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Applying the UNESCO ICT competency framework to evaluate digital competencies among undergraduate students in teacher education in Tanzania

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Abstract. The study employed the UNESCO ICT Competency Framework for Teachers (ICT CFT) to assess undergraduate student-teachers' digital competencies in an educational context. Within the quantitative approach, the study adopted a descriptive cross-sectional research design. The data was collected from a sample of 549 student-teachers through the self-developed questionnaire. Data analysis involved both descriptive and inferential analysis. The study found that student-teachers' digital competencies at both knowledge acquisition and knowledge deepening levels were moderate. However, their digital competencies were moderately higher at the knowledge acquisition level, which signifies confidence in basic digital skills. In addition, it was found that gender and age had statistical significance on perceived digital competencies, particularly at the knowledge acquisition level. Based on the findings, it is recommended that while considering the varying levels of comfort with technology across the gender and age groups, a tiered teacher training programme should be put in place where student-teachers can progress from the basic level to the advanced level of digital competencies.

Keywords: digital competencies, ICT CFT, ICT integration, student-teachers, digital transformation

1. Introduction

There is a universal consensus that Information and Communication Technology (ICT) is a hub and a catalyst for achieving sustainable development goals (SDGs) [13, 43, 46]. In the educational sector, the ongoing digital transformation has created a new wave of digital solutionism, envisioning that education digitalisation can fix challenges facing the educational sector. Digitalisation in education is closely linked to improved inclusive quality education in a digital learning environment [31]. The close link between digital technologies and the quality of education signifies that the digitalisation of educational initiatives can bring multifaceted benefits. Thus, the countries seeking educational transformation empowered by technology should strengthen education digitalisation efforts.

Integration of ICT in education can help to overcome challenges related to access to quality education and promotion of lifelong learning for all [12, 13, 32]. Potentially, the digitalisation of education can bridge the existing inequality gaps and make learning opportunities available for all who want to benefit from them [46]. Nevertheless, when technology is used in conjunction

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with learner-centred learning approaches, it can enhance learners' acquisition of the 21^{st} century skills and address issues connected to sustainable development [14]. There are perceived positive outcomes of digital transformation in education. However, the full educational potentials of digital technologies are not optimally exploited [6, 32].

Factors associated with the effective leveraging of technologies in educational aspects, including pedagogy, are numerous and are probably multiplicative in their effects. However, it is difficult to achieve effective ICT integration in educational endeavours, especially in pedagogical practices, without rethinking the quality of teachers. Scholars are of the opinion that no matter how classrooms are well equipped with digital technologies facilities if teachers lack pedagogical digital competencies, the cherished pedagogical benefits of technologies will not be fully realised [7, 32]. The effective pedagogical use of ICT can be negatively affected by incompetent teachers. This view is consistent with that of Falloon [7] and Mtebe [21] in that lack of pedagogical digital competencies and inadequate technological familiarisation among teachers can explain why pedagogical use of ICT is not yet fully optimised.

Consequently, training and supporting teachers to develop their digital competencies is becoming the central theme in the path of implementation of digital transformation in education [40, 46]. However, developing teachers' digital competencies is a complex undertaking, demanding considering the diversified sets of competencies required to handle the job requirements of a teacher [9, 30]. There are several existing frameworks for guiding digital competence development and assessment in teacher education, notably TPACK [19], and UNESCO ICT competence framework for teachers (ICT CFT) [40]. Together, these frameworks present integral features of diversified pedagogical, technological, and subject matter aspects of teachers' proficiency in technology usage in schools. The present study employed ICT CFT to profile the digital competencies of undergraduate student-teachers in Tanzania. Accordingly, teacher digital competencies include the ability to develop transformative ways of leveraging technology to enhance learning experiences and to promote knowledge acquisitions, knowledge deepening, and knowledge creation [40].

There have been a number of studies to evaluate the pedagogical digital competencies of different audiences, some of which include university student-teachers [15, 28], secondary school teachers [16, 21], tutors in teacher training colleges [17, 23]. The studies have used different teachers' ICT competency frameworks to assess teachers' digital proficiency, namely: Technological Pedagogical Content Knowledge (TPACK) [45], and ICT CFT [1, 16, 17, 21]. The key finding from these studies is that teachers are positive about the pedagogical usefulness of digital technologies. However, most teachers had developed digital competencies at the initial level of knowledge acquisition.

Although some studies have applied ICT CFT to evaluate teachers' digital competencies in Tanzania, a more comprehensive understanding of teachers' digital competencies as informed by ICT CFT is still needed. The existing studies have studied a few aspects of ICT in education. Teachers' technological competencies must be understood from the whole educational perspective because teachers operate within the whole system [34]. In addition, it is not presently clear whether the university-based teacher training offered sufficiently supports student-teachers in developing digital competencies, as informed by ICT CFT. A study on student-teachers' digital competencies in Tanzania will help to add to the body of knowledge of digital competencies for student-teachers in other developing countries. To this end, the study delves into the assessment

of current levels of digital competencies of undergraduate student-teachers to ascertain their preparedness to embark on a digital-infused teaching and learning environment.

1.1. Research purpose and objectives

The purpose of this study was to profile undergraduate student-teachers' digital competencies as informed by ICT CFT. The study was based on the first and second levels of ICT CFT, which are knowledge acquisition (KA) and knowledge deepening (KD), respectively. Two research objectives guided the study: first, to determine the digital competence levels of undergraduate student-teachers, and second, to determine the effects of undergraduate student-teachers' age and gender on their perceived digital competencies.

