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Pre-service Teachers' Technological, Pedagogical and Content Capability and Digital Pedagogy Readiness

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Kishabale Bashir[1] and Luyima Jimmy[2]

Abstract
Despite evident efforts made, limited digital pedagogical practice among pre-service teachers has been noticed. The study sought to investigate pre-service teachers' perceptions of their technological, pedagogical, content capabilities; validate the digital pedagogy readiness model; and establish the influence of technological, pedagogical and content capabilities on pre-service teachers' digital pedagogy readiness. Mishra and Koehler's TPACK Framework (2006) formed the study's theoretical ground to derive the technological-pedagogical-content capability sub-constructs. A 30-item scale was used to collect data from 351 pre-service teachers of Kyambogo University. Descriptive statistical analysis was employed to establish the respondents' perceptions on the variables under study, while Structural Equation Modeling (SEM) was applied to validate the model and test the hypotheses. Findings revealed that pre-service teachers were in agreement regarding their perceptions of the capabilities; the hypothesised digital pedagogy Readiness model showed fit to the data; and. the influence of technological-pedagogical-content capability on pre-service teachers' digital pedagogy readiness was statistically significant. The study enriches existing literature on the role of TPACK in fostering teachers' digital pedagogy which is vital for the 21st century classroom. The findings are further useful to the Ministry of Education and Sports and affiliated agencies in fast tracking the implementation of the Education digital agenda.

Key Words: Technological-pedagogical-content, Digital Pedagogy, Pre-service Teachers, Uganda

Introduction

Today's learners as well as those of the future are expected to possess a set of generic skills like critical thinking, communication proficiency, problem solving, collaboration, creativity and innovation, computational thinking and proficiency in the use of digital technologies. This calls for teachers to have familiarity with an array of pedagogical approaches and appropriate use of information and communication technologies (ICTs) to foster development of learners' generic skills needed for the 21st century workplace (NCDC, 2019; Valtonen et al., 2017). To that end, developing teachers' skill base to improve student learning has continued to be the core aim of teacher education programmes across the globe (Meier, 2021). In the same vein, edu-

[1] Kyambogo University, UGANDA, bkishabale@kyu.ac.ug, ORCID: 0000-0003-0775-1627
[2] Kyambogo University, UGANDA, luyimajimmy@kyu.ac.ug, ORCID: 0000-0001-9213-0731

cational research has also increasingly shifted its focus on teachers' understanding and abilities in the use of digital technologies in classroom practice (Jita & Sintema, 2022; Thohir et al., 2021), given the manner in which teaching and learning processes have been altered by new wave of digital technologies (Bwalya & Rutegwa, 2023). The implication of the aforementioned digital trend therefore is that teacher training institutions have to redefine teacher education curriculum to enable the prospective teachers enhance their pedagogical, content and technological knowledge and skills base for seamless technology integration in classroom practice (Bwalya & Rutegwa, 2023; Salas-Rueda, 2019; Segal et al., 2021). It is therefore important that teacher training institutions embed digital pedagogy in Initial Teacher Training and Education (ITTE) programmes to enable the pre-service teachers appreciate the need to integrate digital tools in their pedagogical practices (Kivunja, 2013). That is because unlike in-service teachers, pre-service teachers develop the skills of technology integration into instructional practices mainly through (i) courses related to instructional/educational technology, (ii) subject-specific methods courses, and (iii) general instructional techniques that are implemented in the context of the entire initial teacher training programme (Mouza, 2016 as cited in Lau, 2018).

Taking full advantage of modern digital tools in education and training calls for a change in pedagogical practices, methodology and curriculum design; and this is what makes digital pedagogy worth discussing (Bekiadridis et al., 2020). The Technological Pedagogical Content knowledge (TPACK) Model provides a rich context for educators to critically evaluate the contribution of digital technology in enhancing pre-service teachers' active pedagogical practices by considering their technological, pedagogical and content knowledge bases (Koehler et al., 2013; UNESCO MGIEP, 2019).

The Ugandan Ministry of Education and Sports developed an Education Digital Agenda Strategy 2021-2025 as a framework for leveraging the integration ICTs in the teaching and learning processes and life-long learning (Ministry of Education and Sports, 2022). However, using technology tools to impact and engage student learning as envisaged in the Education Digital Agenda Strategy can only occur if teachers are digitally predisposed and can demonstrate ability to purposefully integrate technology tools and resources in the classroom. This is very true for example when (Kasirye, 2023) recommended that teacher training institutions need to avail pre-service teachers opportunities to learn how to integrate digital technologies into their instructional training to enhance digital pedagogical readiness. Whereas there are evident efforts made to improve pre-service teachers' competencies for digital tools into teaching and learning, low uptake has been reported in most African countries (Jita & Sintema, 2022; Kafyulilo et al., 2015; Kasoka Masumba & Mutale Mulenga, 2019). In the Ugandan context, low levels of technology integration among both in-service and pre-service teachers have been reported despite the call for effective ICT integration into instructional activities (Guloba & Atwine, 2012; Ministry of Education and Sports, 2017). For example, (Nuwategeka & Odama, 2020) reported low levels of ICT integration by Geography pre-service teachers in their lessons at Gulu University. With the increasing reliance on digital tools, resources and media to support classroom teaching and learning, examining the extent of pre-service teachers' technological-pedagogical-content knowledge is timely to enable teacher training institutions assess themselves regarding the extent to which they are producing teachers who are capable of translating the Education Digital Agenda Strategy of the MOES into reality. As Ahmad (2021) had argued, our ability to use technologies as pedagogical tools calls for competence and ability to carefully link the digital tools to pedagogical orientations and subject area. The purpose of this study was three-fold: to describe the perceptions of pre-service teachers regarding their technological-pedagogical-content capabilities and digital pedagogy readiness; establish the validity of the hypothesized Digital pedagogy Readiness model; and establish the predictive influence of technological-pedagogical-content capabilities on pre-service teachers' digital pedagogy readiness. To achieve the study's purpose, the researcher sought to:

