Designing ICT integrated lesson activities: an intervention to bolster tutors' pedagogical use of ICT competences in Tanzania teacher education

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Abstract

Purpose – The study aims to assess the effectiveness of engaging tutors in designing and using ICT integrated lesson activities in strengthening their pedagogical use of ICT competences.
Design/methodology/approach – Survey data from an intervention group of 70 tutors from two teachers colleges (TCs) were used to compare their level of ICT competences and domains of professional practice before and after the intervention. Document analysis, lesson observations and feedback from the learning management system (LMS) were used to describe tutors' experiences from the intervention.
Findings – There was a statistically significant increase in tutors' level of pedagogical use of ICT competences and domains of professional practice associated with hands-on practice in designing and implementing the intervention.
Research limitations/implications – The intervention focus on hands-on practice, actual teaching and learning needs, and the use of active learning strategies like flipped classroom and the LMS, were useful means for tutors to make sense of pedagogical use of ICT competences.
Practical implications – The results offer useful insights to teacher education institutions and policymakers on how to prepare professional learning and supportive policies to enhance teaching and learning with ICT for addressing the learning needs of the subject matter.
Originality/value – Creating 16 ICT integrated lesson activities helped tutors to learn pedagogical use of ICT competences by doing. Use of such intervention could be a useful strategy in teacher education institutions to reposition ICT competence development from reproducing technological competences toward developing knowledge creators who could innovate their pedagogical practice with support from mentors, digital learning resources and networks.

Keywords ICT competences, ICT integration, ICT-pedagogical competences, Lesson activities, Technological competences
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1. Introduction

Since the turn into the 21st century, development of teacher educators' ICT competences has become a priority across education systems worldwide. A key motive was to develop teachers who could integrate ICT in teaching at schools along the human capital competence development value chain (Becuwe *et al.*, 2017; Nilsson & Lund, 2023). The ICT competence frameworks for teachers provide guidelines on how to teach with ICT (Mishra & Koehler, 2006; Redecker & Punie, 2017; Tondeur *et al.*, 2023; UNESCO, 2018). Teacher educators are expected to synthesize subject content pedagogy with ICT knowledge domains while addressing the learning needs of the subject matter (Koehler, Punya, & Cain, 2013).

Despite the consensus on knowledge domains, the frameworks adopted different foci in their competence development process. Studies assert that the technological pedagogical content knowledge (TPACK) focuses on teaching subjects (Mishra & Koehler, 2006; UNESCO, 2018). Advanced from Shulman's pedagogical content knowledge, TPACK considers subject content (CK) and pedagogical content knowledge (PCK) domains as determinants for technological resources needed to address the learning needs of the subject matter. The ICT Competence Framework for Teachers (ICT-CFT) (UNESCO, 2018) focuses on ICT in education competences, also known as ICT integration in teaching or teaching with ICT. Like TPACK, the ICT-CFT considers quality and relevance learning as a crucial outcome expected of an ICT integration competent teacher educator (Redecker & Punie, 2017; Tondeur *et al.*, 2023; UNESCO, 2018).

The current study focuses on tutors' use of ICT competences in teaching in Tanzania TCs. This focus has been established through analysis on policy intentions, tutors' level of ICT competences in teaching (Lubuva, Ndibalema, & Mbwambo, 2022) and three large-scale initiatives for tutors' ICT competence development in teaching in all public TCs. The first was the ICT project for TCs 2005–2008 initiated by the then Ministry of Education and Vocational Training (MoEVT) under logistical support of the Swedish International Development Agency (SIDA) (Bernt, Ngemera, Edephonce, Uimonen, & Pain, 2014). Second was the Teacher Development and Management Strategy (TDMS) 2008–2013 (MoEVT, 2015), and the third was Teacher Education Support Project (TESP) 2017–2022 by Ministry of Education Science and Technology (MoEST) under logistical support from Global Affairs Canada (Swai, Nkaizirwa, Hugo, Mahenge, & Komba, 2022). Despite the competence development efforts, studies noted actual tutors' ICT use in teaching being dominated by knowledge about ICT rather than teaching and learning with ICT (Kihoza, Zlatnikova, Bada, & Kalegele, 2016; Lubuva *et al.*, 2022). This paper intended to unveil the nature of the problem, design an intervention to strengthen tutors' pedagogical use of ICT competences and evaluate the effectiveness of the intervention. It uses data from a study by the corresponding author, which was submitted to the University of Dodoma in Tanzania in fulfillment of a PhD in education degree award.

