Educational Dimension, 2025, Vol. **12**, pp. 24–40 https://doi.org/10.55056/ed.785

Assessment of student-teachers' digital competencies across educational aspects: the current status and areas for improvement

Raymond Mutasingwa Bitegeko[1], Godlove Lawrent[1] and Juhudi Cosmas[2]

[1]*Department of Educational Foundations and Continuing Education, The University of Dodoma, 1 Benjamin Mkapa Rd., 41218 Iyumbu, Dodoma, Tanzania*
[2]*Department of Educational Management and Policy Studies, The University of Dodoma, 1 Benjamin Mkapa Rd., 41218 Iyumbu, Dodoma, Tanzania*

Abstract. In the present digital age, improved teacher digital competencies are increasingly becoming an important component of teachers' qualifications. The purpose of this study was to investigate the digital competencies level of student-teachers and probe the areas for improvement. The subject of this study was undergraduate student-teachers in their final year of Bachelor of Education degree programmes from the College of Education at one of the public Universities in Tanzania. Purposive and convenience sampling techniques were employed to get a sample of 549 participants. The study employed the UNESCO ICT Competency Framework for Teachers (ICT CFT) as a theoretical framework. The study employed a quantitative approach and descriptive cross-sectional design. Data were collected through an online survey that included six competency areas linked to teachers' professional practices. Data analysis procedures included descriptive and inferential analysis. The findings revealed that student-teachers perceived their digital competencies as moderately higher at the knowledge acquisition level and moderately low at the knowledge deepening level of ICT CFT. The results also demonstrated that student-teachers were more competent in integrating technology in educational aspects that are indirectly linked to teaching (e.g. teacher professional learning, and organization and administration) and less competent in educational aspects that are directly linked to classroom teaching (e.g. pedagogy, and curriculum and assessment). The study further established a positive and statistically significant association between student-teachers' digital competencies and knowledge acquisition and knowledge deepening levels. The results of the present study signify the importance of developing student-teachers' digital competencies across all educational aspects. However, in order to guarantee technology integration in classroom teaching, it is recommended that teacher education programmes focus more on improving student-teachers' digital competencies in competency areas that are directly linked to classroom pedagogical practices.

Keywords: digital competence, digital transformation, ICT CFT, teacher digital competence, student-teachers, technology integration

1. Introduction

1.1. Background

The digitalisation of education is expected to transform teachers' professional practices and broader educational processes significantly. Emerging technologies are reshaping content delivery, instructional strategies, and assessment, while digital solutions such as internet portals and learning management systems are becoming increasingly common [1, 38, 47]. The effective integration of these technologies relies on

0000-0002-3195-5059 (R. M. Bitegeko); 0000-0002-9119-4255 (G. Lawrent); 0000-0002-9704-3554 (J. Cosmas)
groupsae215@gmail.com (R. M. Bitegeko); godlovelaurent@gmail.com (G. Lawrent); karugendo2007@yahoo.com (J. Cosmas)
https://www.udom.ac.tz/staff/staff_profile?id=VG5wbk1nPT0= (J. Cosmas)

teacher digital competencies (TDC), which play a crucial role in enhancing educational quality [36]. A lack of digital competence can impede educational progress. Although research on TDC is growing, understanding teachers' digital competencies within the broader context of their professional practices remains limited.

Embracing the digitalisation of education is a complex and ongoing process, but teachers as transformative agents play a crucial role, often more significant than other factors [16]. The success of digitalisation largely depends on the quality of teachers' competencies and their perception of the value of educational technologies. Mastery of digital competencies is essential for teachers to effectively engage in a digitalised educational environment [2, 22]. This highlights the importance of understanding the various dimensions of digital competencies necessary for teachers to use digital technologies in education effectively.

The literature on TDC presents various fragmented but related dimensions and specific competencies. Starkey [39] identified three implicit dimensions: general computer use, integrating digital technologies into teaching, and professional digital competence. Skantz-Åberg et al. [37] reviewed seven aspects of TDC: technological competence, content knowledge, attitudes toward technology use, pedagogical competence, cultural awareness, critical approach, and professional engagement. Instefjord and Munthe [13] previously identified three aspects: technological proficiency, pedagogical compatibility, and social awareness. From these classifications, two major themes emerge: competencies directly related to technology integration in teaching and those indirectly related. Technological and pedagogical competencies, which are directly linked to teaching, are the most predominant [37].

Building on the ongoing discussion, TDC can be understood as the knowledge, skills, and values needed for integrating digital technology into professional practices [6, 37, 39]. According to UNESCO [44], TDC encompasses areas such as curriculum and assessment, pedagogy, organization and administration, and professional learning. This study focuses on student-teachers' perceived abilities to utilize digital technologies across these aspects of teaching. In this study, student teachers refer to undergraduate students enrolled in teacher education degree programmes. Despite their enthusiasm for leading educational digitalisation, teachers often hesitate to digitise their own pedagogical practices [14, 27]. Additionally, while student-teachers can easily access digital technologies, they often possess digital "lifestyle" skills rather than digital "workplace" skills [18], which poses challenges for effectively using technologies in their professional activities due to inadequate TDC.

Digital competencies are essential not only for teachers but for all professionals and society at large. The knowledge, skills, and attitudes required for the effective use of digital tools are foundational for success, employability, and prosperity in the digital age [6, 41]. Digital technologies are viewed as a catalyst for achieving all 17 Sustainable Development Goals [19, 35]. This underscores the importance of developing technological competencies among citizens. United Nations General Assembly [45] advocates that educational systems worldwide should prepare learners with the required 21st-century skills, including digital skills. Therefore, it is more critical than ever for teachers to possess a set of digital competencies across various educational aspects.

There is a belief that TDC cannot be acquired intuitively; instead, teachers need training and support through continuing professional development [18]. Pre-service teacher training is considered a critical period for shaping student-teachers' belief systems and introducing them to various TDC [3, 14]. It is also an opportune time to familiarize teachers with technology-enhanced content delivery and instructional strategies. However, previous studies have highlighted a lack of focus on developing TDC within undergraduate teacher preparation programs [14, 39]. Furthermore,

pre-service teacher education programs have been criticized for insufficient training and supporting student-teachers in integrating digital technologies into their future classrooms [2, 8, 18, 25].

According to OECD [30], student-teachers are often inadequately prepared to integrate information and communication technologies (ICT) into their pedagogical practices. Scholarly concerns also highlight that transformative approaches to using ICT for content delivery and instructional strategies are not sufficiently emphasized in teacher education [22]. Developing teachers' digital competencies is a dynamic, contextual, and ongoing process that involves continuous development and assessment. This study aims to examine the current status of student-teachers' digital competencies across various educational aspects within the Tanzanian teacher education context.

