.782), 3.24 (SD = 0.698), and 3.19 (SD = 0.754), indicate that majority of PSTs investigated, perceive their competencies in using main computing and network resources, various online applications, and collaborating with peers using digital resources for their learning to be low. The explanation is that their mean scores are lower than the weighted average of 3.36. On the other hand, Items 3 and 4, with mean scores of 3.37 (SD = 0.643) and 3.86 (SD = 0.891), indicate that a majority of the investigated PSTs perceive their competencies to apply digital tools to obtain information from diverse sources, and using models and simulations to explore complex topics to be high. This fact is because their mean scores are greater than the weighted average mean of 3.36. Also, the weighted average standard deviation of 0.754 suggests that the responses from the investigated PSTs were fairly homogeneous, with most respondents' scores clustered around the mean value. The small spread in responses indicates that the PSTs have similar perceptions of their basic ICT competencies.

Research Question Two: What are PSTs' perceptions of application ICT competencies for learning at Nnamdi Azikiwe University, Awka?

Table 3. *PSTs' Perceptions of Application ICT Competencies for Learning at Nnamdi Azikiwe University, Awka*

S/N	Items	N	Mean	Std. Deviation	Remark
1	I can communicate information and ideas effectively using various media and formats.	281	3.08	.769	High Perception
2	I actively participate in groups to develop projects or solve problems using appropriate digital tools and resources.	281	2.93	.842	Low Perception
3	I make decisions using appropriate digital tools and resources.	281	3.02	.798	High Perception
4	I plan and organize the necessary activities to solve a problem or complete a project.	281	2.97	.815	High Perception
5	I create original works as a means of personal expression using digital tools.	281	2.76	.923	Low Perception
	Weighted Average		**2.95**	**0.829**	

Table 3 shows PSTs' perceptions of application ICT competencies for learning at Nnamdi Azikiwe University, Awka. Based on the decision rule for answering the research questions posed in this study, items 1, 3, and 4 with mean scores of 3.08 (SD = 0.769), 3.02 (SD = 0.798), and 2.97 (SD = 0.815) indicate that the majority of PSTs perceive their competencies in communicating information effectively, making decisions using digital tools, and planning activities to solve problems as high. The reasoning is that mean scores are greater than the weighted average mean of 2.95. Conversely, Items 2 and 5, with mean scores of 2.93 (SD = 0.842) and 2.76 (SD = 0.923) indicate that PSTs perceive their competencies in participating in group projects and creating original works using digital tools to be low. This is evidenced by their mean scores being below the weighted average mean of 2.95. The weighted average standard deviation of 0.829 suggests that the responses were fairly consistent, with most PSTs sharing similar views on their application ICT competencies.

Research Question Three: What are PSTs' perceptions of ethical ICT competencies for learning at Nnamdi Azikiwe University, Awka?

Table *Error! No text of specified style in document.*. *PSTs' Perceptions of Ethical ICT Competencies for Learning at Nnamdi Azikiwe University, Awka*

S/N	Items	N	Mean	Std. Deviation	Remark
1	I select, analyze, and ethically use the information obtained through digital resources.	281	3.15	.731	Low Perception
2	I make rational, legal and responsible use of information using ICT.	281	3.28	.687	Low Perception
3	I value ICT as an instrument for continuous learning.	281	3.41	.624	High Perception
4	I appreciate ICT as a medium for collaboration and social communication in my academic pursuits.	281	3.33	.658	High Perception
	Weighted Average		**3.29**	**0.675**	

Table 4 shows PSTs' perceptions of ethical ICT competencies for learning at Nnamdi Azikiwe University, Awka. Based on the decision rule for answering the research questions posed in this study, items 1 and 2, with mean scores of 3.15 (SD = 0.731) and 3.28 (SD = 0.687), indicate that the majority of PSTs perceive their competencies in selecting and ethically using information and making responsible use of ICT as low. This is because their mean scores are lower than the weighted average mean of 3.29. In contrast, Items 3 and 4, with mean scores of 3.41 (SD = 0.624) and 3.33 (SD = 0.658), indicate that PSTs perceive their competencies in valuing ICT as a tool for continuous learning and appreciating ICT for collaboration in academic pursuits as high. This is due to their mean scores being above the weighted average mean of 3.29. The weighted average standard deviation of 0.675 suggests that the responses were relatively homogeneous, indicating that PSTs had similar perceptions regarding their ethical ICT competencies.