a. Describe pre-service teachers' perceptions regarding technological-pedagogi cal-content capabilities and digital pedagogy readiness.
b. Validate the hypothesized pre-service Teachers' digital pedagogy readiness structural model.
c. Examine the influence of:
    i. Technological capability
    ii. Pedagogical capability
    iii. Content capability on pre-service teachers' digital pedagogy readiness

Literature Review

Digital Pedagogy

Harnessing the full potential of digital technologies in the area of instruction is a new challenge that echoes the need to transform teacher training practices, methodology and curriculum design; and this is where the concept of digital pedagogy comes into play. Digital pedagogy is an emerging concept whose definition is continuously evolving with debates among pedagogues gaining momentum.

To some, digital pedagogy focuses on thoughtful use of digital resources as it is about taking a decision not to use them, and about directing attention to the influence digital resources/tools have on the process of learning (Väätäjä & Ruokamo, 2021). Digital pedagogy as argued by Devaki (2018) as cited in Cabanero et al. (2022) is about utilizing components of digital technology to alter the educational experience, with a focus on how to facilitate the teaching-learning process mediated by technology. As a branch of pedagogical science, digital pedagogy encompasses digital technology in the art of instruction to enrich the process of teaching and learning (Cabanero et al., 2022; Toktarova & Semenova, 2020). Meanwhile, Sadiku et al. (2019) looks at digital pedagogy as the use of digital resources to facilitate teaching and learning, covering aspects of instructional design, multimedia and web-based resources.

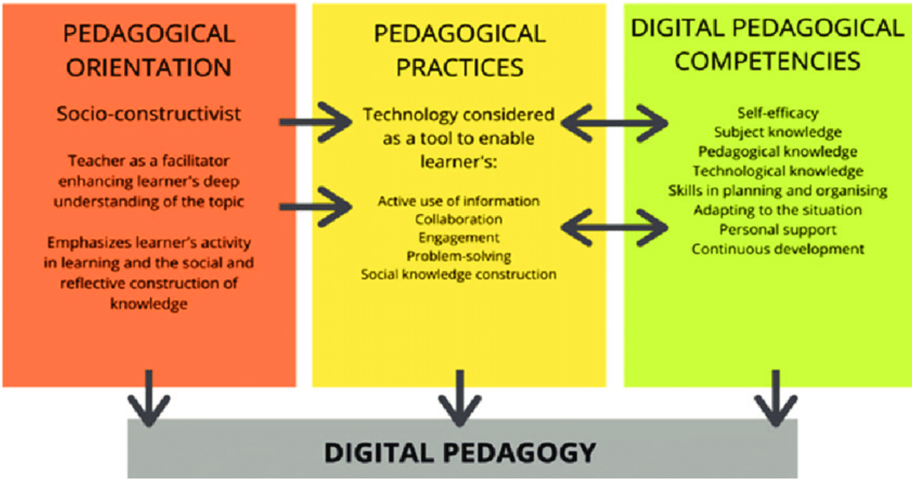

Figure 1. Model of Digital Pedagogy (Väätäjä & Ruokamo (2021)

Väätäjä & Ruokamo (2021) conceptualised digital pedagogy to be comprised of three dimensions of pedagogical orientation, pedagogical practices and pedagogical digital competencies as illustrated in their model of Digital Pedagogy in Figure 1. Pedagogical orientation is the teachers' perception of what the process of learning should look like, how we learn, and how we should be taught (Väätäjä & Ruokamo, 2021). The pedagogical practices dimension focuses on the methods that are used by the teacher to implement the teaching functions (Cabanero et al., 2022; Väätäjä & Ruokamo, 2021). Digital pedagogical competencies are the set of skills needed by the teacher to successfully integrate digital technologies in teaching (Cabanero et al., 2022; Väätäjä & Ruokamo, 2021). From a close analysis of (Väätäjä & Ruokamo, 2021)'s classification of digital pedagogy, the pedagogical orientation and pedagogical practices are comparable to the pedagogical knowledge, while the digital pedagogical competencies are akin to technological knowledge in Mishra and Koehler (2006)'s Technological Pedagogical Content knowledge (TPACK) Framework.

Technological Pedagogical Content knowledge

Mishra and Koehler's (2006) Technological Pedagogical Content knowledge (TPACK) Framework was employed as the theoretical framework for the current study to understand the Technological-Pedagogical-Content capabilities construct. The TPACK framework, an extension of Shulman's Pedagogical Content Knowledge model was proposed by Mishra and Koehler (2006) and is crucial in guiding teachers' integration of technology into instructional activities. As argued by (Bwalya & Rutegwa, 2023), TPACK can be conceived as the competencies that teachers can demonstrate as measured through their content, pedagogical and technological knowledge. To Mishra and Koehler (2006), TPACK is evident when a teacher can demonstrate knowledge of how technology impacts on learners' mastery of subject matter as well as the extent to which pedagogical strategies and content presentation in a particular subject area is altered by technological resources. In terms of philosophical orientation, the current study takes on the transformative view of TPACK which argues that that intersection of the various knowledge areas give rise to unique bodies of knowledge that not a mere integration of the core dimensions, but rather, a distinct body of knowledge that transcends beyond the components as its core. To the transformative view therefore, TPACK is impacted directed by TPK, TCK and PCK and indirectly by TK, PK and CK (Schmid et al., 2020).