2. Literature review

2.1. UNESCO ICT CFT as conceptual framework

This study is based on UNESCO's ICT CFT, which is an internationally recognised tool to guide teacher training and assessment on the use of digital technologies in education [40]. The UNESCO ICT CFT's first version was realised in 2008. The framework was modified and advanced in 2011 and 2018. The latest version of ICT CFT presents 18 digital competencies categorised into six aspects of teachers' professional practices, namely: understanding ICT in education, curriculum, assessment, pedagogy, applications of digital skills, organisation and administration, as well as continuing teacher professional learning [40]. According to UNESCO [2018], the framework is structured over three levels of teachers' digital competencies: knowledge acquisition (KA), knowledge deepening (KD), and knowledge creation (KC), as they appear in table 1.

Table 1
The UNESCO ICT CFT [40].

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

In the present study, KA and KD levels of ICT CFT were employed to evaluate student-teachers' digital competencies in six educational aspects. These two levels correspond precisely with the United Republic of Tanzania (URT) ICT-competency standard for teachers (ICT CST) [35].

The first level is knowledge acquisition (KA), which is identified as the basic level of ICT competencies. At this level, teachers are expected to develop basic digital competencies to support the relevant curriculum context [40]. The goals of KA include understanding ICT policy in education, acquisition of basic knowledge, and use of ICT to enhance teaching. Teachers who are competent at the knowledge acquisition level should be able to use ICT tools and resources

to complement learning goals, organise standard classrooms, and support their professional learning. Ideally, teachers' ICT competence at this level is similar to those competencies identified by *Transforming Education: The Power of ICT Policies* [38] emerging and applying stages, and technological knowledge in the TPACK model [19].

The second level is knowledge deepening (KD), in which the focus is to increase teachers' ability to support students from diverse backgrounds to apply knowledge to solve complex problems encountered in real-world situations [40]. The understanding of ICT in education associated with this level includes teachers' ability to use specific classroom experiences to address national ICT-related goals and priorities. The pedagogy associated with this level includes learner-centred, collaborative and project-based learning. Teachers are also able to use technology to create professional networks with experts and other teachers to support their professional learning.

2.2. Developing student-teachers' digital competencies in Tanzania

The government of the United Republic of Tanzania recognises the importance and role of competent teachers in advancing ICT in education. In keeping with international orientations, the government had adopted ICT CFT and prepared her ICT-CST [35]. ICT-CST reflects on the six domains of teaching professional practices at two levels of ICT CFT: knowledge acquisition (KA) and knowledge deepening (KD). In addition, the newly reversed Tanzanian Education and Training Policy (ETP) of 2014 [41] emphasises that ICT should be integrated into teacher education. In Tanzania, therefore, teacher education programmes are mandated to provide training opportunities and support for all student-teachers to develop digital competencies. In this context, Tanzanian teacher education programmes at the university level provide ICT-related courses envisioning preparing student-teachers to acquire both generic digital skills and digital teaching skills. Technology courses focusing on introduction to information technology and educational technology and media are core courses in most of the teacher education programmes. However, such isolated ICT course provision has been criticised as being ineffective for developing holistic and deeper aspects of ICT competencies needed by student-teachers for pedagogical purpose and their future life [7].

Literature suggests that, in Tanzania, although teachers are optimistic about the potential of technology as a pedagogical tool, they are moderately prepared to spearhead the transformative pedagogical use of emerging digital tools and resources [16, 22, 25]. In addition, it has been noted that the newly qualified teachers use ICT mainly at the minimum level of knowledge acquisition [37] rather than bringing about fundamental pedagogical transformations. Inadequate training and support during initial teacher education have been cited as the sources of lack of ICT competencies among student-teachers [24]. This is consistent with the 2018 Teaching and Learning Survey (TALIS) in Asian countries. According to the TALIS report, more than 50% of the teachers reported that they were not well prepared in ICT in education-related competencies [24]. Poor training is often linked to the use of inadequate training strategies [8] and the lack of role modelling from instructors [36].

2.3. Demographic factors and teacher ICT engagement

Gender and age are among the demographic variables that demonstrate the teachers' technology acceptance and usage. However, there are complementing and contesting findings based on analysis of the influences of age and gender on teachers' digital competencies and usage in teaching and learning. The first perspective is that age and gender have a significant impact on prediction levels of teachers' digital competencies [26, 39, 47]. Most of these studies confirm that male and younger teachers have higher levels of digital competencies and perform slightly better in the pedagogical use of digital technologies than female and older teachers, respectively.

Another contrasting perspective is that there are no significant differences in the digital competencies of teachers according to gender and age [5, 10]. In Tanzania, Kalinga and Ndibalema [16] investigated the effect of age and gender on teachers' technological competencies, and no significant effect was found. The varying conclusions in the literature regarding gender and age gaps in teachers' digital competencies can be attributed to contextual and methodological factors. For example, in some cultures, the gap exists in how boys and girls are exposed to technology in general, consequently affecting their perceptions. From methodological perspectives, age and gender distributions of the sample can significantly affect the findings.

3. Research methodology

3.1. Research design

This was a quantitative study that employed the descriptive cross-sectional design, which is bilateral in nature [33, 44]. Firstly, the study was informed with the descriptive design because the focus was to describe the characteristics of the respondents or statuses [44]. The descriptive study aims to answer the following questions: What? not to why?, portraying the facts and characteristics of the given population [33, 44]. This aligns with research objective one, which aims at providing an overview of the perceived digital competencies of respondents from their perspectives, shedding light on any potential disparities or areas of consensus. Secondly, the study was descriptive-correctional in nature as it also aims at assessing the relationship between variables without attempting any manipulations of the referred variables [44]. This is in accordance with research objective two, which aims at establishing the relationship of statistical significance between demographic factors and perceived digital competencies. Moreover, the study was cross-sectional in nature as the data were collected only once with a very limited time frame [18, 44].