2. Theoretical framework

Tanzania adopted her ICT competence standards for teachers, henceforth ICT-CST (URT, 2015), from the UNESCO ICT-CFT (UNESCO, 2018). This adoption included six domains of professional practice and the first two out of three levels of ICT competences, namely, knowledge acquisition (KA), knowledge deepening (KD) and knowledge creation (KC) (URT, 2015). The first domain "understanding ICT policy in education" considers the necessity for ICT competence development for teaching to take into account policy intentions for ICT in education competences. Second considers understanding curriculum and assessment for learning which provide professional knowledge for teaching. Third is understanding pedagogy which strives for how to teach specifically in learner-centered learning methods as pedagogical competences (Redecker & Punie, 2017). Fourth is how to apply digital skills in

teaching for addressing the learning needs of the subject matter. Fifth is how to organize learning in terms of infrastructure and facilities for effective pedagogical practice. Sixth considers how to utilize learning communities and networks to enhance professional learning and practice (UNESCO, 2018).

Studies unveil some contentious perspectives on whether ICT competences should be learned for technological or pedagogical purposes (Kozma, 2011; Krumsvik, 2014; UNESCO, 2018). Kozma (2011) classified ICT competences as basic "emerging" and "applying" and advanced "infusing" through "transforming" stages. He considers emerging and applying stages as technological competences, same as "KA" in the ICT-CFT, due to their emphasis on technology proficiency as an end. Infusing and transforming are considered pedagogical, same as "KD" and "KC" (UNESCO, 2018), due to their potential in addressing the learning needs within and beyond teaching and learning, respectively. Similarly, Krumsvik (2014) used adoption and adaptation for technological competences, and appropriation and innovation for pedagogical use of ICT competences. What these classifications share in common is that they posit how ICT competences have been developed by either treating competence development as a continuum from basic to advanced level or focusing on intentions where a technological or pedagogical use could be opted.

While these competences could be separately developed based on intentions, several studies, including the current paper, consider appropriate choice and use of the competences relative to the learning needs of the subject matter as more important in teaching than their separation as technological or pedagogical (Knezek & Christensen, 2018; UNESCO, 2018). By appropriate we mean that understanding the subject matter would be incomplete if ICT resources needed would be omitted from the lesson, as cautioned by Koehler *et al.* (2013). The later perspective advocates for a move from emphasis on technology proficiency as an end, to pedagogical use of ICT competences (Suárez-Rodríguez, Almerich, Orellana, & Díaz-García, 2018; UNESCO, 2018). Supporting this advocacy, Obro (2022) underscores the need for pedagogical use of ICT to create a seamless synergy between teaching, learning and hands-on-practice if it has to address the learning needs of the subject matter.

2.1 The study gap

To understand tutors' application of ICT competences in teaching, the study analyzed policy intentions, competence development frameworks and the ICT competence development initiatives as summarized in Table 1.

Content analysis of the documents indicated opportunities and constraints to pedagogical use of ICT competences as an overarching theme. While pedagogical use of ICT competences appeared as an opportunity to tutors' pedagogical practice, constraints to effective practice were not necessarily caused by tutors. This paper unpacks the gap using examples from three subthemes.

2.1.1 Misalignment between policy intentions with practice. Pedagogical use of ICT competences was the policy goal for ICT adoption in Tanzania teacher education. This claim is supported by the ETP "statement 3.3.5" which envisages the use of ICT in education provision at all levels (URT, 2014, p. 44), and the NICTP "statement 3.1.2.2" which clarifies the government commitment to ensure the use of ICT in teaching and learning throughout formal and informal education (URT, 2016, p. 20). At the implementation level, the NF-TCPD strive for integration of science and technology in teaching and learning (URT, 2020). This means that ICT integration in teaching and learning is the lever for developing ICT-pedagogical competences.

Furthermore, the ICT project for TCs, like other competence development initiatives, intended to "improve the quality of education in TCs and Schools by integrating ICT in teacher education in order to make all student-teachers ICT literate up on completing their

Document	Publication year	Focus
1. Tanzanian Education and Training Policy (ETP)	2014	• Statements on ICT use in teaching and learning
2. National ICT Policy of Tanzania (NICTP)	2016	
3. ICT-Competence Standards for Teachers in Tanzania (ICT-CST)	2015	• Level of ICT competences and domains of professional practice
4. UNESCO ICT competence Framework for Teachers (ICT-CFT)	2018	
5. National Framework for Teacher Continuous Professional Development (NF-TCPD)	2020	• Statements on development and use of ICT competences in teacher professional learning
6. Evaluation Report for the ICT project for Teachers' Colleges (2005–2008)	2014	• ICT competence development intentions and actual practice
7. Evaluation report for Teacher Development and Management Strategy (TDMS) (2008–2013)	2015	
8. Baseline survey for Teacher Education Support Project (TESP) 2017–2022	2017	
9. TESP annual implementation report	2019	
10. Tutors' Lesson plans (49) developed from July 2020 to June 2021		Pedagogical use of ICT competences for higher-order learning

