Factors influencing teachers' adoption of digital technologies in Tanzanian special needs classrooms

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Abstract
In the 21st century, teaching increasingly emphasises the use of digital technologies (DT) to enhance learning and equip students with digital skills. However, in developing countries like Tanzania, the adoption and competence of special needs (SN) teachers in DT integration remain limited. This study investigated the factors influencing the integration of DT in SN classrooms, focusing on both adoption and teacher competencies. A total of 80 pre-service and 7 in-service SN teachers in Dodoma, Tanzania, participated in a survey using an adapted questionnaire based on the Technological Pedagogical Content Knowledge (TPACK) and the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) frameworks. Findings indicated that SN teachers held positive attitudes and demonstrated high competencies in using DT. Technological Content Knowledge (TCK) significantly predicted actual technology use ($\beta = .430$, $p < .001$), while Technological Pedagogical Knowledge (TPK) strongly predicted behavioural intention to use DT ($\beta = .802$, $p < .001$). Despite this, challenges such as limited access to digital tools, a lack of authentic training, and a shortage of SN education technology experts were identified. The study recommends embedding technology-focused training into teacher education programs and providing practical, hands-on experiences to strengthen adoption. By combining TPACK and UTAUT2, this study offers a comprehensive understanding of DT integration among SN teachers in Tanzania. It contributes valuable insights to the field of inclusive education and teacher preparation in low-resource contexts.

Keywords: *TPACK, UTAUT 2, in-service, pre-service, digital tech knowledge, special needs, attitudes*

Introduction

Digital technologies (DT) have the potential to enhance learning outcomes for learners with special needs, particularly those with intellectual, developmental, and learning disabilities (IDLD), in Tanzanian inclusive classrooms. However, their adoption by teachers remains limited by several challenges. In special needs education (SNE), DT can enhance personalised

and interactive learning, encouraging participation, creativity, and autonomous learning for different learners (Badr & Asmar, 2020; Fielding & Murcia, 2022). However, effective integration of DT requires teachers to have suitable digital competencies, positive attitudes, and access to appropriate resources, which are often lacking in Tanzania's resource-constrained educational system (Kafyulilo et al., 2016).

Tanzanian SNE teachers face significant challenges in the use of DT, including limited infrastructure, unavailability of assistive technologies, and limited training on technological pedagogical content knowledge (TPACK; Huang et al., 2020; Lameras & Moumoutzis, 2021). Across African contexts, the challenges such as expensive internet, unavailability of IT hardware, and socio-cultural factors, for example, negative attitudes towards technology, are the same challenges that hinder DT integration, with Tanzania facing some additional limitations due to poor awareness and SNE support (Chikopela et al., 2022; Njoroge et al., 2022). These challenges are most evident in inclusive primary schools, where teachers have to meet multiple learner needs with minimal resources, underscoring the necessity of understanding adoption barriers in this context.

The Tanzanian policies, such as the Persons with Disabilities Act (2010) and the National Strategy for Inclusive Education (2021/22–2025/26), mandate accessible education and teacher training in digital skills to promote equal opportunities for students with disabilities (MoEST, 2021; URT, 2010). However, policy gaps, in terms of poor policy frameworks, scarcity of resources, and low awareness, limit the effectiveness of these mandates in SNE settings (Kisalam & Kafyulilo, 2012). Teachers' digital competencies—encompassing skills to support students' ICT use, design technology-mediated learning environments, and adopt inclusive and creative approaches—are critical for overcoming these barriers and aligning with policy goals (Howard et al., 2021; Lameras & Moumoutzis, 2021).

This study examines Tanzanian SNE teachers' DT adoption determinants, including their technological knowledge, attitudinal preparedness, and behavioural intention in inclusive classrooms for IDLD students. By exploring both in-service and pre-service teachers' experiences, the research aims to provide actionable insights into overcoming adoption barriers, such as limited TPACK and infrastructure constraints, through a pragmatic mixed-methods approach (Venable et al., 2016). The findings seek to inform targeted training programs and policy implementation strategies to enhance

DT integration, ensuring equitable and effective education for students with special needs in Tanzania's resource-scarce context.

Literature Review

Special Education and Special Education Teachers' Training in Tanzania

The Tanzanian government has put forward multiple efforts in the provision of education for learners with disabilities, such as the establishment of inclusive and special schools and integrated units, enhancement of teacher training through the establishment of special needs teachers' colleges, such as Patandi, undergraduate special needs education degree programs in public universities, and provision of some disability assistive devices, such as hearing aids and braille machines (Possi & Milinga, 2017).

