Digital Competence and Technological Pedagogical Content Knowledge of Pre-Service Teachers in University of Mindanao

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Abstract
This research delves into examining digital competence and its relationship with technological, pedagogical, and content knowledge (TPACK) among pre-service teachers. The study employs a quantitative descriptive-correlational research design. It utilizes an adapted research instrument to gather data from 205 pre-service teachers who engaged with field experiences and supervised teaching practicums during the second semester of the academic year 2023–2024 at the University of Mindanao – Matina Campus. Mean and Standard deviation were employed to characterize the levels of the variables, while Spearman rho was used to assess their correlation. The findings indicate very high levels of digital competence and technological pedagogical content knowledge among pre-service teachers, with a strong positive correlation between the two variables. The results underscore the necessity of enhancing pre-service teachers' digital competence and TPACK to align ICT skills with pedagogical approaches. This underscores the need for programs supporting technical proficiency alongside pedagogical and content knowledge. Furthermore, the study emphasizes applying theoretical knowledge in practice, particularly in integrating digital resources to enhance student learning.

Keywords: *education, digital competence, technological pedagogical content knowledge (TPACK), pre-service teachers, descriptive-correlational research, Davao City, Philippines*
SDG Indicator: *Goal 4: Quality education*

INTRODUCTION

Education 4.0, rooted in the principles of the Fourth Industrial Revolution (4IR), acknowledges the application of digital technology that ensures teaching-learning experiences go beyond mere computer and electronic materials usage; it must align with a student-centric approach to truly enhance the quality of the learning experience. However, the education sector has been hesitant to embrace technology thoroughly for teaching and learning: primarily, technology has been employed for limited to a didactic approach, which has resulted in low faculty acceptance levels. Although, in the Philippines, schools have been provided with technology and fundamental digital literacy. Nonetheless, there has not been a clear and appropriate objective outlining the intended use of technology within educational institutions—the transformative potential of ICT in education to enhance equitable and high-quality learning experiences. (Alda et al., 2020; Oke & Fernandes, 2020; RT International, 2020; Singh & Kasim, 2019; UNESCO, 2018).

In the 21st century, technology has been noted to have an essential role for teachers as it aids in delivering lessons and learning among students. The framework of the TPACK model also emphasizes strongly that it is necessary to equip future teachers with the ability to integrate technology and ICT-based learning techniques in teaching. This approach builds knowledge

and conceptual change, fostering student engagement and, in particular, mobile and online learning through which students gain self-confidence and participate actively. Therefore, the observation of pre-service teachers' TPACK implementation during teaching practice helps future educators prepare with effective strategies (Alnasib, 2023; Liando et al., 2023; Santos & Castro, 2021; Nuangchalerm, 2020; Shuja et al., 2019).

Lin et al. (2013) highlighted that the Unified Theory of Acceptance and Use of Technology (UTAUT), which was proposed and validated by Venkatesh et al. (2003), integrates eight various models, which includes the Theory of Reasoned Action (TRA), the Technology Acceptance Model (TAM), the Motivational Model (MM), the Theory of Planned Behavior (TPD), a combined (TAM) and (TPB) model, the Model of PC Utilization (MPCU), the Innovation Diffusion Theory (IDT), and the Social Cognitive Theory (SCT). The UTAUT model foresees user acceptance of information technology innovations with up to 70% accuracy, surpassing previous models, thereby establishing the UTAUT as a superior metric. The UTAUT model is beneficial for examining the identifying skills, competencies, and specific training that are necessary to understand the technology usage predictors (Abu et al., 2015). The UTAUT is widely used for studying technology acceptance and facilitating the implementation of information systems (Alyoussef, 2021).

Cebi and Reisoğlu (2020) reported that pre-service teachers exhibit strong digital competence, particularly in communication and collaboration, because of their theoretical coursework and frequent use of digital technologies. Štemberger and Konrad (2021) found that these pre-service student teachers effectively use basic communication tools and open-access teaching materials. However, despite a positive motivation to use technology in teaching, there is a significant lack of problem-solving and content-creation skills. Hence, studies by Galindo-Domínguez and Bezanilla (2021), McGarr and McDonagh (2021), and Fraile et al. (2018) indicated a low level in these areas. Therefore, highlighting more attention to the problem-solving level to create rational solutions to address both digital and contextual problems in a teaching context. (Xu et al., 2023).