Table 1. Reviewed documents

Source(s): Table by authors

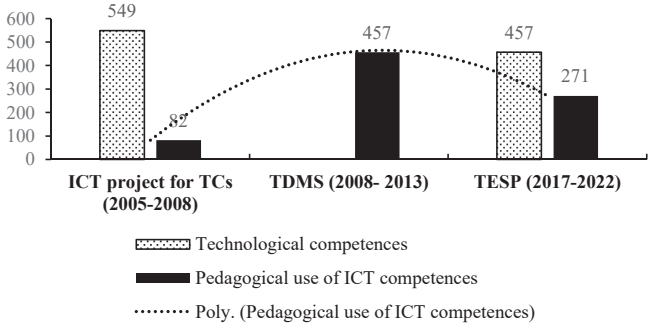
course" (Bernt *et al.*, 2014, p. 50). This means that improving tutors' pedagogical use of ICT competences was an entry point to ensure teachers graduating from TCs were adequately adept to ICT integration in their pedagogical practice, as envisaged by UNESCO (2017). While policies, the competence development frameworks and initiatives to develop ICT competences intended to develop tutors' pedagogical use of ICT competences, the ICT-CST in Tanzania revealed dissimilar focus. Despite its recognition of KD as the potential level for pedagogical use of ICT competences, the framework advocates for technological competences. Its mode of competence delivery asserts that, "In-service teachers need to obtain obligatory ICT in Education 1 '***KA'*** but ICT inEducation 2 '***KD'*** is optional for those teachers that want to excel in ICT integration in education" (URT, 2015, p. 23). This assertion means compulsory technological competences and optional pedagogical use of ICT competences contrary to policy intentions and the body of knowledge for teaching with ICT (Suárez-Rodríguez *et al.*, 2018; UNESCO, 2018; URT, 2016).

Similarly, the curriculum through its framework for subjects learned in TCs (TIE, 2019) supports technological competences through its emphasis on computer studies subject without any option for pedagogical use of ICT competences in TCs. The study drew several implications from this policy and practice misalignment. First, it seemed that TCs were meant to develop all student teachers as teachers of computer studies. Second, TCs were not developing teachers who could integrate ICT in their pedagogical practice. Third, ICT integration in academic and professional subjects learned in TCs was at the discretion of tutors rather than the curriculum. These contrasts reveal what studies consider as systemic barriers to pedagogical use of ICT competences (Messina, Rossi, Tabone, & Tonegato, 2018; Tallvid, 2016). It was highly probable that, what was noted as tutors' limited pedagogical use of ICT facilities (Swai *et al.*, 2022), as well as limited use of open education resources and learning networks (Lubuva *et al.*, 2022), could have a root in this policy and practice gap. Consequently, an intervention was needed to reposition tutors' practice into pedagogical use of ICT competences.

2.1.2 Limited hands-on-practice in pedagogical use of ICT competences. The study noted that the ICT project for TCs, TDMS and TESP developed tutors' technological as well as ICT-pedagogical competences (Bernt *et al.*, 2014; Swai *et al.*, 2022). Technological competences focused on proficiency in word processing, spreadsheet, presentation and file and directory management; use of Internet and email, as well as communication through social media as analyzed by Fraillon, Ainley, Schulz, Duckworth, and Friedman (2019). Pedagogical use of ICT consisted of mapping web resources to subject syllabi, multimedia lesson presentations, using Moodle Learning Management System and e-learning knowledge and skills (Bernt *et al.*, 2014). Despite the great contribution made by the initiatives in strengthening tutors' technological knowledge, ICT competences seemed to be developed with limited hands-on-practice in synthesizing ICT with subject content and pedagogical content knowledge (Lubuva *et al.*, 2022). The results suggested that what was developed was proficiency in technologies with potential value to teaching rather than hands-on-practice in their integration in teaching as recommended across studies (Koehler *et al.*, 2013; Peled & Perzon, 2022; Suárez-Rodríguez *et al.*, 2018). Figure 1 illustrates the competence development trend reflecting this limitation.