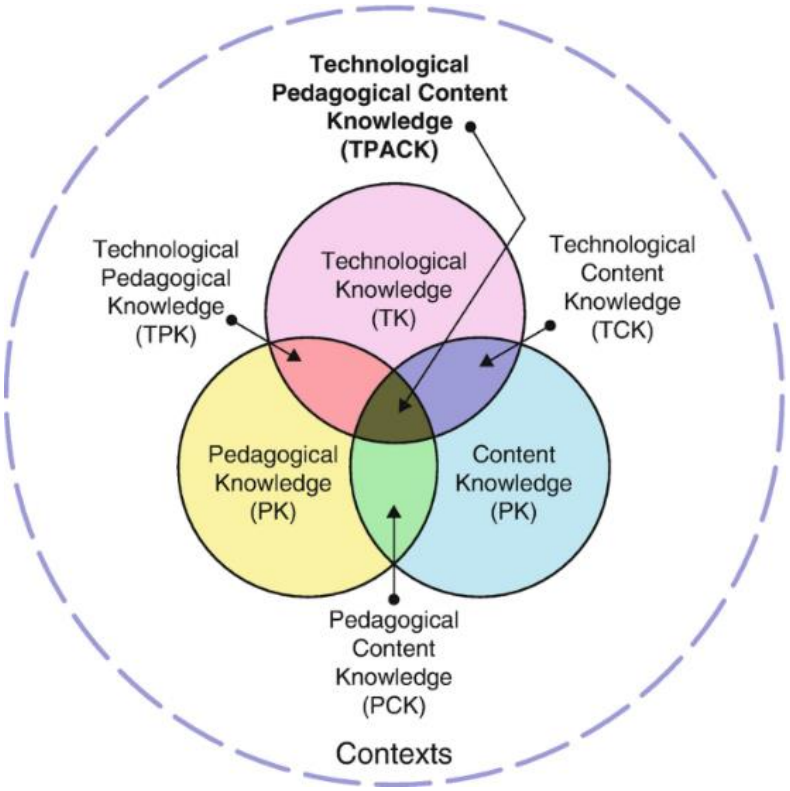
However, Tanzania still faces challenges in disability education, such as a lack of professionals and teaching and learning resources (Ndibalema, 2019; Possi & Milinga, 2017). Among the increasing number of learners with disabilities is the intellectually disabled group (MoEST, 2018, 2019). The National ICT Policy for Basic Education highlights several objectives, including facilitating the development and use of ICT as a pedagogical tool in teaching and learning, and for the professional development of teachers, administrators, and managers. However, it also highlights several challenges, including inadequate training and capacity development, resulting in the underutilization of ICT facilities (URT, 2007).

Theoretical background

Koehler and Mishra (2009) suggest that technology needs to be added to pedagogy and content while teaching today. They further clarified that the active technology is in the form of DT. This means that computers and computer software have now come into play. While other frameworks, such as the European DigCompEdu, exist for assessing teachers' digital competencies, this study adapted the TPACK framework to evaluate both in-service and pre-service teachers' ability to integrate digital technology, ensuring broader applicability. The TPACK framework is formed when pedagogy, content, and technology intersect. The traditional double component that has existed and is persistent among teachers is pedagogical content knowledge (PCK) (Koehler & Mishra, 2009). PCK is the knowledge of better teaching strategies based on the content. Technological content knowledge (TCK) is the knowledge of the technology used for specific content, such as physical, practical simulations. Technological pedagogical knowledge (TPK) is the knowledge of pedagogically suitable technology, such as Web 2.0 tools, presentation software, and game-based software for

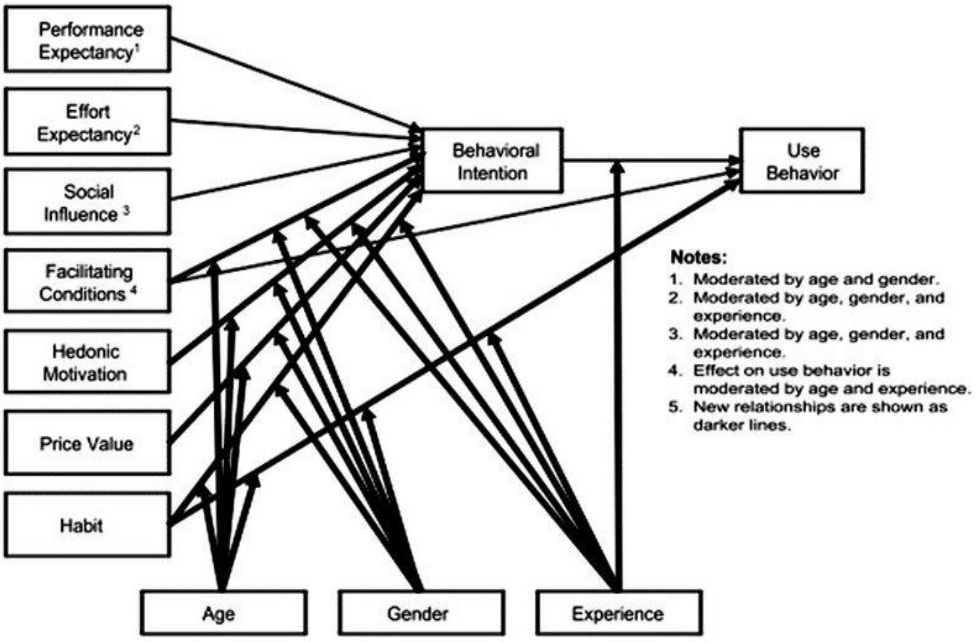
teaching. The intersection of all three forms the TPCK, which is the knowledge of the content with its appropriate technological and pedagogical tools. TPCK was later named TPACK. Figure 1 shows the TPACK knowledge intersections.