3.2. Respondents

Purposive sampling technique was utilised among the population of 650 final, third-year student-teachers from the Department of Educational Foundations and Continuing Education, College of Education of the University of Dodoma. Andrade [2] is opining that in purposive sampling, the inquirer selects prospective respondents and sites for the study because they can purposefully inform an understanding of the research problem. It was anticipated that based on their experiences, the third-year student-teachers had a better understanding of the academic environment in relation to technological pedagogical competencies than their counterparts in the first and

second years. The final sample was 549 (response rate: 84.4%), composed of 323 males (58.83%) and 226 females (41.17%). Regarding age, the majority [376 (68.61%)] of the student-teachers were aged between 21-25 years old, a typical age range of undergraduate student-teachers in Tanzania. About 58 (19.71%) student-teachers were in the 31 and above age group, and the lowest age group was that of 16-20 years old [6 (1.01%)].

3.3. Instrument

The sole research instrument was a self-developed questionnaire based on ICT CFT issued by UNESCO [2018]. The final questionnaire consisted of 52 items, with 4 items that informed the demographic characteristics of the respondents and 48 dedicated to assessing student-teachers' digital competencies. The digital competencies related to teachers' duties were evaluated at two levels of KA (6 competencies, 24 items) and KD (6 competencies, 24 items). The Likert scale with five answer options (1 – Strongly Disagree; 2 – Disagree; 3 – Neural; 4 – Agree; and 5 – Strongly Agree) was adopted.

The questionnaire's development also involved validation. For content analysis, two senior lecturers with over five years of teaching experience in the field of educational technology revised the questionnaire to validate its contents. The suggested changes were incorporated. Subsequently, the researcher conducted the pilot test with 25 respondents who shared similar characteristics with the target population. However, the respondents who participated in the pilot study were not involved in the final sample.

The reliability of the questionnaire was analysed using Cronbach's alpha coefficient. The findings are shown in table 2. Notably, the domain of basic knowledge (Cronbach's alpha – 0.693) has the lowest value but is still acceptable [27]. Other domains yielded Cronbach's alpha values above 0.7, the highest being networking and Cronbach's alpha – 0.832. According to Pallant [27], Cronbach's alpha value above 0.70 is considered acceptable for social science research.

Data collection was digitally conducted using an online survey administration tool (Google Forms). The questionnaire was made available online and subsequently shared with the identified group of student-teachers through WhatsApp groups. This was preceded by physical contact with prospective respondents, during which the researchers explained the goal of the study and sought the respondents' consent and voluntary participation. The data were collected within 14 days.

3.4. Data analysis

Quantitative data from the questionnaire were analysed using IBM Statistical Package for Social Sciences (SPSS) Version 24. Descriptive statistics, notably mean, frequency, and standard deviations, were used to ascertain prospective teachers' perceptions about the level of digital competence.

Two plot visual tools, a histogram with a fitted normal distribution curve and Q-Q (quantile-quantile), were used to test data normality distributions across all 12 digital competencies at two consecutive levels of KA and KD. As indicated in figures 1 and 2, the visual inspection suggests approximate normality. Therefore, parameter tests (t-test, ANOVA) were used to establish the perceived difference in digital competencies and demographic variables.

Table 2
Questionnaire reliability test.

Domains	Number of items	Cronbach's alpha
Knowledge acquisition		
Policy understanding	4	0.788
Basic knowledge	4	0.693
ICT-enhanced teaching	4	0.803
Application	4	0.726
Standard classroom	4	0.809
Digital literacy	4	0724
Knowledge deepening		
Policy application	4	0.718
Knowledge application	4	0.754
Complex problem-solving	4	0.771
Infusion	4	0.786
Collaborative groups	4	0.801
Networking	4	0.832

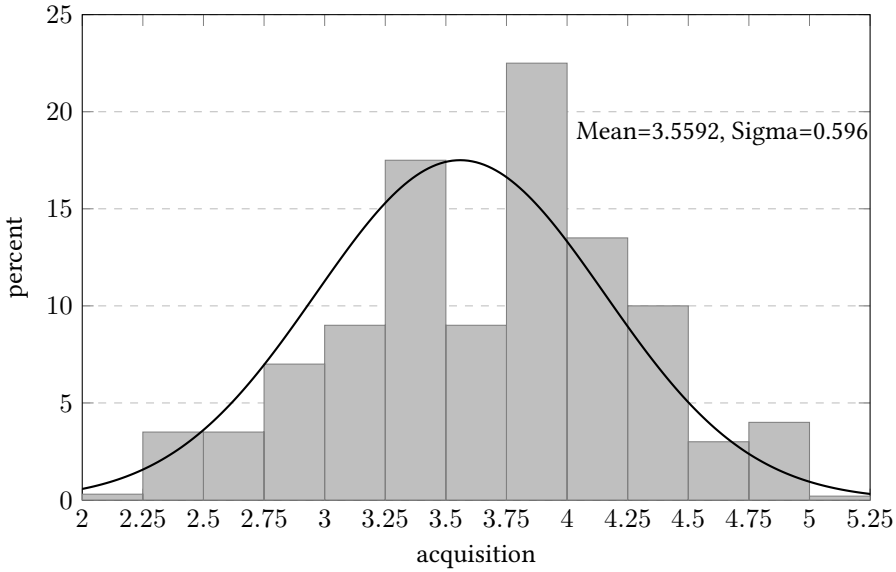

Figure 1: A histogram with a fitted normal distribution curve.