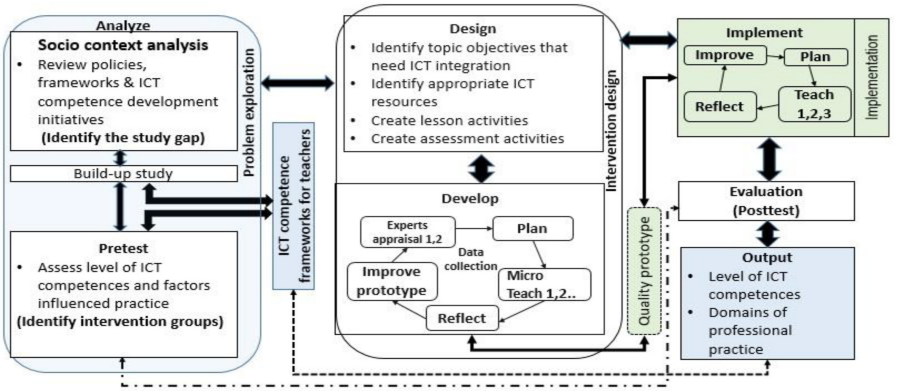
Figure 1 reveals that only 82 tutors were eligible for training in pedagogical use of ICT competences during the ICT project for TCs. This could be due to limited number of tutors who had ICT skills during the project inception in 2005, which could prompt the need to amass technological competences as reflected in Figure 2. However, Bernt *et al.* (2014) reveal that, by 2011, 457 tutors were trained in pedagogical use of ICT competences. Surprisingly, the same number 457 was enrolled for basic ICT skills under TESP, with only 271 who were eligible for training in ICT-pedagogical competences. These statistics suggest that unless the training focused on tutors who had not received any ICT competence training yet, there would be a low and diminishing pedagogical use of ICT competences. It seemed that competence development did not engage tutors in the best possible practice in teaching with ICT (Koehler *et al.*, 2013). Consequently, an intervention was necessary to strengthen tutors' pedagogical use of the ICT competences.

2.1.3 Limited skills in lesson planning for ICT use in higher-order domains. Studies affirm that pedagogical use of ICT competences entails lesson planning and their application in teaching and learning for higher-order cognitive domains accrue (Knezek & Christensen, 2018). However tutors' lesson planning for teaching with ICT (Lubuva *et al.*, 2022) revealed a surprising result because, out of 49 lesson plans prepared between July 2020 and July 2021, only 11 mentioned ICT use, and neither of them indicated how ICT was applied in actual teaching. Furthermore, majority (46) lesson plans identified with lower-order levels of knowledge like define, explain and describe as classified in Bloom's taxonomy (Anderson &



Source(s): Figure by authors

Figure 1. Tutors' ICT competence development trend



Source(s): Figure by authors

Figure 2.
Study phases

Krathwohl, 2001), which indicated low emphasis on higher-order knowledge domains. These findings raised questions on whether student teachers were prepared to actively integrate ICT in their pedagogical practice. Consequently, the need to engage tutors in designing and using ICT integrated lesson activities for pedagogical use of ICT competences became indispensable. Table 2 summarizes identified gaps and intervention action areas.

To address the action areas (Table 2), a rubric for evaluating e-learning tools (Anstey & Watson, 2018) guided the selection of ICT resources. Consideration was made on technologies supporting active learning, higher-order thinking and instant feedback sharing. Moreover, the selection involved other criteria like; accessibility to web and mobile browsers; offline use of OER; freedom for users to import, export and share; and possibility for integration of the lesson activities in the LMS for individuals and group collaborative practice.

2.2 Intervention design

Design-based research in education uses several phases in intervention development. This study was organized in four phases, namely, problem exploration, designing an intervention, implementation and evaluation (McKenney & Reeves, 2012; Plomp & Nieveen, 2013), as summarized in Figure 2.

Need	Action
1. Limited pedagogical use of ICT competences	Integrate subject content, pedagogy and ICT within the lesson activities in the LMS
2. Limited use of OER and learning networks	Integration of appropriate OER within lesson activities by aligning them with learning tasks to be completed in the lesson
3. Limited emphasis on higher-order cognitive domains	Splitting learning tasks into collaborative groups and individual practice sessions in order to maximize practice as in flipped classroom
4. Limited access and accessibility to ICT facilities and the Internet	Integration of lesson activities in the LMS for tutors and student teachers' practice within and beyond TCs using college and their own ICT facilities

Source(s): Table by authors

Table 2.
Intervention action areas

Figure 2 illustrates iterative cycles adopted in coming up with ICT integrated lesson activities. Problem exploration entails analyses conducted to make sense of the problem and its setting as reflected in document analyses (Table 1) and the gaps (Table 2). Pretest survey assessed level of ICT competences before the intervention, and the results were used to determine the intervention group. Intervention design consisted of planning, microteaching and appraising prototypes in order to come up with quality prototype.