Figure 1. TPACK knowledge adapted from (Koehler & Mishra, 2009)



The UTAUT 2 was used because it contains a comprehensive list of technology adoption and use factors from various other technology acceptance models. The model suits the study goal to identify attitudinal, expectations, social and environmental factors influencing technology use by SN teachers (Venkatesh et al., 2012). The UTAUT 2 model has seven factors that determine an individual's intention to use technology. These are performance expectancy (PE), effort expectancy (EE), social influence (SI), facilitating conditions (FC), hedonic motivation (HM), price value (PV), and habit (H). The behavioural intention (BI) determines the use behaviour (UB). These factors were moderated by age, gender and experience. Figure 2 represents the UTAUT 2 model.

Figure 2. The UTAUT 2 model adapted from (Venkatesh, Thong, & Xu, 2012b)



TPACK and UTAUT studies

The integration of DT in teaching and learning requires teachers to have competencies in the use of technologies for subject matter and contexts (Koehler & Mishra, 2009). Pre-service teachers obtain such competencies in their training, while for in-service teachers, various ways, including professional development and self-motivation, can be considered to impart competencies.

Although pre-service teachers' TPACK correlates well with other basic and integrated knowledge domains, technological knowledge (TK) alone does not lead to technology integration in teaching and learning, especially in science subjects (Kartal & Dilek, 2021). Kartal and Dilek (2021) found that TK and TCK did not improve after a technology-based class for pre-service science teachers. They argue that simply introducing instructional technologies and practices into technological integration activities does not necessarily lead to TCK knowledge acquisition. Such knowledge requires the exploration of specific technological tools for a specific subject.

It was observed that SN pre-service teachers in Kuwait had high attitudes toward technology use and understood the potential of using technology in SNE, but needed TPACK knowledge (Alawadh et al., 2019). Alawadh et al.

(2019) assert that pre-service teachers' frequent use of DT did not reflect their self-efficacy in TPACK knowledge integration.

It is a norm that teachers' CK, PK and PCK will be high because they are obtained from the teachers' education programs. Huang, Chen, and Jang (2020b) studied TPACK knowledge among in-service teachers of students with visual impairments in China and Taiwan. It confirmed that the teachers' TPK and TCK were low. This was attributed to limited access to and use of assistive devices, and a shortage of knowledge and skills to use such devices.

With more female teachers in special education in Indonesia, gender is not an issue in TPACK knowledge (Cahyani et al., 2021). This is because all teachers must improve their professions. In contrast, Huang et al. (2020b) found high TK, TPK, and TCK levels among male in-service teachers in China and Taiwan. The study identified that older teachers were more acquainted with CK and PK but needed to improve technology integration than younger in-service teachers.

On the other hand, DT adoption in Tanzania is affected by various factors. Kafyulilo et al. (2012, 2013, 2016) studied ICT integration among pre-service and in-service Science and Mathematics teachers. They identified various factors leading to inefficient teacher preparation and a lack of continual ICT integration. Such factors include limited access to ICTs, a shortage of ICT knowledge among teacher educators, limited use of available ICTs for teacher preparation programs, and personal and institutional factors for continual use of ICTs among Science and Mathematics teachers.

Several attitudinal, competence and environmental factors have been highlighted from the above studies. It has been confirmed that efficacy in basic TPACK knowledge (TK, CK, PK) by teachers' training does not guarantee the integration of technology in classrooms (Kaplon-Schilis & Lyublinskaya, 2019). While it is essential to use technology for disability learning (Lejeune & Lemons, 2021; Shahid et al., 2022), TPACK knowledge among SN teachers seem not sufficient. Little has been reported on TPACK knowledge and DT adoption among K-12 SNE teachers in Tanzania. The study sought to answer the following questions:

i) What are SN teachers' competencies and perceptions of adopting DT in classrooms of students with IDLD in Tanzania?
ii) What TPACK (competence) factors influence the use of DT by SN teachers of students with IDLD in Tanzania?

iii) How can the competencies and adoption of DT by Tanzanian SN teachers of students with IDLD be improved?

The study hypotheses are:
H1: TPACK knowledge influences behavioural intentions to use DT.
H2: TPACK knowledge influences DT use.

Methodology

Study Method

This study employed a quantitative approach to investigate the adoption and digital competencies of pre-service and in-service teachers. Data were collected through a questionnaire. The questionnaire featured a 5-point Likert scale and an open-ended question to assess teacher competencies and adoption factors.