Hypothesis One: There are no significant gender differences in PSTs' perceptions of ICT competencies for learning at Nnamdi Azikiwe University, Awka

Table 6. *One-Way ANOVA Results for Gender Differences in PST's Perceptions of ICT Competencies for Learning at Nnamdi Azikiwe University, Awka*

Variables		Sum of Squares	df	Mean Square	F	Sig.
Basic Competency	Between Groups	0.018	1	0.018	0.054	.816
	Within Groups	92.148	279	0.330		
	Total	92.166	280			
Application Competency	Between Groups	0.542	1	0.542	1.376	.242
	Within Groups	109.773	279	0.393		
	Total	110.315	280			
Ethical Competency	Between Groups	0.334	1	0.334	1.183	.278
	Within Groups	78.630	279	0.282		
	Total	78.964	280			

Based on the one-way ANOVA results presented in Table 6, we fail to reject the null hypothesis for all three ICT competency areas. The analysis revealed no statistically significant differences between male and female PSTs' perceptions of their basic competency ($F(1, 279) = 0.054$, $p = 0.816$), application competency ($F(1, 279) = 1.376$, $p = 0.242$), or ethical competency ($F(1, 279) = 1.183$, $p = 0.278$). All p-values are substantially greater than the 0.05 significance level, indicating that any observed differences in perception between genders are likely due to chance rather than a true difference in the population.

Hypothesis Two: There are no significant academic level differences in PSTs' perceptions of ICT competencies for learning at Nnamdi Azikiwe University, Awka.

Table 1. *One-Way ANOVA Results for Academic Level Differences in PSTs' perceptions of ICT Competencies for Learning at Nnamdi Azikiwe University, Awka*

Variables		Sum of Squares	df	Mean Square	F	Sig.
Basic Competency	Between Groups	5.284	3	1.761	5.619	.001
	Within Groups	86.882	277	0.314		
	Total	92.166	280			

Application Competency	Between Groups	3.883	3	1.294	3.368	.019
	Within Groups	106.432	277	0.384		
	Total	110.315	280			
Ethical Competency	Between Groups	2.075	3	0.692	2.492	.060
	Within Groups	76.889	277	0.278		
	Total	78.964	280			

Based on the one-way ANOVA results presented in Table 7, we reject the null hypothesis for basic and application Competencies but fail to reject it for ethical competency. The analysis revealed statistically significant differences in perceptions among PSTs of different academic levels in their basic competency ($F (3, 277) = 5.619$, $p = 0.001$) and application competency ($F (3, 277) = 3.368$, $p = 0.019$). Both p-values are less than the 0.05 significance level, indicating that the observed differences in perceptions across academic levels may represent true differences in the population. However, for ethical competency, no statistically significant difference was found ($F (3, 277) = 2.492$, $p = 0.060$), as the p-value exceeds the 0.05 threshold for the study.

Post Hoc Test for Basic and Application Competency

A Post Hoc Test is carried out after a One-Way ANOVA when the result indicates a significant difference among the group means. The purpose of the Post Hoc Test is to determine exactly which groups differ from each other. Since the One-Way ANOVA for basic and application competency returned significant p-values ($p < 0.05$), a Tukey HSD Post Hoc Test was conducted to identify the specific differences among the academic levels.

Table 2. *Tukey HSD Post Hoc Test for Academic Level Differences in PSTs' Perceptions of Basic ICT Competency for Learning at Nnamdi Azikiwe University, Awka*

(I) Academic Level	(J) Academic Level	Mean Difference (I-J)	Std. Error	Sig.
100 Level	200 Level	-.17955	0.09534	0.237
	300 Level	-.33996*	0.09425	0.002
	400 Level	-.34576*	0.10279	0.005
200 Level	100 Level	.17955	0.09534	0.237
	300 Level	-.16041	0.08817	0.267
	400 Level	-.16621	0.09729	0.320
300 Level	100 Level	.33996*	0.09425	0.002
	200 Level	.16041	0.08817	0.267
	400 Level	-.00580	0.09623	1.000
400 Level	100 Level	.34576*	0.10279	0.005
	200 Level	.16621	0.09729	0.320
	300 Level	.00580	0.09623	1.000

*The mean difference is significant at the 0.05 level.

The Post Hoc result (Table 8) shows that the mean difference between 100 Level and 300 Level is -0.33996, with a p-value of 0.002. This indicates a significant difference in the perception of basic ICT competency between these two levels, with 300-level PSTs demonstrating a higher perception. Also, the mean difference between 100 Level and 400 Level is -0.34576, with a p-value of 0.005. This shows a significant difference in the perception of basic ICT competency between these academic levels, with 400-level PSTs showing higher perception than 100-level PSTs. However, no other pairs of academic levels showed significant differences in perception of basic ICT competency.