The TPACK model (shown in Figure 2) is made up of three core constructs of TK, PK and CK, which however logically interact to form TCK, TPK and PCK, and hence overall TPACK, resulting into a seven-factor model (Castéra et al., 2020). Each of the constructs has been defined as follows:

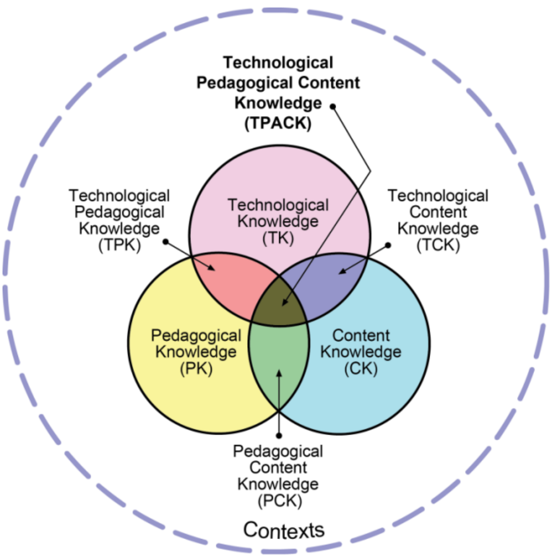

Figure 2. Mishra and Koehler's TPACK Framework (2006)

Technology knowledge (TK) is knowledge related to an array of technological resources, ranging from low-end technologies like paper and pencil to high-end digital technologies covering the Internet, Social Media, application software, and motion graphics (Schmidt and Mishra, 2019).

Content knowledge (CK) refers to knowledge of actual subject matter to be taught/ learnt (Mishra & Koehler, 2006).

Pedagogical knowledge (PK) is knowledge of methodology and teaching-learning processes, including but not limited to instructional planning, classroom management and learner assessment (Schmidt et al., 2009).

Pedagogical content knowledge (PCK) is the teachers' content knowledge that applies to the process of teaching, and differs for the subject areas (Shulman, 1986; Schmidt & Mishra, 2019).

Technology content knowledge (TCK): is the knowledge about how technology can be utilised to create new content representations to enable learners perceive and understand a particular content domain (Schmidt et al., 2009).

Technology pedagogical knowledge (TPK) refers to the teachers' knowledge of how diverse technologies can be applied in the teaching-learning process, and appreciating that applying has considerable impact on the ways teachers carryout instruction (Schmidt et al., 2009).

Technology pedagogical content knowledge (TPACK): is the kind of knowledge the teacher needs to seamlessly integrate technology into the teaching of a given content area. That is, knowledge that enables the teacher to demonstrate intuitive mastery of the complex intersection that exists between the three core dimensions of CK, PK and TK to teach given content area guided by appropriate pedagogical approaches and technology resources (Schmidt & Mishra, 2019).

In the current study, focus was given to the three core dimensions of Technological knowledge, Pedagogical knowledge, and Content knowledge to predict pre-service teachers' readiness for digital pedagogical readiness. In Figure 3, the hypothesised digital pedagogy readiness (DiPeR) model is illustrated, and study hypotheses derived.

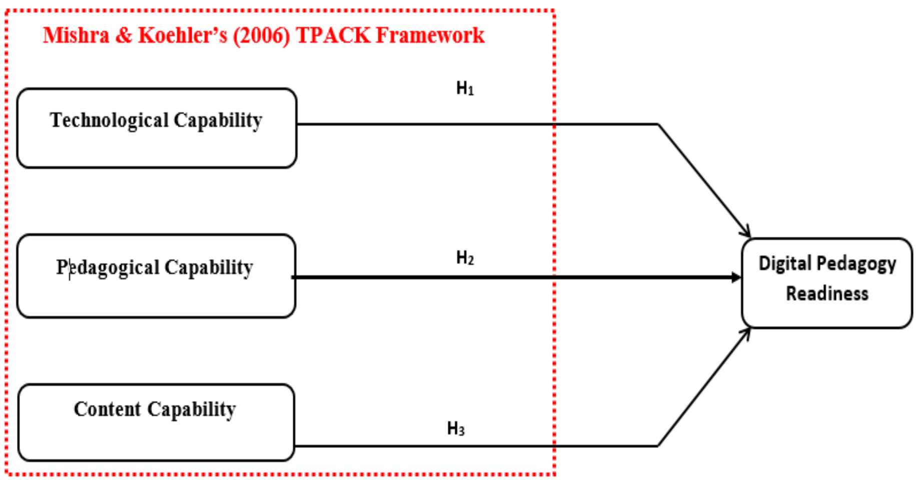

Figure 3. Hypothesised Digital Pedagogy readiness structural model

H1: Pre-service teachers' Pedagogical capability exerts a significant predictive influence on Digital Pedagogy readiness.
H2: Pre-service teachers' Content capability exerts a significant predictive influence on Digital Pedagogy readiness.
H3: Pre-service teachers' Technological capability exerts a significant predictive influence on Digital Pedagogy readiness.