Research Instrument

This study used the adopted TPACK and UTAUT questionnaires to assess digital technology use and competence factors. The TPACK items are adopted from Schmidt, Baran, and Thompson (2009), Koh and Chai (2014a) and Valtonen et al. (2017). Most items in the questionnaire were adopted from Koh and Chai (2014b), a few from Schmidt et al. (2009) and the latest TPACK constructs were extracted from the study by Valtonen et al. (2017). The UTAUT items are adopted from Venkatesh, Morris, Davis, and Davis (2003) and Venkatesh et al. (2012a). The questionnaire contained 41 items in 16 categories of both the TPACK and UTAUT2. It was a 5-point Likert scale. Table 1 shows each item's origin.

Table 1. The instrument items and their origin

SN	Construct	Sample Construct items	Adopted from	No, 0f items
1	Content Knowledge (CK)	I have sufficient content knowledge about Kiswahili teaching.	(Koh & Chai, 2014)	2
2	Pedagogical Knowledge (PK)	I know how to assess a student with intellectual and developmental impairment performance in a classroom. I can assess students with intellectual and developmental impairments learning in multiple ways.	(Schmidt et al., 2009)	5
3	Technological Knowledge (TK)	I know how to solve my technical problems when using digital technologies. I keep up with important new technologies. I can use social media	(Schmidt et al., 2009)	6
4	Pedagogical Content Knowledge (PCK)	Without using technology, I know how to select effective teaching approaches to guide students with intellectual and developmental impairment in thinking and learning Kiswahili subject matter	(Koh & Chai, 2014)	2
5	Technological Content Knowledge (TCK)	I know ICT applications which I can use to better understand the contents of the Kiswahili subject.	(Valtonen et al., 2017)	2
6	Technological Pedagogical Knowledge (TPK)	I can choose technologies that enhance students with intellectual and developmental impairments' learning for a Kiswahili lesson. I am thinking critically about how to use technology in my classroom.	(Schmidt et al., 2009)	7
7	Technological, Pedagogical and Content Knowledge (TPACK)	I can structure activities to help students construct different representations of the content knowledge using appropriate ICT tools.	(Koh & Chai, 2014)	2

SN	Construct	Sample Construct items	Adopted from	No, 0f items
8	Models of TPACK (MTPACK)	My lecturers outside of education appropriately model combining content, technologies and teaching approaches in their teaching.	(Schmidt et al., 2009)	3
9	Performance Expectancy (PE)	Using digital technologies (e.g. mobile phones, laptops, desktops, digital cameras, software, apps, etc.) increases my productivity in teaching.	(Venkatesh et al., 2003, 2012)	2
10	Effort Expectancy (EE)	I find digital technologies easy to use.	(Venkatesh et al., 2003, 2012)	2
11	Social Influence (SI)	People who influence my behaviour think that I should use digital technologies.	(Venkatesh et al., 2003, 2012)	3
12	Facilitating Conditions (FC)	Digital technologies are compatible with other technologies I use.	(Venkatesh et al., 2003, 2012)	2
13	Hedonic Motivation (HM)	Using digital technologies is enjoyable.	(Venkatesh et al., 2003, 2012)	2
14	Price Value (PV)	Digital technologies are a good value for money.	(Venkatesh et al., 2003, 2012)	2
15	Behavioural Intentions (BI)	I intend to continue using digital technologies in the future.	(Venkatesh et al., 2003, 2012)	2
16	Actual Use (U)	Frequent use of Kiswahili learning software, computer applications, printers, photocopiers, interactive whiteboards etc.	(Venkatesh et al., 2003, 2012)	5

The items in the questionnaire were reworded to add the teaching subject (Kiswahili reading) for TPACK constructs and available digital technologies devices for UTAUT constructs. The questionnaire was also contextually modified to reflect the Tanzanian education settings, for example, the use of lecturers in the MTPACK construct. Moreover, some questions about some constructs were left out before the tool reliability check since they were not relevant, for example, the CK construct. The same questionnaire was used for the qualitative part of the study with an open-ended question. The qualitative single open-ended question was constructed from the study question 3 in section 2 above. The questionnaire was later piloted with 24 respondents. The reliability of the questionnaire items was established using Cronbach's alpha and computed using SPSS version 20 to be 0.924. To maintain the high reliability of the questionnaire, some items of the scale and constructs were deleted, such as Habit (H). The items' Cronbach's alphas are shown in Table 2.

Table 2. Questionnaire reliability

Likert Scale	No. of items	Cronbach's alpha
CK	2	.80
PK	5	.76
TK	6	.83
PCK	2	.72
TCK	2	.90
TPK	7	.88
TPACK	2	.89
MTPACK	3	.82
PE	2	.81
EE	2	.85
SI	3	.85
FC	2	.90
HM	2	.80
PV	2	.72
BI	2	.78
U	5	.71

Participants

There are six SNE schools operating in the form of mainstream classes and special-needs units. The participants in this study were in-service teachers from special-needs units in primary schools in Dodoma City, Tanzania. Therefore, special-needs teachers were purposefully selected from these units. Each school unit had at least two special-needs teachers.