Subsequently, three inferential statistical analyses were performed: t-test to compare average mean scores across gender, one-way ANOVA to establish statistically significant differences across the participants' age groups and multiple linear regression analysis for correlation analysis of digital competence levels between KA and KD.

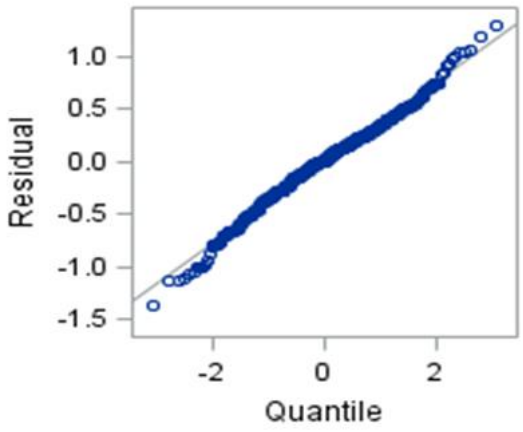

Figure 2: Q-Q plot.

4. Findings

4.1. Student-teachers' levels of perceived digital competencies

The results from the descriptive analysis allowed us to elucidate the respondents' levels of perceived digital competencies as informed by ICT CFT. The assessment involved digital competencies at the KA and KD levels. The findings are based on the scale: 1 – Strongly Disagree; 2 – Disagree; 3 – Neutral; 4 – Agree; and 5 – Strongly Agree. The interpretation of the findings is based on mean score ranges, where low, moderate, and high ranges are from 1.0 to 2.33, 2.34 to 3.66, and 3.67 to 5.00, respectively.

4.1.1. Student-teachers' ICT competencies at the KA level

In the first place, digital competencies at the first level of KA were analysed. Table 3 presents a sample of KA results.

A summary of the findings in table 4 shows that with an over mean score of 3.55, the perceptions of respondents about digital competencies at KA of ICT CFT were moderate. Within the moderate range, the competence domains which received the highest ratings were basic knowledge and application (M = 3.60). Digital literacy received the lowest score (M = 3.52), suggesting that student-teachers were relatively less confident in using digital technologies to support their professional learning. Furthermore, the standard classrooms recorded the highest standard deviation, suggesting varying levels of experience or confidence in organising learners and digital tools in the classroom to support teaching and learning.

Figure 3 presents the grouped digital competencies at the KA level as perceived by student-teachers. The competencies were grouped based on the overall mean scores, whereby those with 1.00 to 2.33 were assigned "low"; those with 2.34 to 3.66 mean scores were labelled "medium/moderate"; while those with 3.67 to 5.00 mean scores were termed "high". Based on this categorisation, more than half (55.82%) of the respondents rated themselves high across all six domains of digital competencies at the KA level. The high rating ranged from 53.55% to

Table 3
Student-teachers perceived ICT competencies at the KA level.

Construct	Items	Mean	SD
PU	I am aware of national policies and priorities related to ICT in education	3.29	0.97
	I can identify how the ICT policy is beneficial to teaching and learning	3.46	0.92
BK	I can compare specific curriculum standards to particular software	3.27	0.96
	I can align specific lesson objectives to particular educational technology	3.45	0.91
IT	I can use ICT to meet the learning needs of learners of different needs	3.69	0.91
	I can prepare ICT-integrated lesson plans	3.14	1.03
A	I can use common computer hardware such as printers and scanners	3.57	1.03
	I can align specific lesson objectives to particular educational technology	3.88	1.00
SC	I can organise students and digital tools in the learning environment	3.51	0.92
	I can support students to use digital tools and resources in the classroom	3.62	0.92
DL	I can use ICT resources to enhance the virtual learning environment	3.51	0.93
	I can use ICT resources to support my acquisition of knowledge	3.45	0.97

Key: PU – policy understanding; BK – basic knowledge; IT – ICT-enhanced teaching; A – application; SC – standard classroom; and DL – digital literacy.

Table 4
Summary of perceived digital competencies at the KA level.

Constructs	Mean	Std. dev.	Interpretation
Policy understanding (PU)	3.53	0.80	Moderate
Basic knowledge (BK)	3.60	0.77	Moderate
ICT-enhanced teaching (IT)	3.55	0.76	Moderate
Application (A)	3.60	0.81	Moderate
Standard classroom (ST)	3.56	0.83	Moderate
Digital literacy (DL)	3.52	0.69	Moderate
Overall KA	3.55	0.66	Moderate

57.74%, the highest being basic knowledge (57.74%), closely followed by application (56.47%) and standard classroom (56.28%).

Regarding medium rating, more than one-third (35.86%) of the respondents also rated themselves medium across digital competence domains, with the percentages ranging from 33.88% to 39.34% at an aggregate percentile of 35.86%. The consistent presence of medium ratings across all examined digital competence domains suggests that there were areas where additional training or support could help student-teachers gain more digital competencies.

Low ratings were regularly the smallest group across all six constructs, with percentages ranging from 7.10% to 9.84% at an aggregate percentile of 8.32%. While low ratings are minimal, the targeted interventions in areas like policy understanding and standard classroom could further reduce these figures.