Methodology

Study Sample profile

Pre-service teachers were selected from the Faculties of Science, Arts and Humanities, Vocational Studies, as well as School of Management and Entrepreneurship at Kyambogo University in Uganda. The faculties formed the stratum from which pre-service teachers were randomly selected. The data came from a sample of 351 teacher trainees that responded to the survey. Descriptive analysis as presented in Table 1 revealed that the majority of the study participants were males (224/351) representing over 63%, followed by 127 females (36.2%). In terms of their study year, respondents from the third-year cohort made up 59.8% (210/351), while the second years constituted 40.2% (141/351). Going by area of specialisation, participants from the Arts and humanities were the majority (30.8%) followed by those from Business studies (28.2%). Meanwhile those from Science and Vocational studies constituted 21.4% and 19.7% of the respondents.

Table 1.
Description of the study sample

Characteristic	**Category**	**Frequency**	**%**
Gender	▪ Male	224	63.8
	▪ Female	127	36.2
Year of study	▪ Second	210	40.2
	▪ Third	141	59.8
Area of specialization	▪ Arts and humanities	108	30.8
	▪ Business studies	75	21.4
	▪ Science	69	19.7
	▪ Vocational studies	99	28.2

n=351

Measures

The study employed a 30-item scale to measure pre-service teachers' technological- pedagogical-content capabilities and digital Pedagogy readiness. The items were generated after a review of related literature and mainly adapted from Bwalya & Rutegwa, 2023; Castéra et al., 2020; Sarri, 2021; Schmid et al., 2020; Schmidt et al., 2009; Shafie et al., 2022). The scales were adapted from the mentioned studies to suit the context of the current study. A five-response category of the Likert scale of "Strongly Disagree", "Disagree", "Undecided", "Agree", "Strongly Agree" was used for the items. Content capability was measured using 9 items (α=.909), Pedagogical capability with 6 items (α=.861), Technological capability with 8 items (α=.861), and Digital Pedagogy readiness with 7 items (α=.872).

To examine the underlying factor structure of pre-service teachers' technological- pedagogical-content capabilities, exploratory factor analysis was conducted based on Principle Component Analysis with Direct Oblimin rotation. Preliminary checks conducted the measurement items justified the applicability of PCA (Kaiser-Meyer-Olkin Measure of sampling adequacy index=.936, and Bartlett's Test of Sphericity was significant $\chi2(435) = 5595.3$, p=.000). PCA based on direct Oblimin rotation for the 30 items extracted three components, with the solution accounting for 57% of the total variance. As shown in Table 2, the results of Principal Component Analysis further revealed that the factor loadings (a measure of correlation between the manifest variable and the factor) all met the threshold (>0.5).

Table 2.
Pattern Matrix

	Component			
	1	**2**	**3**	**4**
tk1	.739			
tk2	.777			
tk3	.590			
tk4	.636			
tk5	.545			
tk6	.664			
tk7	.637			
tk8	.649			
ck1		.532		
ck2		.582		
ck3		.630		
ck4		.731		
ck5		.866		
ck6		.839		
ck7		.795		
ck8		.811		
ck9		.711		
pk1				.526
pk2				.721
pk3				.644
pk4				.621
pk5				.791
pk6				.750
dpr1			.714	
dpr2			.801	
dpr3			.721	
dpr4			.777	
dpr5			.813	
dpr6			.698	
dpr7			.563	

Note: pk=Pedagogical Capability; tk=Technological Capability; Content Capability), and dpr=Digital Pedagogy readiness

To further establish the convergent and discriminant validity of the relationship between the observed variables and latent constructs, Confirmatory Factor Analysis (CFA) was conducted on the data.

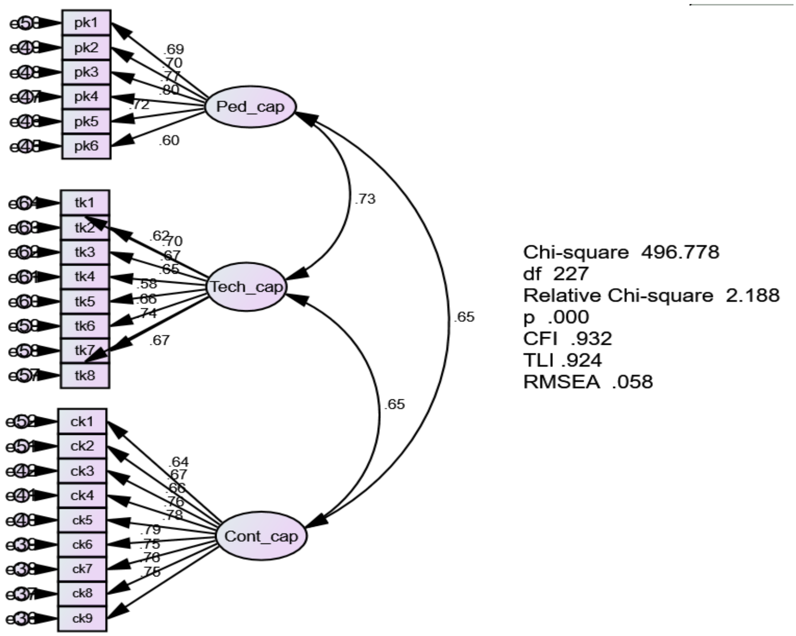

Figure 4. Pre-service Teachers' Digital Pedagogy Readiness measurement model

The results reveal that the three-factor measurement model of pre-service teachers' technological, pedagogical and content capability was satisfactory to represent the data. That is, the observed variables significantly loaded on to each of the factors (As shown in Figure 4). Convergent validity of the factors was established by considering the Average Variance Extracted (AVE) for each of the latent sub-constructs (values along the diagonal in Table…) which exceeded the threshold of 0.5. In addition, the measurement model demonstrated adequate evidence of discriminant validity given that the AVEs exceeded the respective shared variances (shared variances above the diagonal in Table …).