The other group of participants was pre-service teachers at the University of Dodoma, College of Education (COED). These participants take a bachelor's

degree in Special Needs Education, aiming to work in either primary or secondary schools' special needs units. The pre-service teachers were third-year second-semester students. The group has also done two teaching practices in Tanzanian public schools for at least two months. Therefore, they are expected to have pedagogical interaction with their respective students. Such a group is conveniently chosen because it has at least a comprehensive coverage of its bachelor's program, and the program is only available at the university. The program admits around 120-150 student teachers yearly. The sample was chosen to construct a ratio of a minimum of 5:1 by Rahman (2013) which is calculated as 14*5, giving a minimum of 70 participants.

Data analysis

The data were loaded into SPSS version 20, and means were computed. The obtained means summarise teachers' competencies and perceptions as per question 1. Data was also analysed for correlation and regression. The correlation was done first to find out which teacher DT adoption factors relate to teachers' TPACK factors. Multiple regressions were also computed to assess the contribution of each factor toward the BI and the use of DT. Correlation and multiple regression provide answers to question 2. Content analysis was performed on unstructured questions to provide insights for question 3. The unstructured question in the questionnaire was analysed using the following steps: familiarisation with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and reporting (Vaismoradi et al., 2013).

RESULTS

Demographic information

The participants were divided into SN in-service and pre-service teacher groups. SN in-service teachers have teaching experience, whereas most SN pre-service teachers have none, as shown in Table 3 (Liana et al., 2022 Special needs teachers TPACK and UTAUT2 Data, Open Science Framework). Perceptions and attitudes have been found to vary with age, gender and experience as per the UTAUT framework. Nevertheless, the degree programs of in-service teachers show their pedagogical and content competence levels.

Table 3. Participants' demographic information

	In-service	Pre-service
Age		
18-25		72
26-33		11
34-41	3	2
42-49	3	2
50+	1	
Gender		
Female	5	49
Male	2	38
Degree Program		
BED-SPEN		80
MPA	1	
BAED	5	
Diploma in Education	1	
Teaching experience (Years)		
13	1	
14	1	
17	2	
19	1	
20	1	
26	1	
Teaching Subject		
Kiswahili	3	35
Others	4	52

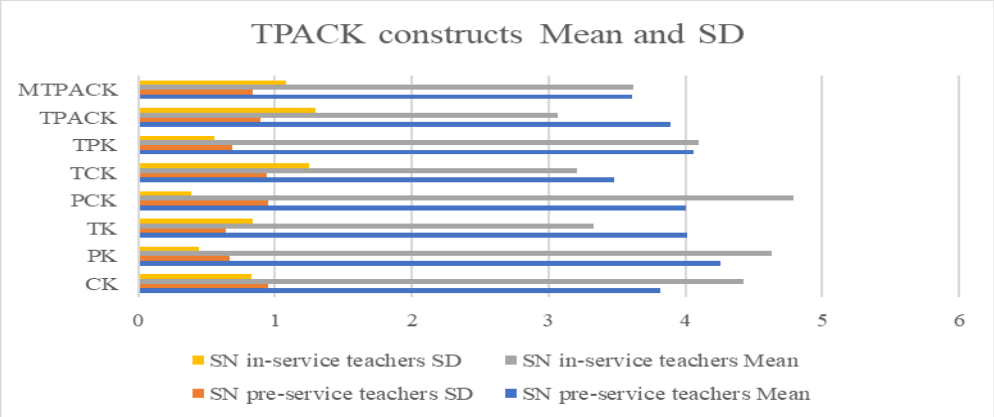
4SN pre-service and in-service TPACK competencies and adoption relationships

TPACK Variables

SN pre-and in-service teachers rated that they have component TPACK knowledge (CK, PK, TK, PCK, TCK, TPK, and TPACK) with minor deviations from the mean for most constructs. While it is common for teachers to have pedagogical content knowledge (PCK, mean=4.00, SD=0.95), SN in-service teachers rate more knowledge compared to pre-service teachers.

SN in- and pre-service teachers also consistently rated to have TK; however, SN pre-service teachers have more TK, Figure 3. SN pre- and in-service teachers have a slight difference in TPK, with in-service teachers having more TPK. SN pre-service teachers have more TCK as compared to SN in-service teachers. Ironically, these SN pre-service teachers seem to have more TPK as compared to TCK. Meanwhile, SN in-service teachers have neutral or medium TPACK, while SN pre-service teachers approach a good level of TPACK. However, both SN teachers agree that their academic role model (MTPACK) influence is neutral.