1.2. Assessment of teachers' digital competencies

Research assessing teachers' digital competencies often relies on ICT competence frameworks, focusing on both generic digital skills and their pedagogical applications [29, 39]. These studies target various teacher categories, including university student-teachers, teacher training college tutors, and secondary school teachers [11, 15, 17, 21, 26, 28]. Findings indicate that teachers' digital competencies often remain at the entry level, suggesting a lack of progression to more advanced levels [17, 21]. Few studies have examined gaps in teachers' digital competencies across specific levels, such as knowledge acquisition, or between consecutive levels. For instance, Mtebe [26] used ICT CFT to assess secondary school teachers' ICT competencies in the classroom. The study revealed that competencies in pedagogy, classroom management, and assessment scored lower than other ICT CFT domains. This suggests that TDCs are dynamic, highlighting the need for continuing professional development, which may also require continuing assessment.

Investigating the digital competencies of student-teachers and identifying gaps across educational aspects is essential. First, from a theoretical perspective, it helps to extend knowledge on ICT frameworks and educational technologies theories by describing the nature of TDC development from the basic level (i.e., knowledge acquisition) to advanced levels (knowledge deepening) to consecutive levels of knowledge creation. Assessing how intermediate-level competencies (knowledge deepening) build on entry-level skills (knowledge acquisition) is crucial for understanding progress in digital competence development. Secondly, from a practical point of view, it is expected that the study will inform the teacher education practitioners about the areas of TDC aspects where student teachers need more support. As such, the findings will guide teacher education programmes to ensure comprehensive ICT integration across education contexts. TDC should be evaluated based on teachers' ability to use technology in diverse educational contexts [33, 37]. Since pedagogy, curriculum, assessment, and professional development are interconnected, advancements in one area can influence others. The findings will provide empirical evidence on the current status of teachers' preparedness and identify areas for improvement. Additionally, the recommendations may serve as valuable insights for similar teacher education programs in developing countries. The research seeks to answer the following questions:

1. What are the perceived ICT competencies of student-teachers across different aspects of education?
2. What is the nature of the relationship between student-teachers' initial knowledge acquisition in ICT and their subsequent levels of knowledge deepening?

1.3. Theoretical considerations

The present study employed ICT CFT [44] to investigate the TDC of undergraduate student-teachers. Established by UNESCO in 2008, the original ICT CFT was revised in

2011 and 2018 [23]. It highlights 18 competencies that enable teachers to integrate ICT into their pedagogical practices and encourage their professional development through collaboration and networking. The ICT CFT (table 1) emphasises the educational usefulness of technologies across six aspects, namely: *understanding ICT in education, curriculum and assessment, pedagogy, applications of digital skills, organisation and administration*, and *continuing teacher professional learning* [44]. The framework further highlights three consecutive levels of teachers' digital competencies proficiency: basic level of knowledge acquisition, intermediate level of knowledge deepening, and advanced level of knowledge creation [44].

ICT CFT is a progression framework in nature, providing guidelines for training and supporting teachers' digital competence development. For example, in the pedagogy aspect, the model proposes competencies ranging from having the ability to integrate technology into the existing pedagogical practices through complex problem-solving to self-management in knowledge society [44].

Table 1
The UNESCO ICT CFT [44].

educational aspects	**knowledge acquisition**	**knowledge deepening**	**knowledge creation**
understanding ICT in education	policy understanding	policy application	policy innovation
curriculum and assessment	basic knowledge	knowledge application	knowledge society skills
pedagogy	ICT-enhanced teaching	complex problem-solving	self-management
applications of digital skills	application	infusion	transformation
organization and administration	standard classroom	collaborative groups	learning organization
teacher professional learning	digital literacy	networking	teacher as innovator

The ICT CFT is internationally recognised and a reference in many national educational systems. Interestingly, Tanzania's ICT competency standards for teachers (ICT-CST) [42] is compatible with the first two levels of ICT CFT: knowledge acquisition and knowledge deepening. Accordingly, these two levels were the focus of assessing student-teachers' digital competencies in the Tanzanian context. These levels of digital competency proficiency are briefly described in the subsequent paragraphs.

Knowledge acquisition is considered as an entry level of TDC. At this level, the ICT CFT emphasises elementary competencies to support relevant educational aspects, including basic technological knowledge and integrating ICT in pedagogical practices [44]. At this level, competent teachers are expected to use technological tools and resources to enhance learning goals, organise standard classrooms, and support their own professional learning [23]. Ideally, the anticipated competencies at knowledge acquisition are similar to those competencies like technological knowledge of the TPACK model [24] and competencies at the basic level of the DigCompEdu framework [34].

Knowledge deepening is considered an intermediate level of ICT CFT. Unlike the previous level, the focus of knowledge deepening is to deepen teachers' ability to use ICT to help students apply knowledge to solve complex problems encountered in real-world situations [44]. Knowledge deepening linked to this level includes teachers' ability to use specific classroom experiences to address national ICT-related goals and priorities, adaptation of learner-centered and collaboration, and project-based learning. In addition, in professional learning, teachers are expected to use technology to create a professional network.

Tanzanian Education and Training Policy [46] underscores the importance of training and supporting the development of TDC among teachers' candidates. In this regard, in Tanzania, teacher education programmes are mandated to prepare teachers with the required set of digital competencies. In response to the need to develop the digital competencies of student-teachers, technology courses focusing on the introduction

to information technology and educational technology and media are core courses in most teacher education programs. In most cases, these courses, which are provided in an isolated model, serve the purpose of introducing teacher candidates to basic ICT skills, which signifies the development of entry-level competencies related to basic computer operations. However, teacher training has been criticised as being ineffective in developing advanced competencies related to knowledge deepening in aspects of ICT in education [10]. According to UNESCO [44], TDC at advanced levels of knowledge deepening and knowledge creation are needed as essential catalysts for pedagogical transformation and the creation of a knowledge society.

2. Methodology

2.1. Research approach and design

This study employed a quantitative research approach and cross-sectional descriptive design [7]. The nature of the study itself influenced the use of a quantitative approach, as quantitative methods are ideal for objectively measuring perceptions and relationships between variables across a large sample [7]. In particular, for research question one, numerical measures facilitate measuring perceived ICT competencies across a broad range of participants, ensuring representativeness and generalizability. On the other hand, to answer research question two on the relationship between initial knowledge acquisition and subsequent knowledge deepening requires data on both variables and a numerical measure of correlation. In this regard, the quantitative approach ensures precise, replicable insights into the patterns between initial and deepening ICT competencies. In addition, basically, the study was cross-sectional descriptive as its purpose was to describe the specific characteristics (i.e. TDC) of student-teachers at a single point in time. Understanding the current status of student-teachers' digital competencies is an important step towards establishing the areas for improvement.

2.2. Context and sampling

Purposive and convenience sampling techniques were employed among a population of 650 final-year student-teachers from the Department of Educational Foundations and Continuing Education at the University of Dodoma. Final-year student-teachers were purposively targeted due to their presumed better understanding of the academic environment and technological pedagogical competencies. Convenience sampling was used to reach accessible and willing participants within this group. Combining both techniques ensured practicality and efficiency, allowing for context-specific data collection from readily accessible participants [9]. Most participants [376 (68.61%)] were aged 21-25, followed by those aged 31 and above [108 (19.71%)], 26-30 years [58 (10.58%)], and the lowest age group was 16-20 years [6 (1.01%)].