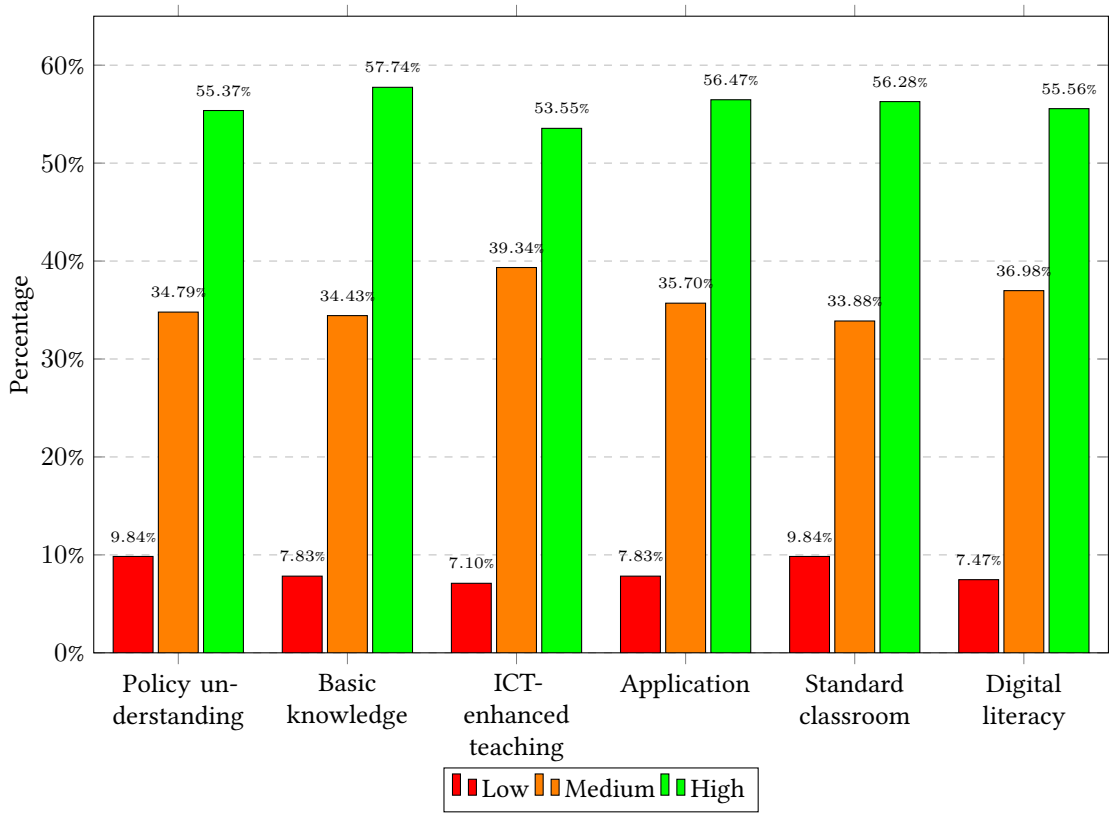

Figure 3: Distribution of student-teachers' digital competencies ratings at the KA level.

4.1.2. Student-teachers' ICT competencies at the KD level

Digital competencies at the second level (KD) were also determined through descriptive analysis. Table 5 presents the sampled items in each corresponding construct.

A summary of the findings in table 6 shows that with over a mean score of 3.49, the perceptions of respondents about digital competencies at the KD level were relatively moderate when compared to that of the KA level (M = 3.55). The highest score mean was networking (M = 3.64), indicating that student-teachers were more confident about using ICT to enhance their professional development through networking. Complex problem-solving received the lowest rating (M = 3.12), suggesting that student-teachers were less confident in applying ICT in complex pedagogical practices such as student-centred pedagogies.

Furthermore, figure 4 illustrates grouped digital competencies at the KD level as perceived by respondents. Similarly, digital competencies were grouped based on the overall mean scores. The aggregated percentile shows that about 46%, 41%, and 13% of the respondents rated themselves as high, medium, and low, respectively. The high and medium ratings ranged from 61.20% to 21.51% and from 52.28% to 30.60%, respectively. The relatively high and medium ratings across all examined digital competencies suggest that training and support are required to elevate student-teachers' knowledge and skills at the KD level.

Table 5
Student-teachers perceived ICT competencies at the KD level.

Constructs	Items	Mean	SD
PA	I can explain and analyse the principles of using ICT in education	3.21	0.99
	I can apply principles of ICT in Education	2.96	0.96
KA	I can learn management platforms (e.g. Moodle, Blackboard)	3.09	1.02
	I can use electronic portfolios to assess learners' learning progress	3.29	10.5
CP	I can design ICT-supported project-based learning activities	3.18	0.99
	I can use ICT to facilitate students to create project plans	3.07	0.99
I	I can operate software packages that are appropriate to the subject area	3.0	1.04
	I can evaluate the accuracy and usefulness of web resources and web-based tools in support of the subject areas	3.02	1.01
CG	I can share electronic content using file sharing applications (e.g. Dropbox, Google Drive)	3.54	1.02
	I can manage students and other learning partners collaboratively online	3.50	0.98
N	I can use an online support forum to ask for and share teaching and learning resources	3.63	0.96
	I can use ICT networks to access and share resources that support teachers' professional development goals	3.66	0.98

Key: PA – policy application; KA – knowledge application; CP – complex problem-solving; I – Infusion; CG – collaborative groups; and N – networking.

Table 6
Summary of digital competencies at the KD level.