Table 3.
Average Variance Extracted

Dimension	**1**	**2**	**3**
Ped_cap	0.71	0.42	0.53
Cont_cap	0.65	0.72	0.42
Tech_cap	0.73	0.65	0.66

Note: (a) Along the diagonal are the Average Variance Explained (AVE) for the sub-constructs; (c) below the diagonal are the correlations; (c) above the diagonal is the shared variance matrix.

Data assumption checks and analysis procedures

Multivariate data analysis commenced with ensuring that the assumption checks for SEM are met to guarantee the authenticity of the results (Hair et al., 2014). Data normality was checked using Normal p-p plot and absolute skewness and kurtosis values at less than ±1; outliers were screened using Mahalanobis Distance values (with maximum value=13.552< critical value of 16.27 for the three predictors), multi-collinearity was checked for with VIF <10 and Tolerance>.1 (Cont_cap VIF=1.722, Tolerance =.581; Ped_cap VIF=1.882, Tolerance =.531; Tech_cap VIF=1.869, Tolerance=.535). Furthermore, correlation coefficients revealed absence of multicollinearity (r=.586 for Cont_cap and Ped_cap; r=.629 for Ped_cap and Tech_cap, and r=.586 for Tech_cap and Cont_cap). Based on SPSS version 20.0 and AMOS version 25.0, the current study employed descriptive statistics to describe pre-service teachers' perceptions; full-fledged Structural Equation Modeling (Based on Maximum likehood estimation in SEM-AMOS) to establish the validity of the hypothesised digital pedagogy readiness structural model, and thereafter examine the direct causal influence of Technology content and pedagogical capabilities on digital pedagogy readiness.

Results

Descriptive Statistics on Pre-service Teachers' TPACK and Digital Pedagogy readiness

The first objective of this study sought to describe pre-service teachers' perceptions regarding technological-pedagogical-content capabilities and digital pedagogy readiness. To achieve the objective, descriptive data analysis based on percentages and means were employed. As reflected in Tables 2 to 5, pre-service teachers' perceptions per observed construct is presented based on percentages, mean score, and finally the overall mean for the latent construct is determined.

Table 4.
Description of pre-service teachers' agreement on Technological Capability

	Percentage					
	SD	**D**	**U**	**A**	**SA**	**Mean**
▪ I have had opportunities to work with various ICTs	10.5	9.4	8.0	38.5	33.6	3.75
▪ I can learn new technologies with ease	8.0	11.7	8.5	37	34.8	3.79
▪ I can solve basic technical problems related to ICTs	8.8	12.3	14	39	25.9	3.61
▪ I can use web-based/online resources	6.8	9.4	11.1	39.3	33.3	3.83
▪ I frequently play around with ICTs	8.5	6.0	4.6	51	29.9	3.88
▪ I am up to date with current developments in ICTs	4.3	10.5	14	39.6	31.6	3.84
▪ I have the technical skills I need to use various ICTs	6.8	9.1	10	39.9	34.2	3.85
▪ Am able to use online communication tools	6.6	10.8	7.4	41.6	33.6	3.85
Overall Mean						**3.8**

N=351; SD (Strongly Disagree), D (Disagree), U (Undecided), A (Agree), SA (Strongly Agree)

Table 2 reveals that pre-service teachers' level of agreement with technological capability was generally over 70% across the eight measurement items. For example, the items '*I frequently play around with ICTs', 'I have the technical skills I need to use various ICTs'*, and *'Am able to use online communication tools*' showed agreement percentage of 80.9%, 74% and 75% respectively. Such level of agreement was further supported by the overall mean of 3.8, which generally confirmed that the pre-service teachers probably possessed the technological knowledge that is critical for implementing digital pedagogy.

Pre-service teachers' pedagogical capability was measured using six items based on the strongly disagree to strongly agree continuum. Data analysis in Table 3 reveals that teachers were overall in agreement regarding the construct based on the measurement items. For example, over 78% of the pre-service teachers indicated their ability to 'Interpret curriculum documents', with a mean score of 4.02., 'Customize my teaching based on student prior learning' with an agreement level of 71% and mean of 3.85, 'Use a variety of appropriate teaching methods' with agreement level of 70% and mean score of 3.78. Moreover, the overall mean score for the six latent constructs was 3.8, which indeed affirmed the pedagogical capability of the pre-service teachers.