Santos and Castro (2021) found that Bulacan pre-service teachers had a strong knowledge of all the TPACK components. Tondeur et al. (2017) emphasized that teacher educators should serve as technology role models and expose complete notions of technology to pre-service teachers to demonstrate their field experience. According to Karakus (2018), the success of the FATIH Project in Turkey depends on integrating technology with classroom activities that create further mastery of TPACK instructional beliefs in Mathematics. Mtebe and Raphael (2018) and Foulger et al. (2015) reported moderate mean TK, TPK, TCK, and TPACK due to ICT being treated as a standalone subject, hindering the development of their pedagogical knowledge. Cui and Zhang (2022) and Ndukwe and Daniel (2020) revealed that emerging technologies improve students' performance and pedagogical decision-making skills. However, Alnasib (2023) identified a gap in online safety training.

However, several issues have been raised regarding the effectiveness of the usage of Information and Communication Technology (ICT) in education, as highlighted by Sastria (2023), it is primarily due to the lack of time allocated for training. Hence, Shin (2015) argued that there is no critical assessment for digital materials and no e-safety rules, supported by Cebi and Reisoglu (2020). Furthermore, the pre-service teachers are comfortable using hardware but not excellent at selecting appropriate software for teaching (Marais, 2023). Hence, it is believed that integrating these devices into pedagogy is still evolving (Maiier & Koval, 2021). Whereas, it is suggested that the pre-service teachers who have personal computers have higher self-perceived proficiency, which justifies their better demonstration of technology integration (Demirtas and Mumcu, 2021).

The urgency of studying and examining the relationship between digital competence (DC) and technological pedagogical content knowledge (TPACK) is crucial for improving

education in the digital age. As highlighted by Singh and Kasim (2019), it is a huge source of concern that pre-service teachers cannot maximize and implement TPACK during teaching practice. Indeed, this condition warrants better TPACK implementation and adoption within the educational environment. This study aims to identify areas where pre-service teachers need support or training to incorporate technology in their pedagogies successfully. By pinpointing these areas, the study findings will bridge gaps in digital competence and TPACK. Little is known about how the pre-service teacher optimized and implemented TPACK during the teaching practice. The study's social value lies in its possibility for quality improvements in educational services provided by pre-service teachers.

Moreover, the study aims to assess and determine the level of digital competence (DC) and technological pedagogical content knowledge (TPACK) of pre-service teachers and to explore the correlation between these two variables. The researchers hypothesize that there is no significant correlation between digital competence and technological pedagogical content knowledge. However, despite this hypothesis, the study's further analysis aims to provide valuable insights and implications regarding how these two variables can effectively enhance teaching practices. These findings are intended to assist and meet the evolving demands of 21st-century education by providing strategies for integrating technology effectively into teaching.

METHOD

Research Respondents

The study's respondents were the pre-service teachers of the College of Teacher Education (CTE) enrolled in practicum for the second semester of the academic year 2023–2024 at the University of Mindanao-Main Campus, Davao City, Philippines. With a total population of 225 pre-service teachers under the College of Teacher Education, 205 respondents were obtained as the sample size. Pre-service teachers were 19 from School A, 22 from School B, 38 from School C, 53 from School D, 40 from School E, and 33 from School F. This sample size ensured a 95% confidence margin and 5% error following the results of the Raosoft sample size calculator.

Moreover, a universal sampling technique was employed to select respondents from the pre-service teachers of the College of Teacher Education Department because they could provide helpful information to test the study's hypothesis. As underscored in the study by Ramoso and Ortega-Dela Cruz (2019) and Richard and Margaret (1990) in Kabera (2009), not all populations have the same probability of being included in the sample, and each one has an unknown probability of being selected. The inclusion of this study includes all enrolled pre-service teachers of the College of Teacher Education, as they are the central focus of this research study. Those who are not pre-service and who back out or withdraw
to participate were excluded from this study.

Research Instruments

The researchers developed two adapted and modified questionnaires; the first one is the Digital Competence Scale, whose basis was from Cebi and Reisoglu (2020); it was used to measure perceived digital competence by pre-service concerning information and data literacy (IDL), communication and collaboration (CC), digital content creation (DCC), safety (S), and problem-solving (PS). Secondly, the TPACK Scale was adapted from the questionnaire of Valtonen et al. (2017), consisting of the indicators: pedagogical knowledge (PK), technological knowledge (TK), content knowledge (CK), pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical and content knowledge (TPACK). The validation of these questionnaires was extensive and resulted in a score of 4.5 or Very Good. The TPACK with

Cronbach Alpha in the pilot testing had an $\alpha = .970$, which means excellent, and digital competence had an $\alpha = .925$, which means excellent—the research questionnaire used five points in a Likert scale in its descriptive equivalence. The study assessed the responses from one (1*) strongly disagree* (SD) to five (5) *strongly agree* (SA).