Constructs	Mean	Std. dev.	Interpretations
Policy application (PA)	3.43	0.78	Moderate
Knowledge application (KA)	3.30	0.85	Moderate
Complex problem-solving (CP)	3.12	0.71	Moderate
Infusion (I)	3.34	0.84	Moderate
Collaborative groups (CG)	3.54	0.81	Moderate
Networking (N)	3.64	0.83	Moderate
Overall KD	3.49	0.71	Moderate

Interestingly, the respondents were relatively more confident in digital networking and collaborative groups. Thus, it can be inferred that the respondents were more likely to use digital technologies in organisations and administration of educational aspects and to advance their teaching careers.

Low ratings were consistently low across all competencies but with a significant range of 18.21% to 8.20% at an aggregate percentile of 13%. Again, digital competencies related to complex problem solving recorded the highest percentage of low ratings (18.21%) and the most substantial

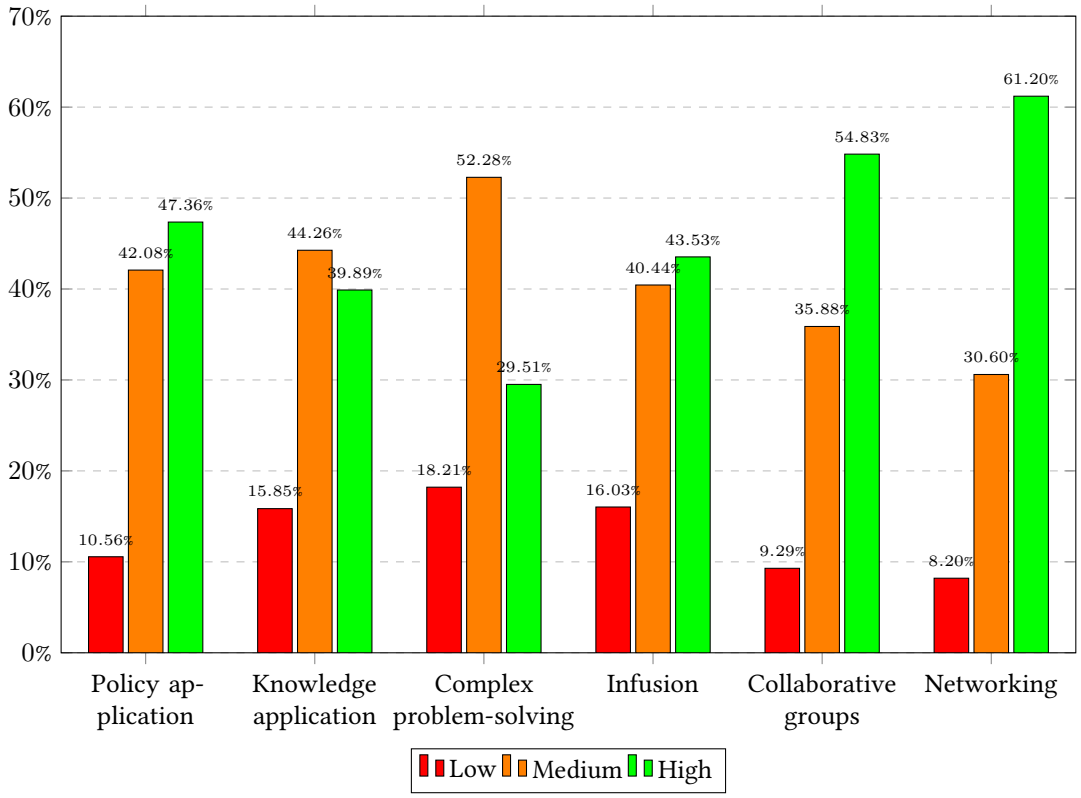

Figure 4: Distribution of student-teachers' digital competence ratings at the KD level.

medium rating percentage (52.28%). This is an indication that attention is needed, especially in supporting student-teachers in developing digital competencies to support effective pedagogical use of technology in complex tasks.

Nevertheless, a comparative analysis of digital competencies between KA and KD levels by "High ratings" was carried out, as it is reflected in table 7.

As illustrated in table 7, more than 50% of the respondents rated themselves "high" across all

Table 7
A comparison between KA and KD levels by "High ratings".

Aspects	**Knowledge acquisition**		**Knowledge deepening**	
	Competencies	**%**	**Competencies**	**%**
1. Understanding ICT in education	Policy understanding	55.37	Policy application	47.36
2. Curriculum and assessment	Basic knowledge	57.74	Knowledge application	39.89
3. Pedagogy	ICT-enhanced teaching	53.55	Complex problem-solving	29.51
4. Applications of digital skills	Application	56.47	Infusion	44.53
5. Organization and administration	Standard classroom	56.28	Collaborative groups	54.83
6. Teacher professional learning	Digital literacy	55.56	Networking	61.20

digitally assessed competencies at the KA level. In contrast, at the KD level, with the exception of collaborative group and networking, other digital competence domain ratings were less than 50%. Again, the evidence can be recorded that the majority of the respondents perceived themselves as possessing more digital competencies at the KA level than at the KD level.

4.2. The effect of gender and age on perceived digital competencies

Inferential statistical analyses were carried out to find out the effects of student-teachers' gender and age groups on their perceived ICT competencies at both KA and KD levels.

4.2.1. The effect of gender and age groups on perceived digital competencies at the KA level

Table 8 presents the results of the independent t-test on knowledge acquisition across gender.

Table 8
Independent t-test for the difference of KA across gender.