Table 5.
Description of pre-service teachers' agreement on Pedagogical Capability

	Percentage					
	SD	**D**	**U**	**A**	**SA**	**Mean**
Given the training I have received, I am able to:						
▪ Interpret curriculum documents	3.4	9.7	8.5	37.9	40.5	4.02
▪ Plan for teaching	9.1	14	13.7	32.2	31.1	3.62
▪ Use a variety of appropriate teaching methods	5.7	13.7	11.1	36.2	33.3	3.78
▪ Customize my teaching based on student prior learning	6.3	8.5	14.5	35.3	35.3	3.85
▪ Sequence learning content using based on context	5.1	11.7	15.7	34.8	32.8	3.78
▪ Use appropriate methods to elicit learner attention and motivation	6.0	11.4	14.2	30.2	38.2	3.83
Overall Mean						**3.8**

N=351; SD (Strongly Disagree), D (Disagree), U (Undecided), A (Agree), SA (Strongly Agree)

Regarding the descriptive assessment of content capability, data analysis in Table 4 reveals that slightly over 60% of pre-service teachers reported general agreement on the measurement items with an overall mean of 3.7. For example, 66% of the respondents reported that they are "abreast with current trends and developments in my subject area" (Mean=3.85) as compared to a mere 17% disagreement on the same item. This was followed by the item where respondents agreed that they "Know the life applications of my subject area" that yielded 60% with a mean of 3.81. The item that yielded the least level of agreement was that on which pre-service teachers reported to have "sufficient knowledge to develop content in my subject area" with an agreement level of over 57.6%, with a mere disagreement level of 20.6%. Thus, it can be deduced that the pre-service teachers that took part in the study have established sufficient ground in terms of their content area, particularly in terms of strong grasp of concepts and theories in the subject area; ability to customize the content to life applications; and keeping track of the current trends and developments in the subject area.

Table 6.
Description of pre-service teachers' agreement on Content Capability

	Percentage					
	SD	**D**	**U**	**A**	**SA**	**Mean**
Given the training I have received, I:						
▪ Have sufficient knowledge to develop content in my subject area	6.6	14	21.9	17.1	40.5	3.71
▪ Have good understanding of concepts and theories in my subject area	10.8	10.3	19.4	19.7	39.9	3.68
▪ Am abreast with current trends and developments in my subject area	8.0	9.1	17.1	21.7	44.2	3.85
▪ Can use various strategies to develop understanding of my subject area	5.7	14	22.2	17.7	40.5	3.73
▪ Can use the latest sources of information to improve my understanding of the subject	5.1	14.5	21.7	25.6	33.0	3.67
▪ Am able to apply subject-specific thinking to my content area	6.8	12.8	21.7	23.1	35.6	3.68
▪ Know of the resourceful persons in my subject area	7.7	13.1	18.8	27.1	33.3	3.65
▪ Know the life applications of my subject area	6.6	9.4	21.9	20.2	41.9	3.81
▪ Know the historical development of important theories and concepts in my subject area	10.0	12.3	17.4	17.4	43.0	3.71
Overall Mean						**3.7**

N=351; SD (Strongly Disagree), D (Disagree), U (Undecided), A (Agree), SA (Strongly Agree)

As presented in Table 5, seven items were used to measure pre-service teacher digital pedagogical readiness. Descriptive data analysis revealed that all items showed an agreement percentage ranging between 71% and 81%. For example, on the higher side, the item "I feel I can create a supportive learning environment using digital tools" showed an agreement percentage of 80.6% with a mean of 3.97. Meanwhile the item "I feel I can use a mix of digital tools for better student engagement" could be considered to have yielded the lowest agreement percentage of 71.8% with an accompanying mean of 3.83. The overall mean of 3.9 which is closer to 4.0 gives further confirmation to level of agreement regarding digital pedagogical readiness.

Table 7.

Description of pre-service teachers' agreement on Digital Pedagogical Readiness

	Percentage					
	SD	D	U	A	SA	Mean
I feel I can:						
▪ Create learning activities for learners using digital tools	7.4	7.1	7.4	45.3	32.8	3.89
▪ Create a supportive learning environment using digital tools	2.6	8.0	8.8	50.7	29.9	3.97
▪ Use a mix of digital tools for better student engagement	5.4	8.0	14.8	42.2	29.6	3.83
▪ Provide on-going feedback to my learners using digital communication tools	3.7	8.5	15.7	45.0	27.1	3.83
▪ Use digital tools to locate resources for teaching (From Google, YouTube)	3.4	7.4	8.0	49.6	31.6	3.99
▪ Do effective lesson delivery using appropriate digital tools	4.3	9.1	10.3	43.0	33.3	3.92
▪ Assess learners using appropriate digital tools	7.4	6.0	13.7	40.2	32.8	3.85
Overall Mean						**3.9**

N=351; SD (Strongly Disagree), D (Disagree), U (Undecided), A (Agree), SA (Strongly Agree)

Validation of the Pre-service Teachers' Digital Pedagogy readiness structural model

In Figure 4, results emerging from full Structural Equation Modeling for pre-service teachers' TPACK elements and Digital Pedagogy readiness are presented to achieve objective two of this study. Objective two was accompanied with H1 which stated that 'the hypothesized pre-service teachers' digital pedagogy readiness structural model fits the data. Based on the recommendations of (Hair et al., 2014) and Matsunaga (2011), the validity of the hypothesised model was established based on absolute, incremental, and parsimonious indices whose thresholds are as indicated in Table 6. As depicted in Figure 4, the results of Structural Equation Modeling of technological, pedagogical and content capabilities on pre-service teachers' digital pedagogy readiness are presented. There is evidence that the hypothesized structural model demonstrated goodness of fit to the sample data as given by the ($\chi 2/df$) =2.191; CFI=.911>.90; TLI=.903 and RMSEA=.058<.08, which are within the recommended limits by (Hooper et al., 2008; Kline, 2016; Matsunaga, 2010; Schumacker & Lomax, 2016).