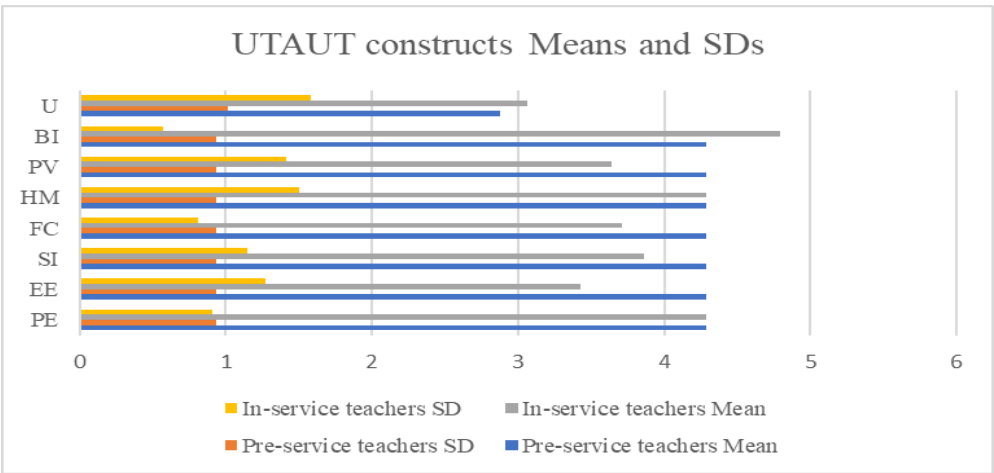
Figure 3. SN pre- and in-service TPACK component knowledge means and standard deviations



UTAUT Variables

Both SN pre-and in-service teachers' expectations of technological adoption in the classroom approach a reasonable level. They are both motivated to use such technologies (HM, mean=4.29, SD_{pre}=.93, SD_{in}=1.50), as seen in Figure 4. However, they both agree to use such technologies rarely. Most SN in-service teachers' UTAUT constructs have greater variability. While both SN pre-and in-service teachers' behavioural intentions to use DT are above a reasonable level, SN in-service teachers have more intentions to use DT in classrooms, Figure 4. Peculiarly, SN in-service teachers are unsure of the effort expectations in using DT in classrooms, while their counterparts' pre-service teachers rate the use of DT slightly higher, Figure 4.

Figure 4. SN pre- and in-service UTAUT component knowledge means and standard deviations.



Relationships between pre-service Teachers' Competencies and technology adoption

Pre-service SN teachers' TPACK component knowledge had significantly low to moderate correlations with other TPACK components of knowledge, as seen in Table 4. Technology adoption factors correlate very highly with each other; for example, performance expectancy is highly correlated with effort expectancy ($r(87) = 1$, $p < 0.01$), similar to all other adoption factors. However, there is no relationship between DT perceptions of pre-service SN teachers and actual use; for example, hedonic motivation towards DT is very low compared to their actual use ($r(87) = .121$, $p > 0.01$), similar to all other adoption factors. The actual use of DT by pre-service SN teachers correlates low to moderate with some of their TPACK knowledge. For example, DT use correlated moderately with TK ($r(87) = .36$, $p < 0.01$), TCK ($r(87) = .37$, $p < 0.01$), TPK ($r(87) = .33$, $p < 0.01$), and MTPACK ($r(87) = .33$, $p < 0.01$).

Meanwhile, pre-service teachers' behavioural intention to use DT is strongly correlated with other DT adoption factors. For example, the behavioural intention to use DT by pre-service SN teachers strongly correlates with their performance, effort expectancy, social influence, facilitating conditions, hedonic motivation, and price value, with $r(87) = 1$, $p < 0.01$. Moreover, the behavioural intention to use DT significantly correlates moderately with some TPACK knowledge of pre-service SN teachers. For example, behavioural intention to use DT was correlated with pedagogical knowledge ($r(87) = .493$, $p < 0.01$), technological knowledge ($r(87) = .36$, $p < 0.01$), technological pedagogical knowledge ($r(87) = .48$, $p < 0.01$), and TPACK ($r(87) = .30$, $p < 0.01$; Table 4). However, their behavioural intention to use DT did not correlate with the actual use of DT.

Nevertheless, TPACK knowledge correlated well with CK, TK, PK, PCK, TPK, TCK, and MTPACK. Moreover, it can be observed that TPACK knowledge significantly correlates moderately with pre-service SN teachers' DT adoption factors, with $r(87) = .303$, $p < 0.01$. However, TPK correlated significantly more with pre-service SN teachers' DT adoption factors than TPACK knowledge ($r(87) = .479$, $p < 0.01$). This means that TPK drives pre-service SN teachers' perceptions of DT adoption. However, there were no significant correlations between in-service SN teachers' DT adoption factors and their TPACK knowledge. This may be because of the small sample size.