The level of digital competence and TPACK is interpreted through a Likert Scale interpretation adapted from Almohtadi and Aldarabah (2021) and Cahapay (2020), respectively. These two are very descriptive to present a score between the range of score of 1.00 to 1.49, which is termed very low and shows that the level of perceived digital competence and TPACK is very low. Then, a score from 1.50 to 2.49 is low and, therefore, indicates low perceived digital competence and TPACK. A score from 2.50 to 3.49 is moderate; thus, it is placed in the middle range, showing their perceived digital competence and TPACK is on a satisfactory level. Then, it would score 3.50 to 4.49 for an interval range of High, which states a very satisfactory perceived digital competence and TPACK. Finally, a score ranging from 4.50 to 5.00 is very high, meaning there is outstanding perceived digital competence and TPACK.

Similarly, the Spearman's rho correlation coefficient was interpreted based on the study findings to test whether there is a relationship between the variables under investigation, according to Selala et al. (2019). According to the interpretation, any correlation coefficient from 0.00 to 0.20 is considered a negligible association of the two variables. This is followed by coefficients from 0.21 to 0.40, which is also considered a weak association of the variables. Then, those falling between 0.41 to 0.60 are considered to be a moderate relationship between variables. Meanwhile, the coefficient of about 0.61 to 0.80 is termed a strong relationship. Lastly, the coefficients that fall between 0.81 to 1.00 are considered to have a very strong significant relationship between the variables.

Design and Procedure

In this study, the researchers employed a descriptive-correlational research design to determine whether there was a significant relationship between digital competence and TPACK. Seeram (2019) described that descriptive-correlational research aims to explain the interaction between the variables. It objectively describes the connection between independent and dependent variables, clarifying how one variable influence another.

While conducting the research and collecting data, the researchers observed and applied the following steps. First, the researchers started the data-gathering procedure with the permission of the College of Teacher Education Pre-Service Coordinator to obtain consent and determine the size of the pre-service teacher population based on school deployment. After that, the researchers conducted personal surveys to directly retrieve the responses from participants at their deployment schools. Despite potential concerns about participants' willingness to participate, they ensured the survey was completed with the target sample size. Notably, the researchers used extensive respondents' confirmation to ensure the accuracy and verification of the collected data.

After the data collection, the researchers systematically organized and encoded it. Then, the researchers handed over the encoded data to a statistician who used statistical methods, specifically the mean, standard deviation, and Spearman's rank correlation coefficient, to analyze the relationship between digital competence and TPACK. The statistician used the software tool SPSS (Statistical Package for the Social Sciences) to measure and calculate each variable and the correlation coefficient between the variables. After conducting the required statistical analysis of the gathered data, the researchers identified and categorized the patterns and trends in the results. These findings were interpreted and integrated into the results and discussion section. The researchers drew conclusions based on the results following the

research objectives. Lastly, the researchers identified practical implications detailing how the study results could benefit the institution and other stakeholders.

RESULTS AND DISCUSSION

Level of digital competence among pre-service teachers

Table 1 presents the level of digital competence of pre-service teachers regarding the indicators, specifically, information and data literacy (IDL), communication and collaboration (CC), digital content creation (DCC), safety (S), and problem-solving (PS). The overall mean score of digital competence was high (*M = 4.48, SD = 0.44),* indicating that pre-service teachers have a very satisfactory perceived digital competence. Among these indicators, communication and collaboration had the highest mean with a very high level *(M = 4.54, SD = 0.54),* indicating an outstanding perceived digital competence in using technology to organize and share information and digital content online. Conversely, problem-solving had the lowest mean score (M = 4.36, SD = 0.56), but this still maintains a high level of digital competence, revealing that pre-service teachers have a very satisfactory level of effectively identifying and solving technical problems when using digital technology.