Expert appraisal was conducted twice by four experts – the first cycle by two from Teacher Education Unit of the MoEST, and the second by two faculty members from College of Education of the University of Dodoma in Tanzania. Feedback from each appraisal was used to improve the prototypes. A quality prototype was uploaded in the Learning Management System (LMS), practiced by tutors in assessed microteaching sessions and implemented in actual classroom in TCs.

In this paper, we used findings from problem exploration to unveil the study gap and report findings from intervention design, implementation and evaluation. The study goal was to assess the effectiveness of engaging tutors in designing ICT integrated lesson activities on their level of pedagogical use of ICT competences. Based on the discussed theoretical framing, the study set to answer two questions posed for this paper.

(1) How did tutors conceive the intervention design and implementation in relation to their pedagogical practice?

(2) To what extent was the intervention effective in enhancing tutors' level of pedagogical use of ICT competences and domains of professional practice?

3. Methodology

3.1 The study context

The study was conducted in two public TCs named as Mkasiwa and Mianzini (pseudonyms) from Dodoma and Iringa regions of Tanzania from February 19, 2020, to July 11, 2022, respectively. The choice of the study location and sites was based on characteristics of interest to the research purpose. Both TCs had experiences of enrolling similar student teachers for science and education subjects at diploma level including experience with student teachers who specialized in the use of ICT in teaching. Moreover, both TCs had experiences in the use of Moodle Learning Management System and had tutors who were trained for pedagogical use of ICT since the ICT project for TCs in 2005 (Bernt *et al.*, 2014) through TESP 2017 (Binde, Sayi, & Kumburu, 2017). Further, the TCs had functional ICT facilities for teaching and learning with the latest technology provided by the TESP project.

3.2 Study design, data collection methods

Informed by pragmatist standpoints (Creswell & Plano Clark, 2018), quasi-experimental and case study strategies were adopted to compare the outcome of the intervention group (N = 41 for Mkasiwa and N = 29 Mianziani TCs) before and after the intervention. A convenience sampling was used to obtain pretest survey respondents, and purposive sampling was done to allow only those who completed pretest survey to participate in posttest (West, 2016). We used data from both pretest and posttest survey to compare tutors' level of ICT competences and domains of professional practice. The variables assessed and their reliability tests are described in Table 3 and a complete questionnaire is shared as Appendix.

Variables labeled TUKA (Table 3) assessed technological competences and TUKD constituted ICT-pedagogical competences.

We used document analysis to collect data from policies, competence development initiatives and written reflections during problem exploration and intervention design.

Variable	Description	Number of items	Cronbach's α
TUKA-G1	Use of word processing, spreadsheet and presentation applications in teaching and learning	3	0.866
TUKA-G2	Use of Internet and e-mail and social media in teaching and learning	3	0.775
TUKD-G1	Use of ICTs in teaching, learning and assessment for learning	7	0.928
TUKD-G2	Use of apps for creating graphics, audio, video and multimedia teaching and learning resources	4	0.931
TUKD-G3	Use of ICTs in content creation, sharing and supporting learners with disabilities	3	0.864
Policy	Understanding ICT in education policy	3	0.649
Curriculum	Curriculum and assessment	4	0.856
Pedagogy	Pedagogy	3	0.706
Organization	Organization and administration	4	0.768
ICT	Use of digital skills	3	0.825
TPL	Tutor professional learning	3	0.793

Table 3. Summary of survey variables and their reliability coefficients

Note(s): Reliability scale: (>0.90) = very highly reliable; (0.80–0.90) = highly reliable; (0.70–0.79) = reliable; (0.60–0.69) marginally reliable and (<0.60) unacceptably low reliability (Cohen, Manion, & Morrison, 2018, p. 774)
Source(s): Table by authors' pretest study data set

Similarly, we used extracts from the LMS, system logs and lesson observation during implementation. We adopted a rubric bearing five attributes for meaningful learning with ICT from Koh (2013), which is accessible from https://ajet.org.au/index.php/AJET/article/view/228/781. The rubric was useful in tracking the use of ICT during the lesson in order to interpret the level of performance in addressing the learning needs of the subject matter. Like the level of ICT competences, meaningful learning with ICT classifies the level of performance across attributes as basic when ICT contribution is in identifying the learning needs only, intermediate level when it is used to set strategies for addressing the learning needs and advanced when it actually address the needs within and beyond teaching and learning (Koh, 2013). The meaningful learning attributes had similar description of proficiency in the use of ICT competences to the UNESCO ICT CFT adopted in this study (UNESCO, 2018). We used inter-rater assessment (Miles, Huberman, & Saldaña, 2014), where a lesson was observed by three observers for consistency of scores relative to applied level of ICT competences.