Table 4. Correlation matrix for pre-service teachers

	CK	**PK**	**TK**	**PCK**	**TCK**	**TPK**	**TPACK**	**MTPACK**	**PE**	**EE**	**SI**	**FC**	**HM**	**PV**	**BI**	**U**
CK	1															
PK	.263*	1														
TK	.272*	.469**	1													
PCK	.439**	.413**	.291**	1												
TCK	.418**	.348**	.419**	.451**	1											
TPK	.419**	.606**	.571**	.522**	.581**	1										
TPACK	.102	.482**	.433**	.346**	.392**	.629**	1									
MTPACK	.180	.357**	.488**	.243*	.513**	.525**	.515**	1								
PE	.196	.493**	.364**	.263*	.071	.479**	.303**	.243*	1							
EE	.196	.493**	.364**	.263*	.071	.479**	.303**	.243*	1**	1						
SI	.196	.493**	.364**	.263*	.071	.479**	.303**	.243*	1**	1**	1					
FC	.196	.493**	.364**	.263*	.071	.479**	.303**	.243*	1**	1**	1**	1				
HM	.196	.493**	.364**	.263*	.071	.479**	.303**	.243*	1**	1**	1**	1**	1			
PV	.196	.493**	.364**	.263*	.071	.479**	.303**	.243*	1**	1**	1**	1**	1**	1		
BI	.196	.493**	.364**	.263*	.071	.479**	.303**	.243*	1**	1**	1**	1**	1**	1**	1	
U	.191	.111	.362**	.266*	.374**	.329**	.243*	.333**	.121	.121	.121	.121	.121	.121	.121	1

Correlation is significant at the 0.05 level (2-tailed)
Correlation is significant at the 0.01 level (2-tailed)

Pre-service SN teachers' competences influence on DT adoption

This study sought to establish a relationship between pre-service teachers' competence and DT adoption in teaching and learning for learners with intellectual and developmental impairments. The following hypotheses were proposed:

H1: TPACK knowledge predicts behavioural intentions to use DT.

H2: TPACK knowledge predicts DT use

The dependent variable, technology use, was regressed with pre-service SN teachers' technological, technological content knowledge, technological pedagogical knowledge, and models of TPACK using the enter method stepwise. The analysis showed a moderate model fit, with F (1, 85) =15.988, $p < .001$, $R^2 = .158$, and Adj $R^2 = .15$. The analysis showed that pre-service SN teachers' TCK had a significant effect on the use of DT ($\beta = .430$, $t = 3.998$, CI=.216, .643, $p < .001$). Moreover, the dependent variable, behavioural intention to use, was regressed with pre-service SN teachers' pedagogical, technological, technological pedagogical, and TPACK knowledge using the enter method. This analysis also showed a moderate model fit, with F (1, 85) = 46.443, $p < .001$, $R^2 = .353$, and Adj $R^2 = .346$. Technological pedagogical knowledge had a significant effect on behavioural intention to use DT ($\beta = .802$, $t = 6.815$, CI=.568, 1.036, $p < .001$). Gender and age were checked for moderating effects and found to have none. Therefore, the hypotheses hold that there is a relationship between TPACK knowledge and DT use or behavioural intention to use among pre-service SN teachers of learners with intellectual and developmental disabilities. Therefore, Hypotheses H1 and H2 hold for pre-service teachers.

Findings from Open-ended Question

The study included an open-ended question on how to improve teaching and learning using DT among individuals with intellectual and developmental disabilities. Content analysis produced codes and themes, as shown in Table 5.

Table 5. Codes and themes on in- and pre-service teachers' opinions

No	Code	Code Frequency	Theme
1	Policy	2	Policy
2	Government support	10	Provision of DT
3	Provision of digital tools	19	
4	Experts availability	11	Quality SNE
5	Training	27	Training
6	Syllabus/curriculum	6	Quality SNE
7	Accessibility of DT	10	Provision of DT
8	Awareness	5	Training
9	DT use	12	Provision of DT
10	ICT course for student teachers	9	Training
11	Research on teaching with DT	1	Quality SNE
12	Quality special needs education	6	

The most prominent opinion was training. Teachers have suggested training in the form of workshops, a course in degree programs, or a short course on the use of DT for special-needs education. In line with the training, the provision of DT in schools is also a prominent opinion. Teachers pointed out that such devices are not present in schools.

Teachers also suggest that for a quality SNE, expertise, research, syllabi, and curriculum are essential. They argued that experts who can mentor learners with intellectual and developmental impairments should be available. At the same time, experts on DT should also be distributed in schools. Teachers also suggest that university curricula should include a course on DT/ICT for teaching and learning. They further pinpointed that syllabuses should also include DT used in classrooms. Other suggestions were that DT help learners perform better, enable effective teaching and learning, motivate learners, and help with intellectual and developmental learners' memories.

Discussion

This study aimed to identify and explore the relationships between the TPACK knowledge of pre- and in-service SN teachers and their adoption of DT in the classrooms, as a step toward integrating computer-assisted instruction. Means and standard deviations were used to assess teachers' competencies and perception levels, while Spearman's correlation measured the linear correlations between their TPACK knowledge and perceptions of DT adoption. Additionally, regression analysis was conducted on highly correlated variables to determine their predictive capacity.