2.3. Instrumentation and data collection processes

A self-developed questionnaire with 52 items was designed to assess teachers' digital competencies in integrating technological tools into education. The items were organized into six educational aspects based on ICT CFT. The assessment focused on two successive proficiency levels: knowledge acquisition and knowledge development levels (see figure 1 for the study's conceptual model).

The first aspect, understanding ICT in education, emphasizes equipping teachers with competencies related to ICT national policy [44]. At the knowledge acquisition level, teachers are expected to be aware of and apply national and institutional ICT policies in education, including identifying guidelines for ICT integration. At the knowledge deepening level, teachers should develop competencies to understand

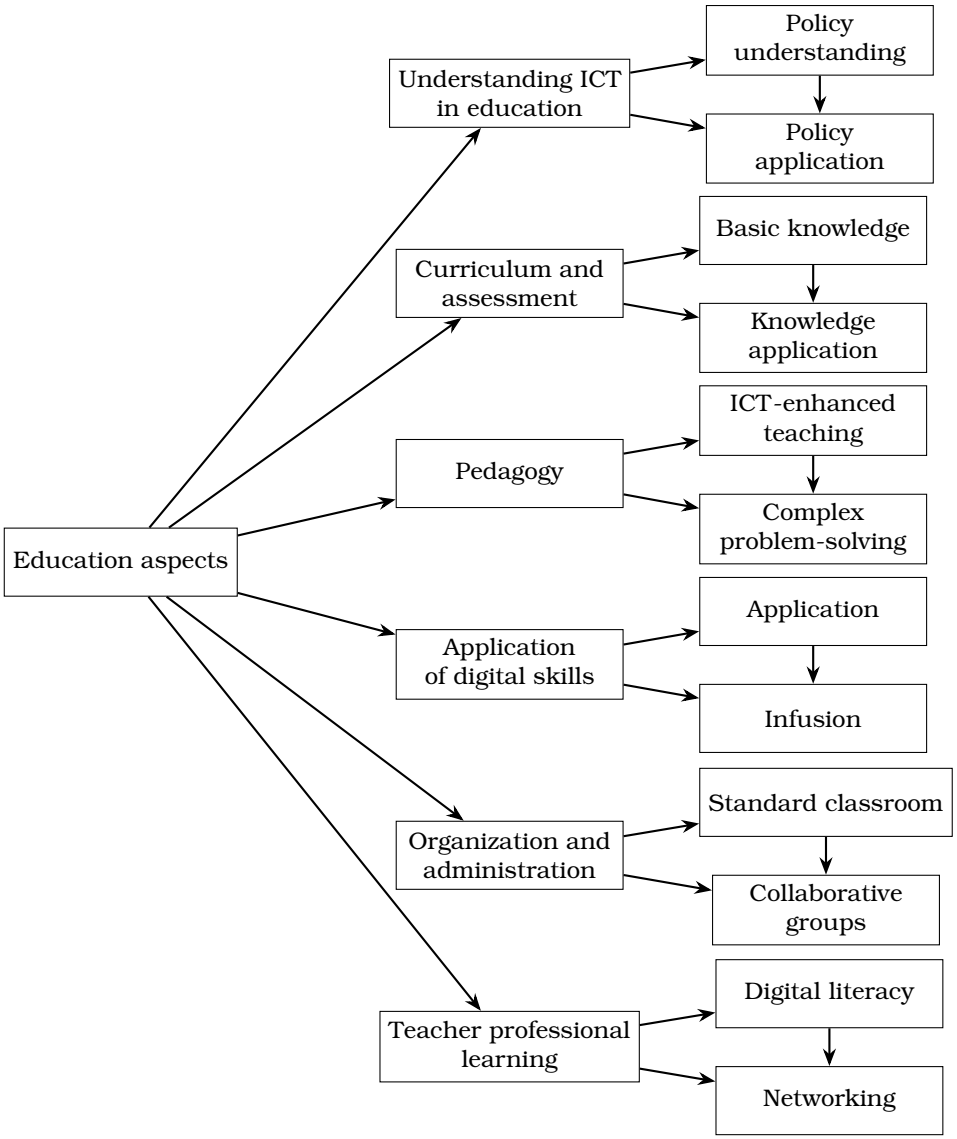

Figure 1: Teachers' digital competencies conceptual model.

ICT in education and effectively integrate it into the curriculum to enhance learning outcomes.

The second aspect, curriculum and assessment, emphasizes teachers' competencies in achieving curriculum objectives and technology-enhanced assessment [21]. At the basic knowledge acquisition level, the focus is on teachers' understanding of how ICT can be used pedagogically—the advanced knowledge deepening level targets teachers' ability to incorporate ICT into both teaching and assessment effectively.

The third aspect, pedagogy, focuses on enhancing teachers' ICT competencies to improve pedagogical practices [44]. This aspect is closely tied to teachers' core responsibilities of teaching and learning. At the knowledge acquisition level, teachers are expected to integrate technology into traditional teaching methods, developing skills to implement technology-enhanced approaches that support teaching and learning. At the knowledge deepening level, teachers should be able to apply ICT to address complex challenges, such as designing technology-enhanced project-based learning and facilitating ICT-enabled collaborative learning.

The fourth aspect, the application of digital skills, requires teachers to acquire competencies related to the educational application of basic digital tools. At the first

level of knowledge acquisition, basic tool competence involves abilities to demonstrate fundamental ICT skills and knowledge, such as the use of the internet and browser to support teaching. The second level of knowledge deepening cherishes competencies related to infusion, applying advanced ICT skills in educational contexts. These focus mainly on teachers' abilities to apply ICT in transformative ways to promote teaching and learning.

The fifth aspect, organization and administration, probes teachers' competencies in classroom administrative use of technologies to facilitate communications and collaboration. It probes teachers' ability to leverage ICT for efficient management of ICT resources within educational settings and supports effective classroom management.

The final aspect, teacher professional learning, focuses on using ICT for ongoing development. At the knowledge acquisition level, teachers need digital skills to join professional learning networks. At the knowledge deepening level, networking competencies are essential for advancing professional growth and reflective teaching.

The questionnaire Likert scale consists of five answer options (1 = strongly disagree to 5 = strongly agree). Table 2 presents the sample items.

Table 2
Sample of questionnaire items.