Table 8.
Summary of Fit Indices for the structural equation model

Model fit category	Fit index	Level of acceptance
Absolute fit	Chi-square (χ^2)	Below the one in the table for critical chi-square values
	Root Mean Square of Error Approximation (RMSEA)	<.05 to <.08
Parsimonious fit	Chi-square/Degrees of Freedom (χ^2/df)	<3 to <5
Incremental fit	Comparative Fit Index (CFI), Tucker-Lewis Fit Index (TLI)	≥.90

To that end, the fit statistics have confirmed a fitting structural model of the influence of technology, pedagogical and content capabilities on digital pedagogy readiness. In addition, the SEM analysis revealed that TPACK capabilities accounted for up to 47% of the variance in pre-service teachers' digital pedagogy readiness.

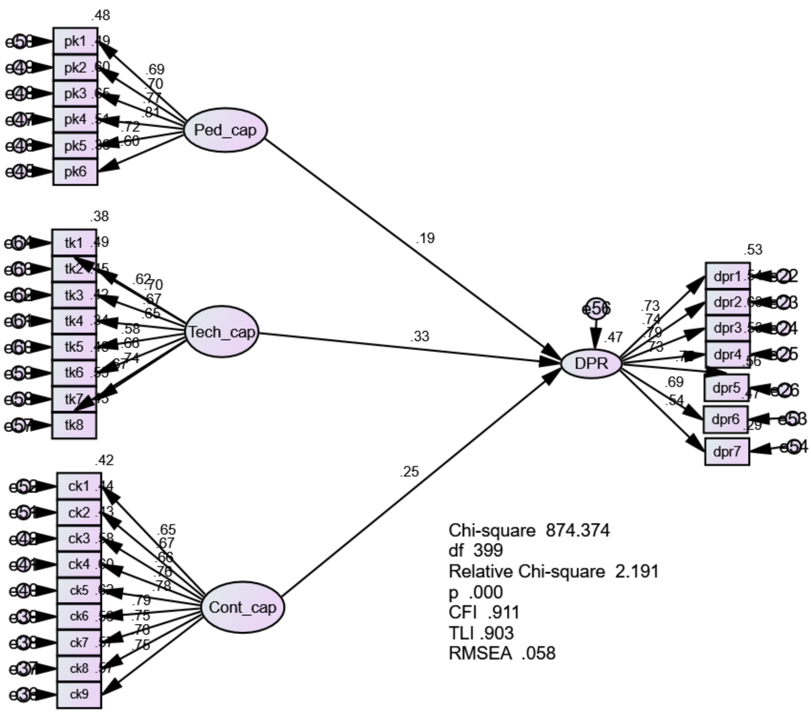

Figure 5. Pre-service Teachers' Digital Pedagogy readiness structural model

Note: Ped_cap (Pedagogical Capability), Tech_cap (Technological Capability), Cont_cap (Content Capability), and DPR (Digital Pedagogy readiness).

Technological-Pedagogical-Content Capability and Digital Pedagogy Readiness

The third objective of the current study sought to examine the influence of TPACK capabilities on pre-service teachers' digital pedagogy readiness, which was accompanied with hypotheses H2 to H4. The three hypotheses were tested using SEM to establish the structural influence of the TPACK capabilities on digital pedagogy readiness. As reflected in Figure 4 and summarized in Table 7, results indicate a positive and statistical influence of the technological-pedagogical-content capability on digital pedagogy readiness. In that respect, the influence of pedagogical capability on digital pedagogy readiness (DPR<---PK) yielded $\beta=.189$, $p=.026$; the influence of content capability on digital pedagogy readiness (DPR<---CK) was $\beta=.250$, $p<.001$; and lastly, the influence of technological capability on digital pedagogy readiness (DPR<---TK) was at $\beta=.331$, $p<.001$. Thus, all the three hypotheses were upheld in view of the statistically significant result, and to that end, objective three of the study was successfully achieved.

Table 9.

Regression Weights and sig. values for the structural model

Structural Paths	Hypothesis statement	β	*p*
DPR ← PK	Pre-service teachers' pedagogical capability exerts a significant predictive influence on digital pedagogy readiness	.189	.026
DPR ←CK	Pre-service teachers' content capability exerts a significant predictive influence on digital pedagogy readiness	.250	***
DPR ←TK	Pre-service teachers' technological capability exerts a significant predictive influence on digital pedagogy readiness	.331	***

***($p<.001$)

Discussion

Guided by Mishra and Koehler's (2006) Technological Pedagogical Content knowledge Framework, the current study aimed at addressing three key concerns. First was to investigate pre-service teachers' perceptions of their technological, pedagogical, content capabilities and digital pedagogy readiness. Descriptive data analysis based on percentages and means revealed that pre-service teachers were generally in agreement regarding items that measured the three capability areas. The study findings support Çakıroğlu et al. (2023), Aziz et al. (2022), Diamah et al. (2022), Sarri (2021), Santos and Castro (2021) where teachers reported high mean scores on Technological Pedagogical Content constructs. The current findings however contradict with those of (Kasirye, 2023) whose assessment of pre-service teacher trainees' abilities to integrate instructional technology reported that pre-service teachers reported as neutral regarding their competencies for technology integration. Meanwhile, Bwalya and Rutegwa (2023) in their analysis reported moderate TPACK self-efficacy among pre-service teachers, noting further that trainees' TPACK self-efficacy was related to their subject specialization, gender and year of study. Schmid et al. (2020) equally reported pre-service upper schoolteachers' technological, pedagogical, content capabilities as moderate based on the mean scores.