Both pre-and in-service SN teachers reported strong levels of TPACK knowledge regarding DT despite the limited availability of technology in Tanzanian schools. This contrasts with Weidlich and Kalz (2023), who found low self-assessment of technological knowledge (TK, TCK, TPK, TPCK) among German pre-service teachers as their study progressed. On the other hand, Valtonen et al. (2019) observed increasing technological knowledge (TK, TCK, TPK, TPCK) throughout pre-service teacher training in Finland. In their study, SN teachers demonstrated greater TPK compared to TCK. Consistent with Valtonen et al.'s (2019) study, Tanzanian SN pre-service teachers were found to approach a good level of TPACK. However, the self-assessment differences highlighted in previous studies suggest that Tanzanian SN teachers, who are at an intermediate stage of TPACK acquisition, might overestimate their competencies. On the negative side, that former statement might imply that Tanzanian teachers' TPACK might be low. Therefore, enhancing teacher training curricula and ensuring access to digital learning tools are important steps towards fostering teacher training in Tanzania. Consequently, these SN pre-service teachers should be trained in technology use by including technological content and pedagogical instructional courses with field experiences in teacher training programs.

Unlike in Finland (Valtonen et al., 2019), the models of TPACK in Tanzania seem to have less impact on both pre-and in-service SN teachers. As DT adoption in the Tanzanian education system is still in its early stages, even teacher trainers may lack sufficient knowledge of integrating DT into teaching and learning. This suggests a need for professional development programs focused on training both teachers and teacher trainers in using DT effectively, especially for SNE.

The correlation analysis revealed relationships between SN pre-service teachers' competencies, their intentions to adopt DT and their actual use of it in classrooms. However, this could not be assumed for the smaller group of in-service SN teachers. Although SN pre-service teachers' TPACK knowledge relates significantly to their expectations and perceptions of adopting DT, as in Mohammad-Salehi and Tabrizi (2021), their TPK relates more to their actual use of DT in classrooms. This suggests that teachers' use of DT for teaching and learning, especially among SN students, goes hand in hand with their technological pedagogical capabilities. However, awareness of DT's usefulness does not necessarily translate into effective integration or use, as noted by Wah and Hashim (2021). Limited teaching experience may also contribute to pre-service teachers' low DT use.

Despite their relatively high technological knowledge, SN teachers expressed a need for more DT training to implement it in classrooms effectively. This indicates a lack of confidence in their ability to apply technology in pedagogical and content-related contexts. SN pre-service teachers pinpoint that practical training on some technologies, such as learning applications, devices such as tablets, PCs and whiteboards and their utility would be essential to them. They also emphasised the importance of training in the pedagogical uses of these technologies. Previous studies by Aktas and Ozmen(2021); Alawadh (2019) and Valtonen et al. (2019) similarly, stressed the need for training to enhance teachers' TCK and TPK, which would improve their perceptions and attitudes toward DT use. Tondeur et al. (2020) Recommended pre-service teachers' training includes the synthesis of qualitative evidence (SQD) model strategies, such as role models' influence, reflection on the use of technology in education, inclusion of technology instructional practices in the curriculum, collaboration with peers, authentic experiences of teaching with technology and feedback provision to be essential in enhancing these teachers' perceptions. Authentic learning, as suggested by Strydom, Wessels and Anley (2021), would also benefit Tanzanian SN teachers by aligning training with real-world teaching challenges. This also implies that teacher trainers should lead by example and provide authentic experiences to empower these future educators.

Pre-service SN teachers' TCK predicted 16% of the use of DT in classrooms. This suggests that pre-service SN teachers occasionally use technological subject matter content, similar to the use of actual devices. Valtonen et al. (2019) contended that TCK is challenging to develop as content-specific technologies are rarely used. It can be further contemplated that pre-service SN teachers are not aware of such technological content examples, applications, and simulations; their encounter with DT for such content is also minimal. This is also confirmed by qualitative data – the provision of digital tools is an emerging theme/suggestion. These teachers recommended that the government provide such tools to teachers and schools for their use. Furthermore, pre-service SN teachers' behavioural intention to use was predicted by their TPK.

While Tanzania's DT adoption and competence levels may be comparable to those of other East African countries, such as Kenya and Uganda, similar efforts to enhance DT use among SN pre-and in-service teachers could yield comparable results. However, in countries like South Africa, DT integration in classrooms is more advanced (Strydom et al., 2021), with teachers focusing on improving DT use and addressing the digital divide (Gudmundsdottir, 2010).

Conclusion

This study reveals that Tanzanian teachers' adoption of DT for inclusive classes of students with IDLD is shaped by moderate to high TPACK, particularly in technological pedagogical knowledge, but limited by inadequate infrastructure, insufficient training, and socio-cultural barriers. Pre-service teachers show stronger adoption intentions influenced by their competencies, while in-service teachers face greater variability in perceptions and resource constraints. The findings highlight the need for targeted TPACK-focused training, provision of digital tools, and stronger policy implementation to overcome these barriers. Though the small sample size limits generalizability, suggesting future research with larger samples and longitudinal training evaluations.

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