3.3 Intervention group identification

The study used average performance of all 70 respondents in 14 pretest survey variables for KD to select the intervention group as summarized in Table 4.

College	Group code	Number of participants	Competence description
MKASIWA	1A	23	Basic level
	2A	12	Intermediate level
	3A	6	High level
MIANZINI	1B	14	Basic level
	2B	8	Intermediate level
	3B	7	High level

Table 4. Summary of intervention group

Note(s): Scale: 1–2.9 = basic; 3–3.9 = intermediate; 4–5= high level
Source(s): Table by authors' pretest study-dataset

In Table 4, groups described as "basic" and "intermediate" were the target of the intervention because they seemed to have low performance in pedagogical use of ICT competences. However, the group with "high level" was involved in the study as mentors who supported the rest of the groups while learning from the intervention. Mentorship role was informed by assisted and potential development assumptions by Vygotsky (1978). This role was extended to include researchers and experts who appraised the intervention.

3.4 Data analysis

3.4.1 Quantitative data. The study adopted a paired sample *t*-test to compare the effectiveness of the intervention between pretest and posttest using overall KD mean scores and means scores for domains of professional practice as informed by Pallant (2016).

3.4.2 Qualitative data. We transcribed audio data verbatim and sorted to obtain words and phrases conveying related meaning. We identified emerging themes and classified their supporting evidences according to frequency of occurrence in relation to how tutors experienced pedagogical use of ICT competences. Data from rubric were analyzed descriptively based on average rating of the lesson activities in each attribute for meaningful learning with ICT (Koh, 2013). Results from the rubric, and meaningful words and phrases from reflections and feedback from participants' practice in the LMS, formed evidences for interpretation of findings.

4. Results

4.1 Tutors' conception of intervention design and implementation

4.1.1 Design. Results from this subsection focused on tutors' written reflections which indicated their experiences in intervention design and implication in addressing gaps in their conception of pedagogical use of ICT competences. Findings are summarized in Table 5.

Results (Table 5) reveal tutors' positive sentiments on their participation in intervention design. Lessons learned (column 1) indicate qualities of lesson activities as effective, applicable and practical manifested through learning by doing, use of OER and subject-specific apps and collaborative solution creation. Aspects in column 2 labeled most striking signify the intervention balance between theoretical knowledge "process" with hands-on-practice "practice" for higher order domains accrue. The likelihood to apply (column 3) indicates perceived usefulness of the lesson activities in tutors' pedagogical practice.

4.1.2 Implementation. Results from this section focused on classroom observation of 16 ICT integrated lesson activities in microteaching sessions. These sessions focused on tutors' subject groups for languages (Swahili, English and communication skills), science and mathematics (physics, chemistry, biology and mathematics), humanities (Geography, history and development studies) and education (curriculum and teaching, educational psychology and foundations of education). The results for each lesson across attributes for meaningful learning with ICT are summarized in Table 6.

Results (Table 6) reveal that the lesson activities had consistent rating ($\bar{x} = 2$ through 3) between low and high performance with variation in frequency of lessons across meaningful learning attributes. Scores were distributed between applying and infusing level of performance. Prominence of applying stage means the use of ICT across meaningful learning attributes focused on identifying the learning needs of the subject matter. At infusing, the focus was in setting strategies and addressing the learning needs within lessons while transforming the stage addressing the needs within and beyond

Lessons learnt, participant and college	Most striking	Likelihood to apply
1. I learnt ICT integration by doing *(biology - Mianzini)*	*Creating and using assessment items* for my lesson in the LMS *[practice]*	*5 = Very high*
2. Excellent in improving my ICT integration capacity *(chemistry - Mianzini)*	Using search criteria to identify and use appropriate e-books and videos in my lesson *[process]*	*5 = Very high*
3. A fantastic way to foster lesson understanding *(communication skills - Mianzini)*	Splitting lesson tasks for groups and individuals' online and classwork using flipped class methodology *[practice]*	*4 = High*
4. *Provokes creativity* in information searching and organizing ideas in a lesson (*biology - Mkasiwa)*	When to use (timing) a particular ICT resource, e.g. multimedia *[process]*	*4 = High*
5. The process was *participative! I appreciate* learning how an app (GeoGebra) could work in my lesson *(mathematics - Mkasiwa)*	Planning practice activities for groups, individuals and collaborative class work supported by a tutor *(flipped classroom) [practice]*	*3 = Average* Need more assistance and practice
6. E-books and video were *a strong supplement* to my lesson, I learnt ICT operations not known to me before *(geography – Mkasiwa)*	Linking lesson content with appropriate ICT resources like texts, e-books and video *[process]*	*5 = Very high*