Competency	**Sample items**
	Knowledge acquisition level
Policy understanding	I am understanding of national policies and priorities related to ICT in education
Basic knowledge	I can compare specific curriculum standards to particular software
ICT-enhanced teaching	I can use ICT to meet the learning needs of learners of different needs
Application	I can use common computer hardware such as printers and scanners
Standard classroom	I can organise students and digital tools in the learning environment
Digital literacy	I can use ICT resources to enhance the virtual learning environment
	Knowledge deepening level
Policy application	I can explain, analyse and apply the principles of using ICT in education
Knowledge acquisition	I can learn management platforms (e.g. Moodle, Blackboard)
Complex problem-solving	I can design ICT-supported project-based learning activities
Infusion	I can operate software packages that are appropriate to the subject area
Collaborative groups	I can share electronic content using file-sharing applications (e.g. Dropbox, Google Drive)
Networking	I can use an online support forum to ask for and share teaching and learning resources

The questionnaire was validated through multiple strategies. For content analysis, two senior lecturers reversed the questionnaire items to validate their contents, and the suggestions given were incorporated. Next, a pilot study was carried out with 25

student teachers who shared similar backgrounds with the targeted participants.

The questionnaire's reliability was tested through Cronbach's alpha coefficient. The Cronbach's alpha coefficient for each competence domain was as follows: policy understanding (.788), basic knowledge (.693), ICT-enhanced teaching (.803), application (.726), standard classroom (.809), digital literacy (.724), policy application (.718), knowledge application (.754), complex problem-solving (.771), infusion (.786), collaborative groups (.801), and networking (.832). With the exception of basic knowledge (.693), other domains yielded Cronbach's alpha values above 0.7. Together, they are considered accepted for social science research [32].

Subsequently, a histogram with a fitted normal distribution curve and Q-Q (Quantile-Quantile) were used to test data normality across all items. As indicated in figures 2 and 3, the visual inspection suggests approximate normality.

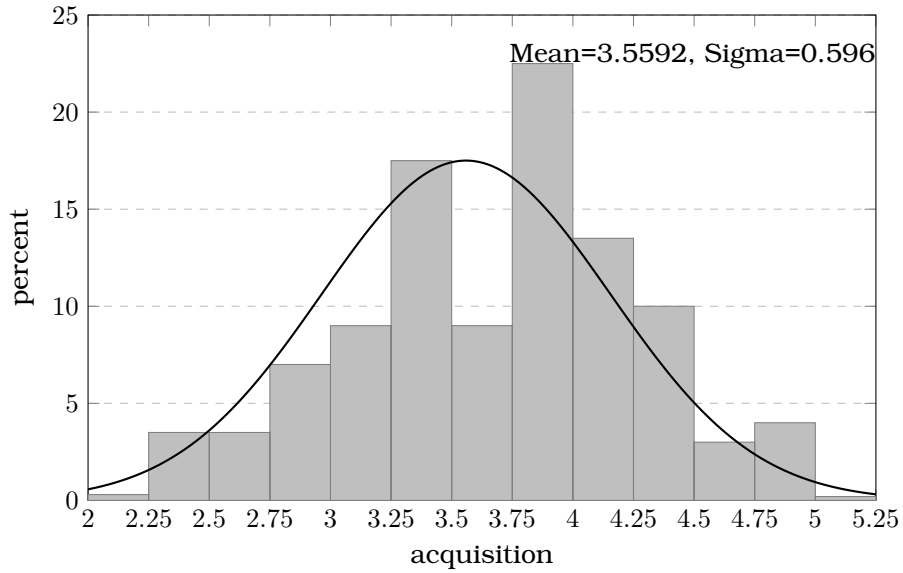

Figure 2: A histogram with a fitted normal distribution curve [5, p. 304].

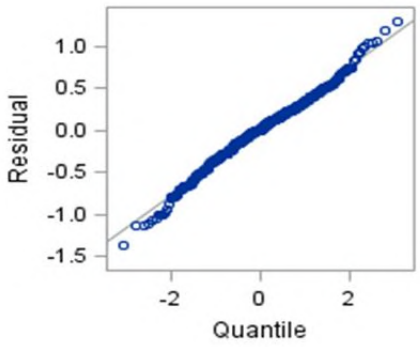

Figure 3: Q-Q plot [5, p. 305].

The questionnaire was constructed using a Google Forms application. Data were collected virtually. Initially, the targeted sample was informed about the study's objective and asked to participate voluntarily. The Google Forms link was shared among prospective respondents through social media, including WhatsApp groups. Responses were accepted within one week after 549 responses were guaranteed; hence, access to the Google survey form was closed.

2.4. Data analysis

Descriptive and inferential statistics were performed through the SPSS software. Descriptive analysis was carried out to answer research question one on perceived ICT competencies of student-teachers across aspects of education. This involved the performance of descriptive statistical central tendencies including means, standard deviations and percentages [7]. Next, inferential analysis was performed in order to answer research question two, which is about determining the nature of the relationship between student-teachers' initial knowledge acquisition in ICT and their subsequent levels of knowledge deepening. At this stage, inferential analysis involved multiple linear regression analysis to ascertain the correlation between digital competencies at initial knowledge acquisition and the succession level (i.e. knowledge deepening).

3. Findings

3.1. Student-teachers' perceived digital competences

Student-teachers' self-assessment of their digital competencies was assessed in six areas related to teachers' professional practices. By employing a Likert scale, each aspect was also assessed at two levels of knowledge acquisition (KA) and knowledge deepening (KD), respectively. In the context of this study, it is important to note that Likert-scale responses were treated as ordinal data. While the numerical values indicate ranking, it does not infer proportional differences between them. Instead, patterns and relative comparisons were analysed without assuming that a response of '4' is twice as significant as a response of '2'. This approach ensures valid interpretations and prevents misrepresentation of respondents' perceptions. Table 3 presents the descriptive statistical findings for each level along with the corresponding aspect. The findings are based on a Likert-type assessment of 1 to 5. Based on this scale, the interpretations of mean scores were based on three categories: low (1.0-2.3), moderate (24-3.6), and high (3.7-5.0).

Table 3
Student-teachers' perceived digital competencies.

Educational aspects	**Competence levels**	**Mean**	**Standard deviation**
Understanding ICT in education	Policy understanding (KA)	3.53	0.80
	Policy application (KD)	3.43	0.78
Curriculum and assessment	Basic knowledge (KA)	3.60	0.77
	Knowledge application (KD)	3.30	0.85
Pedagogy	ICT-enhanced teaching (KA)	3.55	0.76
	Complex problem-solving (KD)	3.12	0.71
Application of digital skills	Application (KA)	3.60	0.81
	Infusion (KD)	3.34	0.84
Organization and administration	Standard classroom (KA)	3.56	0.83
	Collaborative groups (KD)	3.54	0.81
Teachers' professional learning	Digital literacy (KA)	3.52	0.69
	Networking (KD)	3.64	0.83
Overall, KA		**3.55**	0.66
Overall, KD		3.49	0.71

The descriptive findings in table 3 indicate that overall, student-teachers' digital competencies in both knowledge acquisition and knowledge deepening across all

six aspects are moderate. However, perceived digital competencies in knowledge acquisition are slightly higher than knowledge deepening, indicating a gap between knowing and doing.

The findings reveal that student-teachers' digital competencies are generally at moderate levels across various aspects. In understanding ICT in education, both policy understanding (mean=3.53) and policy application (mean=3.43) are moderate, indicating a gap between awareness and deeper understanding. In curriculum and assessment, basic knowledge (mean=3.60) is notably higher than knowledge application (mean=3.30), suggesting a stronger grasp of fundamental ICT concepts than their application in assessments.