The second goal of the paper was to validate the adequacy of the digital pedagogy readiness (DiPeR) model. Results based on SEM revealed a fitting model to the data with all indices within the recommended range with ($\chi 2/df$) =2.191; CFI=.911>.90; TLI=.903 and RMSEA=.058<.08 (Awang, 2015; Hair, Black, Babin, & Anderson, 2016; and Matsunaga, 2011). The validity of the hypothesised digital pedagogy readiness (DiPeR) structural model has confirmed the applicability of the TPCK constructs that were adapted from Mishra and Koehler's (2006) TPACK framework. Zhang and Chen (2022) reported that EFL teachers' TPACK had a positive influence on their application of technology resources in both online and face-to-face instructional settings. Zhang and Chen (2022) however did to indicate which component of TPACK contributed to that influence but rather their overall TPACK. Khine et al. (2019) in their assessment of teacher trainees' TPACK in the ICT context revealed that the technological, pedagogical, content constructs were found to have a statistically significant association with the knowledge that teachers need to integrate technology in the classroom.

The third objective was to establish the predictive influence of technological, pedagogical and content capabilities on pre-service teachers' digital pedagogy readiness. The objective was accompanied by three hypotheses that were tested at 0.05 significance level. Data analysis based on SEM showed that the three variables significantly predicted pre-service teachers' digital pedagogy readiness, accounting for 47% of the variance in the outcome variable. In terms of the individual structural relationships, the predictive influence of technological capability on digital pedagogy readiness yielded β=.189, p=.026. The finding aligns with Aziz et al. (2022) who in their assessment of TPACK readiness and ODL adoption reported a statistically significant relationship between teachers' technological knowledge and readiness to implement Open Distance Learning practices in Malaysian context. In addition, Ali et al. (2020) in their assessment of pre-service elementary school teachers' TPACK reported a statistically significant influence of technological knowledge in integrating TPACK practices in the classroom in Pakistan context. Better still, Abebe (2021) technological knowledge significantly predicted the TPACK self-efficacy and development of pre-service teachers.

Regarding the influence of content capability on digital pedagogy readiness, data analysis revealed a statistically significant result (β=.250, p<.001), with content capability accounting for about 25% variance in pre-service teachers' digital pedagogy readiness. The finding has supported the argument by Mishra and Koehler (2006) that teachers' knowledge of subject matter is critical to how well they understand the extent to which pedagogical strategies and representation of content are altered by technology integration. In terms of empirical findings, Ali et al. (2020) found that CK exerted a statistically significant influence on pre-service elementary school teachers' integration of technology resources in classroom. Similarly, Santika et al. (2021) highlighted the existence of a strong correlation between content knowledge and TPACK practices of Economics teacher trainees. To the contrary however, Abebe (2021) reports that content knowledge did not significantly predict PST's integration of technology into classroom practice.

Lastly, hypotheses three of this study postulated that pre-service teachers' technological capability exerts a significant predictive influence on digital pedagogy readiness. Results from data analysis indeed revealed that technological capability had a statistically significant influence on digital pedagogy readiness at β=.331, p<.001. In other words, technological capability accounted for about 33.1% variance in pre-service teachers' digital pedagogy readiness. As the teachers' ability to understand technology use in the classroom is increasingly becoming a critical component of teacher education and training (Jita & Sintema, 2022), it is equally important that today's teachers are ready for technology integration to upscale their instructional activities (Segal et al., 2021). Indeed, the same voice has been echoed in several empirical studies. For example, Salas-Rueda (2019) pointed out that teachers' knowledge of pedagogical competency enhances the integration of technology into classroom practice, Abebe (2021) found that pedagogical knowledge efficacy showed significantly predictive on pre-service teachers' overall TPACK effectiveness, while Santika (2021) reported that a strong correlation exists between PK and TPACK practices for the pre-service teachers.

Conclusion and Recommendations

Using Kyambogo University as the study context, current study described the perceptions of pre-service teachers' technological-pedagogical-content capabilities and digital pedagogy readiness; established the validity of the hypothesized digital pedagogy readiness model; and established the predictive influence of technological-pedagogical-content capabilities on pre-service teachers' digital pedagogy readiness. Based on the results of the study, it was concluded that; (i) pre-service teachers were in agreement regarding their perceptions of technological-pedagogical-content capabilities and digital pedagogy readiness, (ii) technological, pedagogical and content capabilities significantly impact pre-service teachers' readiness to integrate technology into classroom practice. The results on the validity of the hypothesised digital pedagogy readiness model and influence of technological-pedagogical-content capabilities digital pedagogy readiness have strengthened those postulations made by Mishra and Koehler (2006) in the TPACK framework regarding the role of the core dimensions of technological, pedagogical and content knowledge as enablers of classroom technology integration. In terms of instructional practice, the paper sheds light on the importance of paying attention the three core TPACK components in initial teacher training programmes, which should not only be limited to the pedagogical areas but should cut across the spectrum of pre-service teacher training. Regarding recommendations for further research, two recommendations are forwarded: First, future studies should further investigate how pre-service teachers actually integrate technology in instructional planning, lesson delivery and learner assessment during school practicum given their level of technological-pedagogical-content capability. Secondly, areas of continuous professional development critical to supporting pre-service teachers after they join the teaching profession should be profiled so that adequate support mechanisms are instituted and institutionalized.

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