Source(s): Table by authors

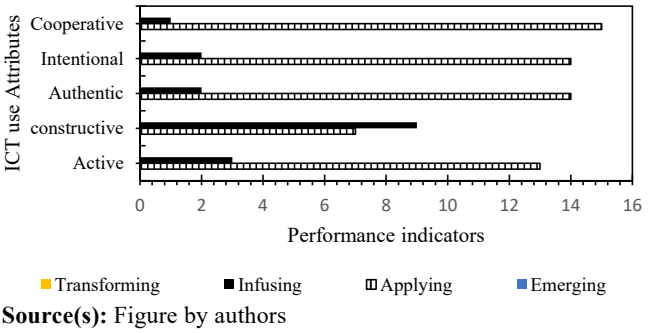
Table 5. Tutors' feedback from the intervention design process

Lesson	Active	Constructive	Average Authentic	Intentional	Cooperative
1. Listening skills	2.7	2.7	2	2.3	2.7
2. Notes taking skills	2.3	2.7	2	2.3	2.3
3. Oral presentation	2.7	3	2	2.3	2
4. Application of GeoGebra in solving mathematic problems	2.7	3	2	2.3	2
5. Application of trigonometric special angles	3	2.3	3	2.3	2.3
6. Surface tension	2	2.3	2.7	3	2
7. Application of electrolysis in daily life	2.3	3	1.3	2.3	2.3
8. Chemistry of life in the environment	3	2.3	2	2	2.7
9. Structure and functions of the heart	2.3	2.7	2	2.3	2.7
10. Protein synthesis	2.3	2	2	2.3	2.7
11. Geography teaching methods: faulting	2	3	2.7	2.7	2.7
12. Government and politics	3	3	2.3	3	2.3
13. Instructional media	2.3	3	2.3	2.3	2.7
14. Concept of education	3	3	2.3	2.3	2.3
15. Classical conditioning learning theory	2.7	3	3	2.7	2.3
16. Operant conditioning learning theory	2.3	3	2.7	2.7	3

Note(s): Scale: 0 = no ICT use; 1 = emerging; 2 = applying; 3 = infusing; 4+ = transforming
Source(s): Table by authors

Table 6. Lesson observation inter-rater assessment

teaching and learning. Frequency of scores for each lesson across the attributes is summarized in Figure 3.



Source(s): Figure by authors

Figure 3.
Microteaching inter-rater assessment

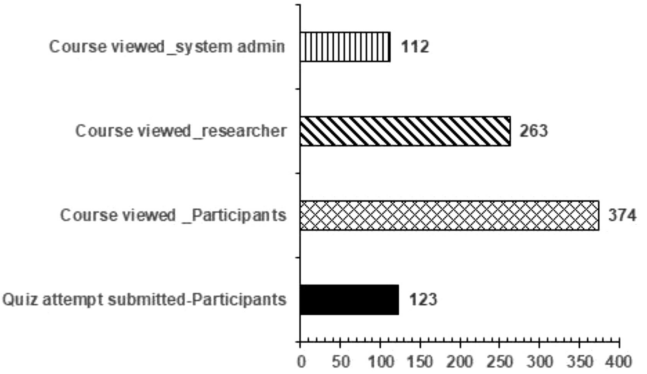
Going by specific attributes, active attribute had 13 lessons rated $\overline{x} = 2$ through 2.7, which means there was substantial engagement of participants with the subject matter using ICT, while three lessons had high rating $\overline{x} = 3$, which signified active engagement with the subject matter using ICT. Constructive attribute had high rating $\overline{x} = 3$ in nine lessons, suggesting ICT resources enabled participants to articulate their personal understanding of the subject matter. Seven lessons had rating $\overline{x} = 2$ through 2.7, which showed ICT use supported a small part of respective lessons.