The pedagogy aspect shows a significant disparity, with a higher mean for ICT-enhanced teaching (3.55) compared to complex problem-solving (3.12), highlighting a need for training in problem-solving with technology. In applications of digital skills, proficiency is moderate for application (mean=3.60) but lower for infusion into teaching strategies (mean=3.40). The organization and administration aspect shows moderately high scores for both standard classroom (3.56) and collaborative groups settings (3.54). Lastly, in teacher professional learning, higher competence is observed in networking (mean=3.64) than in digital literacy (mean=3.52), indicating a need for further development in digital skills and reflective practices.

The mean values of student-teachers' digital competencies across six educational aspects are summarized in figure 4. Among these aspects, teacher professional learning has the highest mean (3.58), followed by organization and administration (3.55). Conversely, pedagogy has the lowest mean (3.34), indicating a relative weakness in this area compared to others.

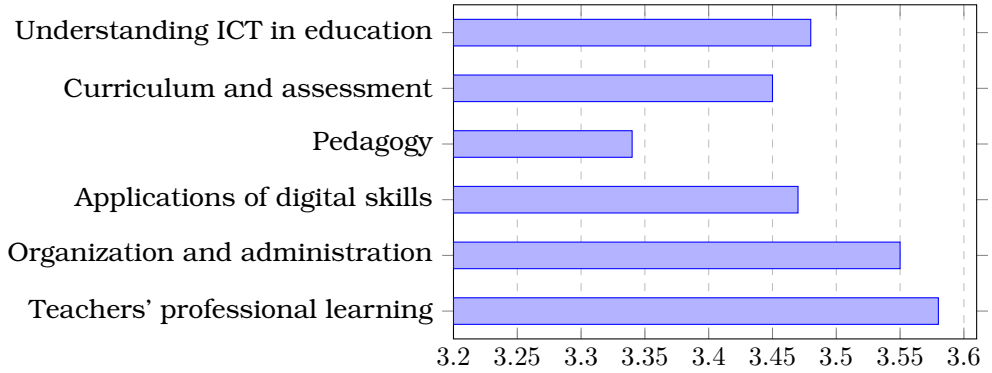

Figure 4: Mean values of student-teachers' digital competencies.

Figure 5 illustrates the response distributions for knowledge acquisition and knowledge deepening levels. The results show that a higher percentage of knowledge acquisition respondents (54.28%) had more agreement compared to knowledge deepening respondents (42.62%). Knowledge deepening had slightly more disagreement (4.74%) compared to knowledge acquisition (3.64%). Generally, the majority of responses fall under 'agree' and 'neutral', establishing that student-teachers had positive or neutral perceptions, with more respondents in knowledge acquisition agreeing compared to knowledge deepening.

The substantial proportion of neutral responses for both knowledge acquisition (46.08%) and knowledge deepening (35.70%) indicate that more than one-third of the respondents neither agreed nor disagreed with the ICT CFT statements presented to them. This might indicate varied perceptions and uncertainty among student-teachers regarding teachers' digital competencies across the presented educational aspects. In addition, the findings might echo the lack of enough knowledge about teachers' digital

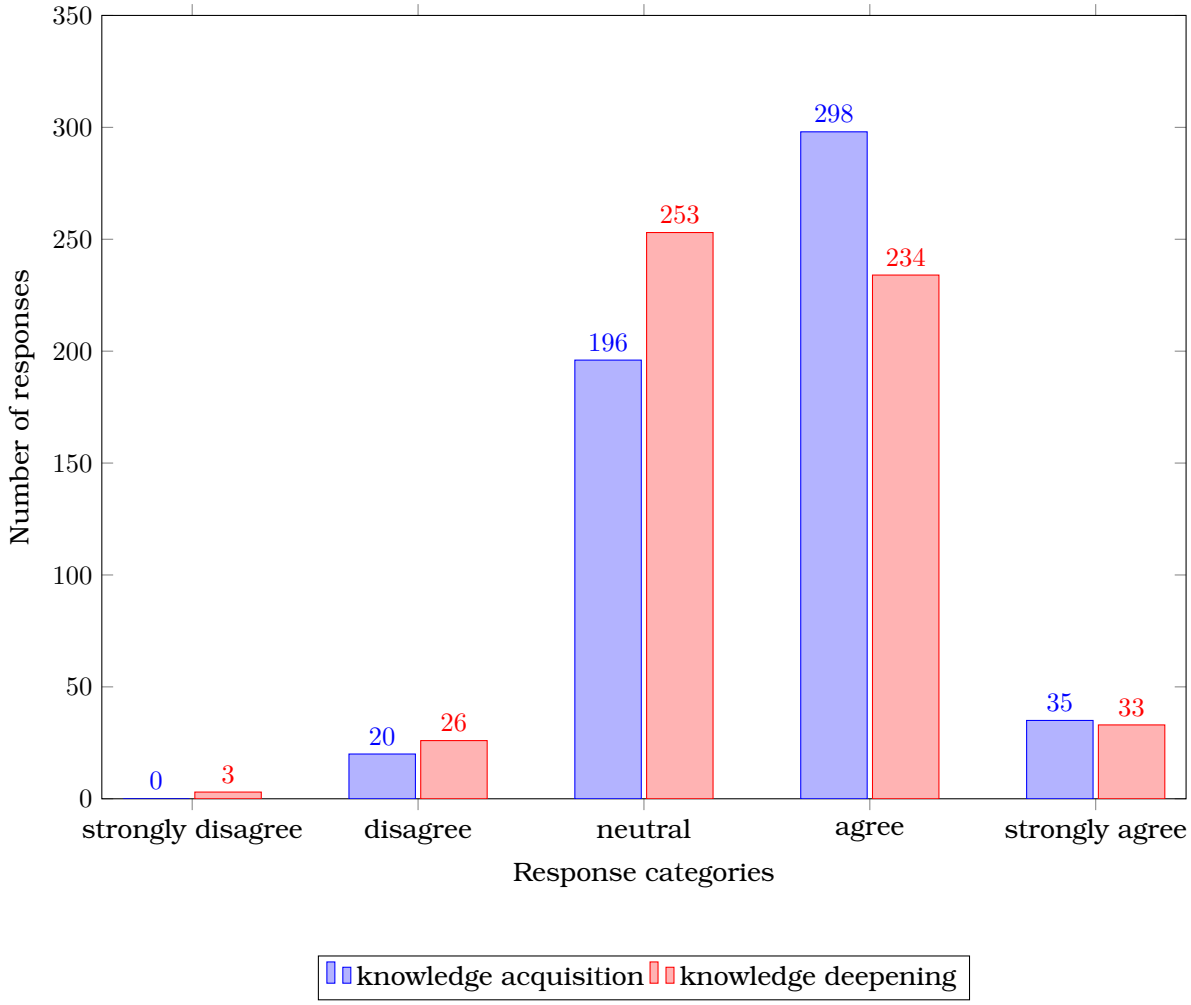

Figure 5: Responses distribution for knowledge acquisition and knowledge deepening based on ICT CFT.

competencies to inform a strong opinion.