Table 3. *Tukey HSD Post Hoc Test for Academic Level Differences in PSTs' Perceptions of Application ICT Competency for Learning at Nnamdi Azikiwe University, Awka*

(I) Academic Level	(J) Academic Level	Mean Difference (I-J)	Std. Error	Sig.
100 Level	200 Level	-0.14804	0.10556	0.498
	300 Level	-0.30132*	0.10436	0.022
	400 Level	-0.26410	0.11384	0.096
200 Level	100 Level	0.14804	0.10556	0.498
	300 Level	-0.15328	0.09764	0.397
	400 Level	-0.11606	0.10774	0.704
300 Level	100 Level	0.30132*	0.10436	0.022
	200 Level	0.15328	0.09764	0.397
	400 Level	0.03722	0.10657	0.985
400 Level	100 Level	0.26410	0.11384	0.096
	200 Level	0.11606	0.10774	0.704
	300 Level	-0.03722	0.10657	0.985

*The mean difference is significant at the 0.05 level.

The Post Hoc result (Table 9) shows that the mean difference between 100 Level and 300 Level is -0.30132, with a p-value of 0.022. This indicates a significant difference in the perception of application ICT competency, with 300-level PSTs demonstrating higher perception than 100-level students. However, no other pairs of academic levels showed significant differences in the perception of application ICT competency.

DISCUSSION

The study investigated preservice science teachers' perception of ICT competencies for learning at Nnamdi Azikiwe University, Awka. For basic ICT competency, the findings revealed most PSTs perceived their competence in applying digital tools to obtain information from diverse sources and employing models and simulations to explore complex topics as high. The findings also revealed that most PSTs perceived their competency in utilizing main computing and network resources, various online applications, and collaborating with peers using digital resources as low. The high perception of competency in using models and simulations likely stems from the increasing availability and integration of such tools within the science curriculum. These interactive resources offer engaging ways to explore complex concepts, potentially leading to a more positive perception of their usability and effectiveness. Conversely, the lower perception of competency in utilizing computing and network resources, online applications, and collaborative tools could be attributed to several factors, such as limited access to reliable internet connectivity, insufficient training on specific software or platforms, and a lack of familiarity with collaborative online environments. Similarly, in the study by Amosun et al. (2015), preservice social studies teachers in Southwestern Nigeria exhibited poor ICT knowledge, with 95.7% scoring below average in their ICT knowledge test. Although the current study's participants fared better overall, the lower perception scores in areas such as interacting with peers and using network resources suggest that the gap in ICT knowledge might persist, particularly concerning interactive and collaborative applications of ICT. Chukwuemeka et al. (2019) also reported variations in technological knowledge among preservice teachers in South-west Nigeria, indicating that while these teachers were competent in basic ICT skills, their ability to integrate these effectively into teaching practice was limited. The findings from this study align with those results, as PSTs exhibited competency in some basic ICT tasks but fell short in areas requiring more advanced or interactive use of technology.

For application competency, PSTs reported high perceived competency in communicating information effectively using various media and formats, making decisions using digital tools, and planning activities to solve problems. However, they reported lower perceived competency in actively participating in group

projects and creating original works using digital tools. The higher perceived competency in communication and decision-making using digital tools suggests that PSTs are comfortable using ICT for individual tasks requiring information dissemination or problem-solving. This could be due to the frequent use of presentations and online research in their academic work. However, the lower scores in group project participation and original content creation point to a gap in collaborative and creative applications of ICT. This could be attributed to a lack of opportunities for collaborative projects using digital tools within the curriculum, insufficient training on collaborative software, or a lack of confidence in creating original digital content. These findings are comparable to those of Dogo et al. (2021), who found that while mathematics and science teachers in secondary schools in Bauchi State, Nigeria, had access to various ICT tools, only 44% had a fair knowledge of using these tools for lesson presentation. Like the PSTs in this study, these teachers struggled with applying ICT for more complex tasks, such as creating original digital content or engaging in collaborative projects. Eger et al. (2018) also found that master's level students demonstrated significantly higher ICT competencies in technical areas like problem-solving and software use than first-year students. This aligns with the current study's findings that PSTs had higher competencies in making decisions using digital tools but struggled with more creative applications of ICT, such as content creation. The lower scores in content creation are concerning because they suggest that PSTs may not be fully prepared to integrate ICT into the more creative and innovative aspects of teaching and learning, such as designing interactive lessons or digital projects. Moreover, Zhao et al. (2021) found that fourth-year students had higher self-perceived digital competency than first-year students, particularly in advanced skills like data management and digital communication. Similarly, the current study found that PSTs showed higher competency in communicating information using various digital media but lagged in creating original works. This suggests a gap between using ICT for communication and collaboration versus more creative, content-based applications.