Variable	Mean ± Std	Mean difference	95% CI	t-value	*p*-value
Gender		0.2285±0.5858	0.1287-0.3283	4.50	**<.0001**
Male	3.6533±0.6012				
Female	3.4248±0.5631				

The results show that the mean score value of males (3.6533) is higher than the mean of females (3.4248), and their difference (0.2285) is statistically significant ($p <$. 0001). Generally, the significant finding is that males have higher levels of digital competencies than females.

Furthermore, to assess the mean difference of ICT competencies at the KA level across different age groups, one-way ANOVA was used, as it is vivid in table 9.

Table 9
One-way ANOVA for the difference in KA level across age groups.

Age group compared	Difference between means	Simultaneous 95% CI		*p*-value
4 – 3	0.04858	-0.19590	0.29307	0.0788
4 - 2	0.28426	0.12030	0.44822	**0.0236**
4 – 1	0.62412	0.03837	1.20986	**0.0013**
3 – 2	0.23568	0.02381	0.44754	**0.0301**
3 – 1	0.57553	-0.02538	1.17645	0.0544
2 – 1	0.33986	-0.23304	0.91275	0.2341

Key: in age group 1 – 16-20 years; 2 – 21-25 years; 3 – 26-30 years; 4 – 31 and above years.

As illustrated in table 9, there was a statistically significant difference across age groups. Generally, the significant finding is that the older age group tends to have higher levels of digital competencies than younger groups.

4.2.2. The effect of gender and age groups on perceived digital competencies at the KD level

Similarly, an independent t-test was conducted to ascertain the effect of gender on digital competencies at the KD level. The results show that there is a statistically significant mean difference (p=0.0357). The mean difference is 0.1151 between male and female student-teachers, as in table 10.

Table 10
Independent t-test for the difference of KD across gender.

Variable	Mean ± Std	Mean difference	95% CI	t-value	p-value
Gender		0.1151±0.6301	0.007-0.2224	2.11	**0.0357**
Male	3.4432±0.6561				
Female	3.3282±0.5908				

The findings reveal a gender-based statistically significant difference at the KD level, with males having slightly higher mean KA levels than females.

Again, one-way ANOVA was performed to find out whether there is a difference in digital competencies at the KD level across age groups, as in table 11.

Table 11
One-way ANOVA for the difference of KD across age groups.

Age group compared	Difference between means	Simultaneous 95% CI		p-value
4 - 3	0.07817	-0.18543	0.34177	0.2333
4 - 2	0.19025	-0.03818	0.41868	0.1002
4 - 1	0.57266	-0.07524	1.22056	0.3124
3 - 2	0.11208	-0.06470	0.28886	0.0911
3 - 1	0.49449	-0.13705	1.12603	0.0714
2 - 1	0.38241	-0.23528	1.00010	0.3024

Key: in age group 1 – 16-20 years; 2 – 21-25 years; 3 – 26-30 years; 4 – 31 and above years.

The results show that there is no statistically significant difference in the different age groups. All the p-values are above 0.05.

Finally, in assessing the association between ICT competence levels between KD and KA, multiple linear regression analysis was used. The model involved other controlling variables, such as gender and age. Dummy variables were created for the categorical variables before being included in the model, as in table 12.

The results show that KD was statistically significant as it was associated with KA (p<.0001). It was observed that a unit increase in KA resulted in an average increase of KD by 0.83152 units.

Table 12
Multiple linear regression for the association between KD and KA levels.

Variable	Parameter estimates	Standard error	t-value	*p*-value
Intercept	0.38108	0.17962	2.12	0.0343
Knowledge acquisition	0.83152	0.03017	27.57	**<.0001**
Male	-0.06383	0.03616	-1.77	0.0781
Female	Ref			
16-20 years	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

5. Discussion

This study evaluated the level of digital competencies among undergraduate student-teachers in 12 domains at the KA and KD levels as informed by ICT CFT. Another important aspect of this study was to establish whether there are differences in digital competencies among undergraduate student-teachers based on their gender and age groups. The following discussion of the findings is based on these two aspects.

5.1. Student-teachers' perceived digital competencies

Descriptive analysis, which examined six digital competence domains at the KA level, revealed that student-teachers' digital competencies were at the moderate level. An aggregate percentile of high rating also revealed that nearly 50% of the student-teachers were either at the moderate or low levels. These results align with those of Buluma and Walimbwa [4] who studied the digital competencies development of student-teachers in Uganda. At the basic level, student-teachers had low to moderate digital competencies related to digital content creation. Similar conclusions were recently reached by Moorhouse [20] where the newly qualified teachers reported low digital competencies and did not feel practically prepared for the pedagogical use of ICT.

Within an overall moderate range, the findings from the present study show that student-teachers were more competent in applying technological knowledge in curriculum and assessment, as well as in pedagogy. These findings were consistent with the previous studies, which reported relatively good digital competencies of student-teachers in ICT basic knowledge [28]. Familiarity with digital tools and resources can be a reason to explain the student-teachers' digital competencies in these domains.