3.2. Nature of the relationship of student-teachers' digital competencies between knowledge acquisition and knowledge deepening levels

Research question two was set to probe the nature of relationship of student-teachers' perceived digital competencies between two consecutive levels of ICT CFT. To this end, multiple linear regression analysis for the association between knowledge deepening and knowledge acquisition was carried out. Dummy variables were created for the categorical variables before being included in the model.

The results show that knowledge deepening was statistically significantly associated with knowledge acquisition ($p < .0001$). It was observed that a unit increase in knowledge acquisition results in an average increase of knowledge deepening by 0.83152 units.

Gender and age categories as explanatory variables are not statistically significant at the conventional 0.05 level. Specifically, the estimate of males (-0.06383) indicates that while there is a slight negative association compared to females, it is not statistically significant. These findings suggest that male and female responses are generally similar. This might limit any substantial effect of gender on the dependent variable. Similarly, the age categories (21-25, 26-30, and 30+ years) have relatively high p-values, indicating no statistically significant difference from the reference category

Table 4
Multiple linear regression analysis.

Variable	**Parameter estimates**	**Standard error**	***t*-value**	***p*-value**	R^2
Intercept	0.38108	0.17962	2.12	0.0343	0.513
Knowledge acquisition	0.83152	0.03017	27.57	**<.0001**	
Male	-0.06383	0.03616	-1.77	0.0781	
Female	Ref				
16-20	Ref				
21-25 years	0.11604	0.15516	0.75	0.4549	
26-30 years	0.11877	0.16350	0.73	0.4679	
30 and above years	0.00397	0.15974	0.02	0.9802	

(16-20 years). This is because, possibly, the dependent variables (e.g., knowledge deepening) are equally distributed across age groups. Furthermore, the insignificant effect of age might be due to age range, as it does not capture enough variation in behaviour or characteristics relevant to the dependent variable. Finally, the strong significance of knowledge acquisition (i.e., $p < .0001$) suggests that it explains a substantial amount of variation in the dependent variable. This could overshadow relatively small associations with gender and age, which may contribute to their lack of significance.

4. Discussion

The importance and necessity of equipping 21st century teachers with technological competencies are well recognised at the global scale [44]. It is envisioned that pre-service teacher training is an ideal time to equip inspiring teachers with digital competencies essential to navigate their future professional responsibilities [4, 20, 40]. Among other ICT conceptual frameworks, ICT CFT is highly recommended for guiding the development and assessment of digital competencies of teachers of different categories. In Tanzania and elsewhere, ICT CFT has been used to assess the digital competencies of secondary school teachers [17, 26] and tutors of teachers' colleges [21]. The key finding from these studies is that teachers' digital competencies are confirmed at the initial level of knowledge acquisition.

However, there are very few empirical studies ascertaining the digital competencies of student-teachers based on ICT CFT (e.g. Harada et al. [12], Ogundolire [31]). The present study applied ICT CFT to evaluate the digital competencies of student-teachers in pre-service teacher education at one of the largest university-based colleges of education in Tanzania. The study investigated the current status of undergraduate student-teachers' digital competencies and proposed areas for improvement.

Descriptive analysis showed that the majority of the surveyed undergraduate student-teachers perceived their digital competencies as moderate at both knowledge acquisition and knowledge deepening levels of ICT CFT across six aspects of education. However, student-teachers' perceptions of digital competencies were moderately higher at the initial knowledge acquisition level than at the consecutive level of knowledge deepening. These findings are related to the previously published findings, indicating the low to moderate level of student-teachers and newly qualified teachers' digital competencies [11, 12, 31, 43].

Descriptive analysis reveals that student-teachers' responses showed the highest competencies in teacher professional learning and organization and administration. These areas reflect their abilities to use digital technology for collaboration and networking, aligning with Štemberger and Konrad [40], who found that student-

teachers are more adept at using digital tools for these purposes compared to other tasks. This proficiency may stem from the widespread use of digital technologies for social networking [4]. However, the focus on generic technological skills rather than educational application may limit their effectiveness in enhancing collaborative pedagogical practices [39]. Thus, it is recommended that teacher training programs further develop digital literacy and invest in strengthening networking and collaborative skills to foster more effective professional learning communities.

The pedagogy aspect had the lowest mean score, followed by curriculum and assessment. The findings of this study concur with those of Ogundolire [31] and Tárraga-Mínguez, Suárez-Guerrero and Sanz-Cervera [43] whereby student-teachers reported a lack of digital competencies in the area of pedagogy and application of digital skills in teaching and learning. The actors, such as lack of authentic experiences and project-based learning related to direct pedagogical use of ICT, might precipitate these findings. Educational aspects such as pedagogy, curriculum and assessment, as well as application of digital skills are more closely related to teaching and learning. Therefore, the lack of digital skills linked to these aspects poses challenges in developing digital competencies among teachers.

The findings further indicated that the majority of student-teachers' responses fell under 'agree' and 'neutral', establishing that student-teachers have positive or neutral perceptions. The substantial proportion of neutral responses for both knowledge acquisition (46.08%) and knowledge deepening (35.70%) indicate varied perceptions and uncertainty among student-teachers regarding teachers' digital competencies across the presented educational aspects. In addition, the findings might echo the lack of enough knowledge about teachers' digital competencies to inform a strong opinion.

The multiple linear regression analysis established positive and statistically significant associations between the development of digital competencies at knowledge acquisition and knowledge deepening levels of ICT CFT. This observed positive and statistically significant parameter estimate for knowledge acquisition suggests that improvement of competencies at the initial stage is strongly associated with positive competence development at the subsequent competence level. The findings highlight the importance of the development of basic technological competencies as they influence advanced digital competencies. According to UNESCO's ICT CFT [44], teachers should be trained and supported on their journey of learning to teach with technology through three consecutive stages: knowledge acquisition, knowledge deepening, and knowledge creation.

5. Conclusion and recommendations

The study utilized the ICT Competency Framework for Teachers (ICT CFT) to assess the digital competencies of undergraduate student-teachers. The results revealed that student-teachers' digital competencies were moderate at both the knowledge acquisition and knowledge deepening levels of ICT CFT, with a stronger confirmation of competencies at the knowledge acquisition level. Aspects of teachers' professional practices directly related to teaching and learning, such as pedagogy and curriculum and assessment, had the lowest mean scores. This suggests that student-teachers are inadequately prepared to integrate ICT into their future pedagogical practices.

Interestingly, the study found that student-teachers are more likely to embrace digital technology for aspects such as teachers' professional learning, and organization and administration, which are indirectly linked to teaching and learning. Based on these findings, it is recommended that technology-enhanced professional learning be utilized to develop student-teachers' technological pedagogical competences.