Table 1: *Level of digital competence among pre-service teachers*

Indicators	***Mean***	***SD***
Information and data literacy (IDL)	4.50	0.50
Communication and collaboration (CC)	4.54	0.54
Digital content creation (DCC)	4.42	0.62
Safety (S)	4.51	0.49
Problem Solving (PS)	4.36	0.56
Overall	**4.48**	**0.44**

The study findings showed that communication and collaboration had the highest mean score among the indicators of digital competence. Similar evidence is presented by Cebi and Reisoğlu (2020), proving that pre-service teachers have higher digital competence in communication and collaboration, information and data literacy, and safety. It is claimed to be due to the theoretical learning focus in teacher training courses and, at the same time, few practical experiences through the regular usage of digital technologies in their everyday lives. Similarly, Štemberger and Konrad (2021) discovered that student teachers use simple tools for communication and effective practices regarding digital resources consisting of emails, blogs, forums, video conferences, and social media. However, with the existence of these competencies, there lies a significant deficiency in the areas of problem-solving and content creation.

Moreover, the findings identify problem-solving as the lowest mean score among indicators. Although the findings showed that problem-solving has the lowest mean score

among indicators, it still implied a high and very satisfactory level of digital competence. These findings are coherent with both Mcgarr and McDonagh (2021) and Fraile et al. (2018), as they also identified that pre-service teachers frequently reported a lower digital competence, especially in content creation and problem-solving despite having a positive disposition towards technology in teaching. Furthermore, Galindo-Domínguez and Bezanilla (2021) noted that pre-service teachers have low digital problem-solving skills that reflect a low capacity to recognize needs, processes, issues, and resolutions when navigating digital tools amidst technological advancement. Hence, Xu et al. (2023) emphasized that pre-service teachers are expected to acquire problem-solving skills in order to develop rational strategies, engage more, and resolve both digital and situational problems in their teaching.

Level of Technological Pedagogical Content Knowledge (TPACK) among pre-service teachers

Table 2 presents the level of TPACK of pre-service teachers in terms of pedagogical knowledge (PK), technological knowledge (TK), content knowledge (CK), pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical and content knowledge (TPACK). The overall mean score of TPACK was high *(M = 4.49, SD = 0.43),* indicating a very satisfactory TPACK. Among the indicators, technological pedagogical knowledge (TPK) had the highest mean score *(M = 4.54, SD = 0.51),* suggesting that pre-service teachers have a very high level and an outstanding level to use ICT in teaching as a tool for reflective thinking, creative thinking, critical thinking, and problem-solving. On the other hand, technological knowledge (TK) gained the lowest mean score *(M = 4.36, SD = 0.60)*, but this still signifies a high level of TPACK, indicating that pre-service teachers have a very satisfactory level of using new technology with new features and solving ICT related problems.

Table 2: *Level of technological, pedagogical, and content knowledge among pre-service teachers*

Indicators	***Mean***	***SD***
Pedagogical Knowledge (PK)	4.49	0.55
Technological Knowledge (TK)	4.36	0.60
Content Knowledge (CK)	4.40	0.60
Pedagogical Content Knowledge (PCK)	4.51	0.51
Technological Pedagogical Knowledge (TPK)	4.54	0.51
Technological Content Knowledge (TCK)	4.53	0.51
Technological Pedagogical and Content Knowledge (TPACK)	4.52	0.48
Overall	**4.49**	**0.43**

The findings highlight that among the indicators of TPACK, Technological Pedagogical Knowledge (TPK) scores the highest mean, indicating an outstanding level. This aligns with Santos and Castro's (2021) study, affirming that pre-service teachers in Bulacan have strong knowledge across all TPACK components. Furthermore, Tondeur et al. (2017) emphasize the essential role of teacher educators in modeling technology to significantly enhance pre-service teachers' TPACK abilities during their field experience. Hence, Karakus (2018) discussed Turkey's FATIH Project, which integrates technology into classroom activities and improves pre-service teachers' TPACK instructional beliefs in mathematics by using computer technology as an instructional method. Consequently, pre-service teachers demonstrate high levels of mathematical knowledge for teaching, supported by method courses in teaching technologies, material design, and computer applications in mathematics.

Subsequently, the findings highlight that Technological Knowledge (TK) has the lowest mean score among TPACK indicators but still indicates a high and very satisfactory level. Sastria (2023) discussed that pre-service science teachers struggle to effectively use ICT due to limited training time. It is also revealed by Mtebe and Raphael (2018) study that moderate mean scores in TK, TPK, TCK, and TPACK are due to universities treating ICT as a standalone subject that hinders the pedagogical development to foster 21st-century skills in students effectively. Moreover, Foulger et al. (2015) emphasize that independent technology courses are less effective in developing pre-service teachers' TPACK compared to modeling technology integration practices by teacher educators throughout their programs.