Furthermore, if we compare descriptive results for the KA level (table 4) with results for the KD level (table 6), it is clearly noted that at both levels, the mean scores were at moderate range. These findings suggest that student-teachers generally perceived themselves to have moderate competencies in foundational understanding and basic digital skills, as well as digital skills to transform pedagogical practices. However, by having a close look at the tables 4 and 6, and the comparison between KA and KD levels by "High ratings" (table 7) within the moderate range, the differences exist between student-teachers digital competencies at the KA and KD levels. Student-

teachers' digital competencies were moderately higher at the KA level than at the KD level across the six educational aspects. These findings suggest that student-teachers were relatively more competent in integrating digital technologies into their existing pedagogical practices than in using digital technologies to transform the teaching and learning processes. The findings share similarity with previous studies that both prospective and practising teachers possess digital competencies at the minimum level of knowledge acquisition [16, 21, 37]. This may be partly attributed to the fact that, in most cases, teacher training focuses on an introduction to basic ICT skills and less on learning to teach with technology as a pedagogical tool [8]. The problem may further be rooted in the lack of digital competencies among teacher educators, prompting failure to play their role model of ICT integration in teaching and learning. This was revealed by Lubuva, Ndibalema and Mbwambo [17] that tutors' level of ICT competencies in teachers' colleges in Tanzania is at the minimum level of knowledge acquisition. Tutors with basic ICT skills are likely not to use digital technologies in the classroom, consequently negatively impacting the preparedness of student-teachers.

5.2. The influence of demographic factors on perceived digital competencies

Regarding gender, both KA and KD levels have a significant value <0.05. This shows a statistically significant difference in the evaluation of male and female respondents in relation to digital competencies. The findings of the current study concede with the previous studies [26, 47] by establishing the gender gap related to digital competencies and using technology. In contrast to the studies that support the existence of a gender gap in technology acceptance and usage, other studies [5, 10, 16] found no statistical significance to establish a gender gap in relation to the digital competencies and usage in teaching and learning.

The findings of the present study also show that, on average, males' perceptions of their digital competencies are slightly higher than those of their counterparts, suggesting that male respondents' sustainable digital competence assessment is higher than that of female respondents. The gender gap towards technological acceptance and uses in teaching and learning was also observed in the previous studies that male teachers had greater positive attitudes and digital competencies [15, 28]. In contrast to the findings of this study, Pérez-Navío, Ocaña-Moral and Martínez-Serrano [29] suggest that female teachers have a higher level of digital competencies and perform slightly better than male teachers in information searching for their academic activities.

Concerning age groups, the findings of the present study suggest an age group-based gap that can influence the perceived digital competencies of student-teachers, especially those competencies at the knowledge acquisition level. This is in line with the findings from some previous studies; for example, Palacios-Rodríguez et al. [26] and Guillén-Gámez et al. [11] suggest that age is a contributing factor to student-teachers' digital competence development and their intentions to use ICT as a pedagogical tool. However, other previous studies, such as Binyamin, Rutter and Smith [3], confirm that age is not an influencing factor on student-teachers' digital competencies and its applications in teaching and learning. The inferential analysis of the present study also establishes that older age groups tend to have higher levels of perceived digital competencies than younger groups. For example, a statistically significant difference between age 31+ years and 16-20 years was p=0.0013. In contrast to the findings of the present

study, Vázquez-Cano et al. [42] found that teachers' attitudes and perceived applications of digital competencies were more positive among young age groups and less positive among old age groups. Gender and age are key demographic factors that may shape students' experiences, dispositions, and access to digital resources, prompting different self-perceived digital competencies. In total, the findings of this study suggest that age and gender as demographic factors do influence student-teachers' learning to teach with technology, consequently determining the perceived level of digital competencies.

6. Conclusion and recommendations

Successful pedagogical transformation empowered by digital technologies requires well-trained teachers with a set of pedagogical digital competencies. This can be achieved through the provision of teacher training and professional development that trains and cultivates heightened teachers' digital competencies. The study concludes that student-teachers' perceived digital competencies at both knowledge acquisition and knowledge deepening levels were moderate. However, teachers' digital competencies were moderately higher at the knowledge acquisition level than at the knowledge deepening level across most educational aspects.

The findings suggest that student-teachers' preparedness for technological integration might be more focused on basic digital tools rather than on how to use them to transform pedagogical practices. Limited digital competencies at the deepening level can be seen as an obstacle that hinders future teachers from fully taking advantage of emerging technologies for modern pedagogical practices. It is recommended that a tiered teacher training programme be put in place where student-teachers can progress from the basic level to the advanced level of digital competencies.

The findings show that demographic factors, especially gender and age, influence the digital competencies of student-teachers and have crucial implications for teacher education. A gender gap in perceived digital competencies might echo broader societal trends in early upbringing, where boys and girls have different supports and opportunities to use technology. Female student-teachers are more likely to feel less confident to engage with digital tools in teaching and learning. While it is universally accepted that young teachers are more conversant with digital tools due to their upbringing, this might not be the case when it comes to the pedagogical use of digital tools. It is recommended that training programmes should be designed to offer training in the pedagogical use of technology that considers the varying levels of comfort with technology across genders and age groups.

The study contributes to the scholarly body of knowledge about student-teachers' digital competencies as informed by ICT CFT. It has considerable implications for teacher educators and other educational stakeholders who might be interested in understanding the state of the art regarding the digital competencies of future teachers. The findings likely help teacher educators to identify important key areas to strengthen student-teachers' training and support for better pedagogical transformation. It is also envisioned that teacher education institutions may consider the revealed gender and age differences when planning teacher training programmes to ensure gender and age-sensitive balanced support.

The delimitation of this study was a sample of undergraduate student-teachers at the College

of Education at one of the largest public universities in Tanzania. Additionally, the examined variables were limited to digital competence constricts, age, and gender in relation to the perceived digital competencies. Further studies of the same nature could be conducted involving large samples from more than one university-based college of education. Nevertheless, it is recommended that further studies focus on additional demographic variables such as academic specialisations and the academic levels of participants.

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