This study underscores the importance of equipping student-teachers with digital competencies across all educational aspects during pre-service training. The focus should not only be on the quantity of digital tools and resources but also the quality of training and support provided. Comprehensive and carefully planned teacher training and support are essential to enhance ICT integration in teaching and learning, ultimately preparing a workforce capable of leveraging emerging technologies to transform education.

References

[1] Alimdjanova, D.N. and Azmieva, E.E., 2020. Use of Modern Digital Technologies in the Education System. *ECLSS Online 2020a: 1st ECLSS International Online Conference on Economics and Social Sciences. Samarkand Branch of Tashkent University of Economics, Samarkand / Uzbekistan, May 20-21, 2020*. pp.181–185. Available from: https://www.academia.edu/download/106442797/Samarqand_konferensiya_materiali_3_.pdf#page=197.

[2] Alnasib, B.N.M., 2023. Digital Competencies: Are Pre-Service Teachers Qualified for Digital Education? *International Journal of Education in Mathematics, Science and Technology*, 11(1), pp.96–114. Available from: https://doi.org/10.46328/ijemst.2842.

[3] Aslan, A. and Zhu, C., 2017. Investigating variables predicting Turkish pre-service teachers' integration of ICT into teaching practices. *British Journal of Educational Technology*, 48(2), pp.552–570. Available from: https://doi.org/10.1111/bjet.12437.

[4] Ata, R. and Yıldırım, K., 2019. Exploring Turkish Pre-Service Teachers' Perceptions and Views of Digital Literacy. *Education Sciences*, 9(1), p.40. Available from: https://doi.org/10.3390/educsci9010040.

[5] Bitegeko, R.M., Lawrent, G. and Cosmas, J., 2024. Applying the UNESCO ICT competency framework to evaluate digital competencies among undergraduate students in teacher education in Tanzania. *Educational Technology Quarterly*, 2024(3), p.298–318. Available from: https://doi.org/10.55056/etq.769.

[6] Cabero-Almenara, J., Gutiérrez-Castillo, J.J., Palacios-Rodríguez, A. and Barroso-Osuna, J., 2020. Development of the Teacher Digital Competence Validation of DigCompEdu Check-In Questionnaire in the University Context of Andalusia (Spain). *Sustainability*, 12(15), p.6094. Available from: https://doi.org/10.3390/su12156094.

[7] Creswell, J.W. and Plano Clark, V.L., 2018. *Designing and Conducting Mixed Method Research*. 3rd ed. Sage Publications. Available from: http://bayanbox.ir/view/2360519664443692 58/9781483344379-Designing-and-Conducting-Mixed-Methods-Research-3e.pdf.

[8] Donelan, H., 2016. Social media for professional development and networking opportunities in academia. *Journal of Further and Higher Education*, 40(5), pp.706–729. Available from: https://doi.org/10.1080/0309877X.2015.1014321.

[9] Etikan, I., Musa, S.A. and Alkassim, R.S., 2016. Comparison of Convenience Sampling and Purposive Sampling. *American Journal of Theoretical and Applied Statistics*, 5(1), pp.1–4. Available from: https://doi.org/10.11648/j.ajtas.20160501.11.

[10] Falloon, G., 2020. From digital literacy to digital competence: the teacher digital competency (TDC) framework. *Educational Technology Research and Development*, 68(5), pp.2449–2472. Available from: https://doi.org/10.1007/s11423-020-09767-4.

[11] Gudmundsdottir, G.B. and Hatlevik, O.E., 2018. Newly qualified teachers' professional digital competence: Implications for teacher education. *Euro-*

pean Journal of Teacher Education, 41(2), pp.214–231. Available from: https://doi.org/10.1080/02619768.2017.1416085.

[12] Harada, A.S., Gomes, J.A., Guerra, O.U., Ruiz, R. and Calderón, R., 2022. Digital Competences: perceptions of primary school teachers pursuing master's degrees from eight African countries. *South African Journal of Education*, 42(3). Available from: https://doi.org/10.15700/saje.v42n3a2063.

[13] Instefjord, E. and Munthe, E., 2015. Preparing pre-service teachers to integrate technology: an analysis of the emphasis on digital competence in teacher education curricula. *European Journal of Teacher Education*, 39(1), pp.77–93. Available from: https://doi.org/10.1080/02619768.2015.1100602.

[14] Instefjord, E.J. and Munthe, E., 2017. Educating digitally competent teachers: A study of integration of professional digital competence in teacher education. *Teaching and Teacher Education*, 67, pp.37–45. Available from: https://doi.org/10.1016/j.tate.2017.05.016.

[15] Jiménez-Hernández, D., González-Calatayud, V., Torres-Soto, A., Martinez Mayoral, A. and Morales, J., 2020. Digital Competence of Future Secondary School Teachers: Differences According to Gender, Age, and Branch of Knowledge. *Sustainability*, 12(22), p.9473. Available from: https://doi.org/10.3390/su12229473.

[16] Kalimullina, O., Tarman, B. and Stepanova, I., 2020. Education in the Context of Digitalization and Culture: Evolution of the Teacher's Role, Pre-pandemic Overview. *Journal of Ethnic and Cultural Studies*, 8(1), p.226–238. Available from: https://doi.org/10.29333/ejecs/629.

[17] Kalinga, T. and Ndibalema, P., 2023. Teachers' technological competences in enhancing teaching and learning in secondary schools in Tanzania. *Educational Technology Quarterly*, 2023(2), pp.121–140. Available from: https://doi.org/10.55056/etq.434.

[18] Kirschner, P.A. and De Bruyckere, P., 2017. The myths of the digital native and the multitasker. *Teaching and Teacher Education*, 67, pp.135–142. Available from: https://doi.org/10.1016/j.tate.2017.06.001.

[19] Law, N., Woo, D. and Wong, G., 2018. *A Global Framework of Reference on Digital Literacy Skills for Indicator 4.4.2*, Information Paper 51. Montreal, Quebec: UNESCO Institute for Statistics.

[20] Lindfors, M., Pettersson, F. and Olofsson, A.D., 2021. Conditions for professional digital competence: the teacher educators' view. *Education Inquiry*, 12(4), pp.390–409. Available from: https://doi.org/10.1080/20004508.2021.1890936.

[21] Lubuva, E.E., Ndibalema, P. and Mbwambo, E., 2022. Assessment of Tutors' Level of ICT Competencies in Teaching in Teacher Education in Tanzania. *Journal of Learning for Development*, 9(3), pp.436–454. Available from: https://doi.org/10.56059/jl4d.v9i3.705.

[22] Marais, E., 2023. The Development of Digital Competencies in Pre-Service Teachers. *Research in Social Sciences and Technology*, 8(3), pp.134–154. Available from: https://doi.org/10.46303/ressat.2023.28.

[23] Mattar, J., Santos, C.C. and Cuque, L.M., 2022. Analysis and Comparison of International Digital Competence Frameworks for Education. *Education Sciences*, 12(12), p.932. Available from: https://doi.org/10.3390/educsci12120932.