Correlations between Digital Competence and Technological Pedagogical and Content Knowledge

Table 3 presents the results of the correlation analysis between digital competence (DC) and technological pedagogical content knowledge (TPACK) among pre-service teachers. The Spearman's rho correlation analysis revealed that there is a significant positive relationship between the two variables, *r (205) = .669, p = (.000)*. As per coefficient guidelines, this value indicates a strong positive correlation strength between digital competence and TPACK. Furthermore, the p-value of .000 indicates that the null hypothesis can be rejected at the 0.05 significance level. Consequently, it confirms that a statistically significant relationship exists between digital competence (DC) and technological pedagogical content knowledge (TPACK) among pre-service teachers.

Table 3: *Correlations between digital competence and technological pedagogical content knowledge*

Digital Competence (DC)	**Technological Pedagogical and Content Knowledge (TPACK)**							
	PK	TK	CK	PCK	TPK	TCK	TPACK	**Overall**
Information and data literacy (IDL)	.596** (.000)	.426** (.000)	.569** (.000)	.541** (.000)	.514** (.000)	.460** (.000)	.514** (.000)	**.641** (.000)**
Communication and collaboration (CC)	.447** (.000)	.388** (.000)	.477** (.000)	.458** (.000)	.434** (.000)	.385** (.000)	.429** (.000)	**.540** (.000)**
Digital content creation (DCC)	.460** (.000)	.389** (.000)	.489** (.000)	.445** (.000)	.504** (.000)	.491** (.000)	.500** (.000)	**.567** (.000)**

Safety (S)	.436** (.000)	.341** (.000)	.420** (.000)	.450** (.000)	.424** (.000)	.422** (.000)	.437** (.000)	**.509** (.000)**
Problem Solving (PS)	.512** (.000)	351** (.000)	.467** (.000)	.471** (.000)	.518** (.000)	.435** (.000)	.531** (.000)	**.594** (.000)**
Overall	**.581** (.000)**	**.444** (.000)**	**.562** (.000)**	**.560** (.000)**	**.556** (.000)**	**.510** (.000)**	**.562** (.000)**	**.669** (.000)**

The results of correlation analysis between the indicators of digital competence and TPACK showed information and data literacy as the highest correlation with TPACK, *r (205) = .641**, p = (.000),* which indicates a strong positive correlation with information and data literacy and TPACK of pre-service teachers. Despite safety having the lowest correlation coefficient with TPACK, *r (205) = .509**, p = (.000),* safety still maintains a moderate correlation with TPACK. While safety may not be as strongly associated with TPACK as other indicators, it remains an essential component of overall digital competence among pre-service teachers.

The relationship between information and data literacy and technological pedagogical content knowledge shows a strong positive correlation. Cui and Zhang (2022) underscore this connection by observing that using emerging technologies and tools can improve student performance and elevate pedagogical decision-making. Ndukwe and Daniel (2020) affirm that these technologies support student-centered teaching methods. Moreover, Prachagool et al. (2022) also highlight that pre-service teachers can facilitate learning cognitive knowledge, attributes, and skills in various learning areas to enhance students' effectiveness and sustainability of learning through information technology. However, Altun (2019) found that only 2% of pre-service teachers actively use digital tools for professional and academic enhancement, suggesting a significant underutilization of these resources.

Furthermore, the findings highlight a moderate correlation between safety and technological pedagogical content knowledge. Alnasib (2023) noted that pre-service teachers with basic computer training often have lower competencies in online safety. This indicates a gap in training that needs to be addressed in privacy, reputation management, and security against online threats. Cebi and Reisoglu (2020) found that pre-service teachers often lack practical application of safety and ethical use. Shin (2015) exemplified this issue by critiquing the lack of critical evaluation for external digital content used in lesson plans. Despite the content being educationally appropriate, there was an absence of guidelines for e-safety, which is crucial in managing online interactions and protecting students from threats like bullying and inappropriate content.

In addition, the findings also reveal other indicators that exist among the two variables. The correlations between indicators of TPACK with digital competence showed that the highest correlation was pedagogical knowledge (PK) with digital competence. It was found to have a moderate correlation, *r (205) = .581**, p = (.000)*, indicating a moderate correlation between PK and digital competence. At the same time, the lowest correlation was technological knowledge (TK) with digital competence, *r (205) = .444**, p = (.000),* which indicates a moderate correlation between TK and digital competence. While TK may not be as strongly associated with digital competence as other indicators, it remains a vital component of overall TPACK among pre-service teachers.