For ethical ICT competency, PSTs demonstrated high perceived competency in valuing ICT for continuous learning and appreciating its role in academic collaboration. However, their perceived competency was lower in selecting, analyzing, and ethically using information obtained through digital resources and making rational, legal, and responsible ICT usage. The high scores in valuing ICT for learning and collaboration suggest a positive attitude towards technology's role in education. This reflects a growing awareness of ICT's potential to enhance learning outcomes. However, the lower scores in ethical ICT use indicate a need for more explicit training on responsible technology use. These findings are consistent with previous studies such as Tondeur et al. (2018), who found that while preservice teachers in Belgium demonstrated competency in using ICT for learning and instructional practices, ethical competencies such as responsible and legal use of technology were often underdeveloped. Similarly, Baydas and Yilmaz (2018) found that preservice teachers used ICT mainly for communication and basic research, and less on ethical considerations in technology use. The present study's finding of lower scores in ethical ICT use reflects this broader trend, where the ethical dimensions of ICT competencies are often overlooked in teacher education programs. Etokeren and Abosede (2021) likewise found that science education lecturers in Rivers State, Nigeria, had low competencies in the ethical use of ICT, such as ensuring data privacy and responsible use of digital tools. This finding aligns with the current study's results, where PSTs demonstrated a lower perception of competency for ethical ICT use, particularly in selecting and analyzing information responsibly. Fagbohun et al. (2018) also highlighted that the absence of a positive ICT culture contributed to poor ethical ICT use among students. While the present study did not explicitly examine sociocultural factors, the finding that PSTs had a low perception of ethical ICT competency suggests that broader cultural and educational influences may be shaping their ethical attitudes toward technology.

Regarding gender differences in PSTs' perceptions of ICT competencies for their learning, the findings revealed no significant gender differences across all three domains—basic, application, and ethical competencies. The p-values for all ANOVA tests exceeded the 0.05 threshold, indicating no statistically significant differences between male and female PSTs' perceptions in any competency area. This is a positive finding, as it suggests that gender disparities in ICT competencies, which have been noted in previous studies such as Teo et al. (2015) and Siddiq and Scherer (2019), may be diminishing in the context of PSTs at Nnamdi Azikiwe University, Awka. However, this finding is also supported by some

studies. For example, Danner and Pessu (2013), in their study of ICT competencies among undergraduate teacher preparation students at the University of Benin, found no significant gender differences in their overall ICT competency assessment. While they focused on a different population and employed different assessment methods, the absence of a significant gender gap aligns with the present study's findings. Similarly, Cabezas-González et al. (2021), while finding some nuanced gender differences in specific ICT usage areas, did not report an overall significant gender difference in digital competency among their sample of pre-service educators in Spain. Although their study also employed different methodologies, the lack of a significant overall gender effect supports the current study's conclusion that gender disparities in ICT competency may not be universally prevalent. The contrast between these findings and those reporting significant gender gaps highlights the contextual nature of gender influences on ICT competencies, suggesting that factors beyond gender, such as access to resources, pedagogical approaches, and cultural norms, play a significant role. Therefore, the present study's findings contribute to a more nuanced understanding of the complex interplay between gender and ICT competency in pre-service teacher education.

On the other hand, the study's findings revealed significant differences in PSTs' perceptions of basic and application ICT competencies across different academic levels but no significant difference in their perceptions of ethical competency across these levels. The Post Hoc Test further revealed that third-year (300-level) and fourth-year (400-level) PSTs had significantly higher perceptions of basic and application ICT competencies compared to their first-year (100-level) counterparts. These findings align with those of Zhao et al. (2021), who found that fourth-year students had higher self-perceived digital competency than first-year students, particularly in areas requiring more advanced skills. Similarly, Eger et al. (2018) found that master's level students demonstrated significantly higher ICT competencies than first-year students, particularly in technical areas such as software use and problem-solving. Danner and Pessu (2013) also reported that students with more formal computer training, typically acquired through higher levels of education, exhibited higher levels of ICT competency. This supports the current study's finding that higher-level PSTs tend to have better perceptions of ICT competencies, possibly due to increased exposure to ICT tools and applications as they progress through their studies.