[24] Mishra, P. and Koehler, M.J., 2006. Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge. *Teachers College Record*, 108(6), pp.1017–1054. Available from: https://doi.org/10.1111/j.1467-9620.2006.00684.x.

[25] Morris, T.H., 2018. Vocational education of young adults in England: a systemic analysis of teaching–learning transactions that facilitate self-directed learning. *Journal of Vocational Education & Training*, 70(4), pp.619–643. Available from:

https://doi.org/10.1080/13636820.2018.1463280.

[26] Mtebe, J.S., 2020. Applying UNESCO ICT Competency Framework to Evaluate Teachers' ICT Competence Levels in Tanzania. In: J. Keengwe, ed. *Handbook of Research on Innovative Pedagogies and Best Practices in Teacher Education*. Hershey, PA: IGI Global, pp.305–366. Available from: https://doi.org/10.4018/978-1-5225-9232-7.ch020.

[27] Mtebe, J.S., Fulgence, K. and Gallagher, M., 2021. COVID-19 and Technology Enhanced Teaching in Higher Education in sub-Saharan Africa: A Case of the University of Dar es Salaam, Tanzania. *Journal of Learning for Development*, 8(2), pp.383–397. Available from: https://doi.org/10.56059/jl4d.v8i2.483.

[28] Ngao, A.I., Sang, G. and Kihwele, J.E., 2022. Understanding Teacher Educators' Perceptions and Practices about ICT Integration in Teacher Education Program. *Education Sciences*, 12(8), p.549. Available from: https://doi.org/10.3390/educsci12080549.

[29] Nguyen, L.A.T. and Habók, A., 2024. Tools for assessing teacher digital literacy: a review. *Journal of Computers in Education*, 11(1), pp.305–346. Available from: https://doi.org/10.1007/s40692-022-00257-5.

[30] OECD, 2016. *Skills for a Digital World*. (Policy Brief on The Future of Work). Paris: OECD Publishing. Available from: https://www.oecd.org/content/dam/oecd/en/topics/policy-issues/future-of-work/skills-for-a-digital-world.pdf.

[31] Ogundolire, H.F., 2020. *Implementation of UNESCO framework for the acquisition of ICT-competency of Technical and Vocational Education in Federal College of Education Akoka, Lagos*. Ph.D. thesis. University of Ibadan. Available from: https://pgsdspace.ictp.it/xmlui/handle/123456789/1388.

[32] Pallant, J., 2007. *SPSS Survival Manual: A Step by Step Guide to Data Analysis using SPSS for Windows*. 3rd ed. McGraw-Hill Education. Available from: https://tinyurl.com/ywww3xfu.

[33] Pettersson, F., 2018. On the issues of digital competence in educational contexts – a review of literature. *Education and Information Technologies*, 23(3), pp.1005–1021. Available from: https://doi.org/10.1007/s10639-017-9649-3.

[34] Redecker, C., 2017. *European Framework for the Digital Competence of Educators: DigCompEdu*. Luxembourg: Publications Office of the European Union. Available from: https://web.archive.org/web/20240720025143/https://publications.jrc.ec.europa.eu/repository/handle/JRC107466.

[35] Sachs, J.D., Schmidt-Traub, G., Mazzucato, M., Messner, D., Nakicenovic, N. and Rockström, J., 2019. Six Transformations to achieve the Sustainable Development Goals. *Nature Sustainability*, 2(9), pp.805–814. Available from: https://doi.org/10.1038/s41893-019-0352-9.

[36] Siddiq, F., Olofsson, A.D., Lindberg, J.O. and Tomczyk, L., 2024. Special issue: What will be the new normal? Digital competence and 21st-century skills: critical and emergent issues in education. *Education and Information Technologies*, 29(6), pp.7697–7705. Available from: https://doi.org/10.1007/s10639-023-12067-y.

[37] Skantz-Åberg, E., Lantz-Andersson, A., Lundin, M. and Williams, P., 2022. Teachers' professional digital competence: an overview of conceptualisations in the literature. *Cogent Education*, 9(1), p.2063224. Available from: https://doi.org/10.1080/2331186X.2022.2063224.

[38] Sousa, R.D., Karimova, B. and Gorlov, S., 2020. Digitalization as a New Direction in Education Sphere. *E3S Web of Conferences*, 159, p.09014. Available from: https://doi.org/10.1051/e3sconf/202015909014.

[39] Starkey, L., 2020. A review of research exploring teacher preparation for the digital age. *Cambridge Journal of Education*, 50(1), pp.37–56. Available from: https://doi.org/10.1080/0305764X.2019.1625867.

[40] Štemberger, T. and Konrad, S.Č., 2021. Attitudes Towards using Digital Technologies in Education as an Important Factor in Developing Digital Competence: The Case of Slovenian Student Teachers. *International Journal of Emerging Technologies in Learning*, 16(14), pp.83–98. Available from: https://doi.org/10.3991/ijet.v16i14.22649.

[41] Tafazoli, D., Huertas-Abril, C.A. and Gomez-Parra, M.E., 2019. Technology-Based Review on Computer-Assisted Language Learning: A Chronological Perspective. *Píxel-Bit. Revista de Medios y Educación*, (54), pp.29–43. https://www.researchgate.net/publication/330213900. Available from: https://doi.org/10.12795/pixelbit.2019.i54.02.

[42] Tanzania UR. Ministry of Education and Vocational Training and UNESCO Office in Dar-es-Salaam, 2015. *ICT competency standards for teachers in Tanzania*. Available from: https://unesdoc.unesco.org/ark:/48223/pf0000234822.

[43] Tárraga-Mínguez, R., Suárez-Guerrero, C. and Sanz-Cervera, P., 2021. Digital Teaching Competence Evaluation of Pre-Service Teachers in Spain: A Review Study. *IEEE Revista Iberoamericana de Tecnologias del Aprendizaje*, 16(1), pp.70–76. Available from: https://doi.org/10.1109/RITA.2021.3052848.

[44] UNESCO, 2018. *UNESCO ICT Competency Framework for Teachers*. Paris: United Nations Educational, Scientific and Cultural Organization. Available from: https://unesdoc.unesco.org/ark:/48223/pf0000265721.

[45] United Nations General Assembly, 2015. Transforming our World: The 2030 Agenda for Sustainable Development. Available from: https://www.unfpa.org/resources/transforming-our-world-2030-agenda-sustainable-development.

[46] United Republic of Tanzania, 2014. Education and Training Policy. Available from: https://static1.squarespace.com/static/5ae8cdb955b02c7c455f14c5/t/5af272eb758d46e6d5ef90e1/1525838585075/education+and+training+policy+2014-eng+3cln+fixed.docx.

[47] Wang, C., Chen, X., Yu, T., Liu, Y. and Jing, Y., 2024. Education reform and change driven by digital technology: a bibliometric study from a global perspective. *Humanities and Social Sciences Communications*, 11(1), p.256. Available from: https://doi.org/10.1057/s41599-024-02717-y.