The research findings highlight a moderate correlation between pedagogical knowledge (PK) and digital competence among pre-service teachers. Marais (2023) discusses that while pre-service teachers are comfortable using hardware in school settings, they struggle with

selecting and using software for teaching. This gap is influenced by their university experiences, where technology is typically viewed as a resource rather than a teaching tool.

Conversely, the lowest correlation between TPACK indicators and digital competence was observed in Technological Knowledge (TK), indicating a moderate correlation. This finding corresponds with the Maiier and Koval (2021) study, which highlights that while pre-service teachers frequently engage with digital tools, their ability to integrate these tools pedagogically is still developing. Despite this, most pre-service teachers understand the importance of categorizing digital tools to improve teaching efficiency during internships. Hence, Demirtas and Mumcu (2021) discovered a variation in the ICT integration skills among pre-service teachers, favoring those with personal computers and higher self-perceived technological proficiency—the ability to integrate ICT advances when pre-service teachers improve their technological skills.

The UTAUT model effectively supports the findings that pre-service teachers indeed have high levels of digital competence and TPACK. These findings align with Yildiz (2024), who observed that pre-service teachers with higher levels of TPACK are capable of integrating GeoGebra in their teaching effectively. Furthermore, the UTAUT model effectively explains how the adoption and use of GeoGebra occur for these teachers.

The integration of UTAUT in educational studies offers an essential insight into the predictors of actual technology use among future educators. High levels of digital competence and TPACK among pre-service teachers indicate they are well-equipped to use technology in their practice. Readiness in this regard is essential for adaptation to modern education systems, whereas the effective use of technology is required more and more to improve teaching and learning outcomes.

In summary, the results indicate that the digital competence of the pre-service teachers is positively and significantly related to their TPACK. Besides, there were positive relationships between digital competence and the subdimensions of TPACK that emphasized the role of digital competencies in helping attain a deeper understanding of the interaction among technology, pedagogy, and content knowledge during effective technology integration. Hence, the ability to identify these competencies is important in preparing pre-service teachers to use technology effectively in their teaching practices.

CONCLUSIONS AND RECOMMENDATION

The findings show that the pre-service teachers had very high and outstanding levels in all indicators of digital competence (DC), information and data literacy (IDL), communication and collaboration (CC), digital content creation (DCC), and safety (S). While, problem-solving (PS) at a high level, representing a very satisfactory level. Also, regarding technological pedagogical content knowledge (TPACK), the findings evidently show that the pre-service teachers demonstrate a very high level and outstanding level in TPK, TCK, TPACK, and PCK. Meanwhile, the other indicators, particularly PK, CK, and TK, show a high level, indicating a very satisfactory level. Overall, the study results reveal a significant positive relationship between digital competence (DC) and technological pedagogical content knowledge (TPACK).

The study's findings are compatible with the UTAUT theory on understanding technology adoption among pre-service teachers, which provides guidance in designing effective pre-service teacher education programs to prepare pre-service teachers intended for the digital era. In other words, the interconnectivity of these models further emphasizes the importance of performance expectancy, effort expectancy, social influence, and facilitating conditions for preparing future teachers. Ultimately, it shows a direct correlation between pre-service teachers' digital competence and TPACK.

Based on the study's findings, it is recommended that teacher education institutions should continue integrating technology into their educational programs to help pre-service teachers improve their confidence more in TPACK abilities. Hence, the development of a TPACK framework in designing programs for pre-service teachers is necessary for effectively attaining the educational goals that would ensure success in the 21st century. Furthermore, it is recommended that seminars, hands-on activities, and digital pedagogy training will be integrated to allow pre-service teachers to acquire the skills and develop confidence through which they can engage with technology within the education setting. Moreover, future researchers must delve deeper into digital competence, particularly in problem-solving among pre-service teachers. This will assist in gathering evidence and developing interventions to enhance these skills and fortify the foundation of technological skills.

The study relies on self-reported assessment of pre-service digital competence and TPACK. While these self-reports provide insights into individuals' perceptions of their competence, they have inherent subjective influence. Hence, future researchers could employ a different methodological approach to address the limitations of self-reported data. One promising avenue is to use the same questionnaire but have it completed by supervisors or teachers responsible for evaluating pre-service teachers' performance to provide a more objective assessment of pre-service teachers' digital competence and TPACK.

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