Implication of Findings

The study's findings hold several important implications for teacher education programs, curriculum developers, policymakers, and educational institutions, particularly in integrating ICT into science education. For example, the low perception of ICT competencies observed among PSTs suggests that teacher education programs should focus more on enhancing ICT training. While the current curriculum equips students with basic ICT skills, the gaps in creative, collaborative, and ethical ICT use indicate a need for more practical, hands-on experiences that foster these competencies. Teacher training programs should integrate more project-based learning, simulations, and collaborative tasks that require PSTs to use ICT in innovative and interactive ways. This will better prepare future educators to effectively integrate technology into their teaching practices. Similarly, the lower competencies perceptions of PSTs in ethical ICT use imply that ethical considerations surrounding technology are not sufficiently emphasized in the current teacher training curriculum. This has important implications for how PSTs navigate issues such as digital privacy, intellectual property, and the responsible use of online resources when they enter the classroom. Teacher education programs must include structured and deliberate ethical ICT training to ensure that future educators are well-versed in legal and moral technological implications, helping foster responsible digital citizenship among their students.

The lack of significant gender differences in PSTs' perceptions of ICT competencies is a positive outcome, but it also suggests that gender-neutral ICT development strategies must be maintained and even strengthened to ensure that all PSTs, regardless of gender, have an equal opportunity to advance their ICT skills. This finding implies that ongoing efforts to challenge gender stereotypes in technology use are working, but continued attention is necessary to ensure no regression. Teacher education programs should continue to provide an inclusive environment that encourages both male and female students to engage with technology confidently and equally. Also, the implication of the significant differences in ICT competencies perceptions of PSTs across academic levels suggests that ICT proficiency improves with continuous exposure. Thus, there is a need for early and consistent

incorporation of ICT training throughout the teacher education program. This has important implications for curriculum design, as it highlights the necessity of introducing ICT training at the onset of a student's academic journey and progressively building on these skills as students advance. Ensuring early and continuous ICT engagement will enable PSTs to develop a strong foundation buildable throughout their education.

Furthermore, the findings that PSTs struggle with certain aspects of ICT use, particularly in creating original works and collaborating with peers using digital tools, imply a resources and support gap. Educational policymakers and institutions must ensure that teacher education programs possess up-to-date ICT infrastructure, including access to computers, software, high-speed internet, and technical support. Additionally, policies should be developed to ensure that all PSTs have equitable access to these resources to enhance their learning experiences and ICT competencies development. As ICT becomes increasingly integral to modern education, this study's findings imply that future science teachers must be furnished with not only the technical skills to use ICT but also the pedagogical knowledge to integrate it effectively into their classrooms. Teacher education programs should focus not only on the technical aspects of ICT but also on using technology to enhance student engagement, promote collaborative learning, and foster scientific inquiry. This will prepare preservice teachers to create dynamic, technology-enhanced learning environments well-suited to 21st-century educational demands.

CONCLUSION

The study's findings concluded that most PSTs at Nnamdi Azikiwe University, Awka, perceive their ICT competencies for learning across basic, application, and ethical dimensions to be high. However, there are notable gaps in these perceptions, especially in ICT applications for collaborative and creative purposes and in their ethical use of ICT. While they are relatively proficient in ICT usage for individual tasks, such as communicating information and exploring complex scientific concepts, they struggle with creating original digital content and fully integrating digital tools for collaborative learning and project development.

The absence of significant gender differences in PSTs' perceptions of ICT competencies indicates progress toward gender equality in technology use within this population. This suggests that both genders receive equitable opportunities to develop their ICT skills critical for fostering inclusive and balanced technology integration in future classrooms. The study further highlights the influence of academic progression on the perception of ICT competencies, with more advanced PSTs demonstrating higher levels of perception in basic and application ICT competencies. This suggests that continued exposure to ICT tools and practices throughout their training is crucial in enhancing PSTs' technological abilities. However, the lack of significant differences in ethical ICT competency across academic levels indicates that ethical awareness may not develop naturally with increased exposure to ICT. This underscores the need for deliberate and structured training on the ethical use of technology at all stages of teacher education.

Suggestions for Further Study

A longitudinal study may be undertaken by future researchers to monitor the growth of ICT competencies from the beginning to the completion of teacher education programs. Second, these researchers can choose to investigate how in-service science teachers' ICT competency relates to their classroom effectiveness.

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