Authentic 14 lessons rated $\overline{x} = 2$ through 2.7, which means ICT use enabled participants to diagnose real-world phenomena related to the subject matter. Two lessons enabled participants to diagnose and propose a solution to the real-world phenomenon. Intentional attribute had 14 lessons rated $\overline{x} = 2$ through 2.7, indicating ICT was used to diagnose personal learning gaps of the subject matter, but they could not be able to address the gaps. Two lessons show that ICT enabled participants to diagnose their personal learning gaps and set pathways to address the gaps. Finally, in cooperative, 15 lessons were rated $\overline{x} = 2$ through 2.7, which means participants had limited collaborative engagement with the subject matter knowledge using ICT, with the exception of one subject. Overall, applying was the most prominently rated practice. What seemed to constrain high rating in infusing and transforming include limited Internet connectivity in TCs during microteaching, which necessitated interactive activities like quizzes in the LMS to be practiced offline. To address the constraint, researchers used a mobile D-link which connected 35 to 40 devices with wireless Internet. These devices include computers in TC ICT labs, tutors' smartphones and laptops which facilitated practice of the lessons in the LMS. The solution was possible because the LMS was accessible in web and mobile operating systems like Android through a mobile app "MUKI -LGTI," which was accessible in Google Play store. Figure 4 displays the frequency of practice in the LMS consisting of participants (tutors and student teachers), researcher and system admin.

Apart from researchers' and system admin, 374 participants' system logs suggest the frequency of access to course content like e-books or video, probably downloaded for their offline use. The most important indicator of practice was 123 individual participants' quiz attempts and submission for automated feedback in the LMS.

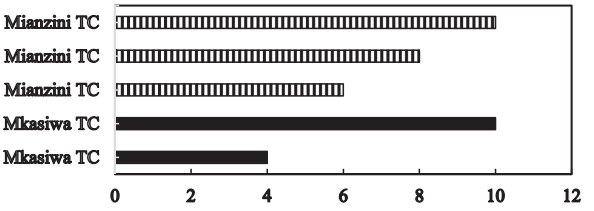
4.1.3 Tutors feedback from intervention practice. Quiz results from the LMS (Figures 5 and 6) reflect tutors' testimonies of intervention practice. Figure 5 indicates tutors' performance in mathematics by duty station.

Findings (Figure 5) reveal that out of 10 individual quiz items assessed, two tutors one from each TC attempted all questions correctly. Despite the variation of scores across other participants, tutors' from both TCs could use GeoGebra calculating device in solving posed mathematical problems. Since the LMS allowed for multiple attempts, the rest of tutors could



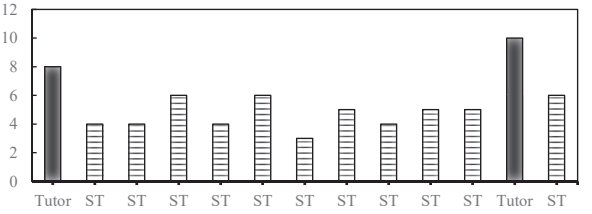
Source(s): Figure by authors

Figure 4.
System logs for participants' activities in the LMS



Source(s): Figure by authors

Figure 5.
Participants' quiz scores in the use of GeoGebra calculating device



Source(s): Figure by authors

Figure 6.
Tutors' and student teachers' quiz results for listening skills lesson - Mkasiwa TC

be in a position to revise and retake the quiz individually and in groups with support from OER and mentors within TCs or beyond.

Similarly, Figure 6 displays tutors' and student teachers' (ST) self-test-quiz for Listening skills in communication skills subject.

Findings (Figure 6) reveal higher tutors' scores (8 and 10) than student teachers (3–6) out of ten quiz items. Tutors' high scores could be attributed to intensive engagement with intervention design and implementation in collaboration with mentors. The opposite seemed to be true with student teachers who interacted with the lesson activities at implementation stage only. The power of practice coupled with perceived usefulness of the intervention could be some of the reasons for tutors' high performance. Nevertheless, the findings suggest that student teachers could most likely demonstrate similar performance as tutors if they had an opportunity to design and use lesson activities for their pedagogical practice with support from tutors.

Further, the study assessed individual tutors' views on how they experienced the lesson activities in the LMS. Extract 1 indicates tutors' views from Mkasiwa and Mianzini TCs extracted on Tuesday, June 28, 2022, and Monday, July 11, 2022, respectively.

Extract 1. Participants' experiences on the use of the lesson activities in the LMS

(1) In fact, **the program** is nice and valuable for today's generation full of digital technologies12:47 PM **(geography - Mkasiwa)**.
(2) This **platform** is highly recommendable for students to do their remedial learning 12:45 PM; it helps students to practice themselves on their own time and improve themselves in their remedial learning 12:48 PM **(mathematics – Mkasiwa).**
(3) The questions designed are **appealing.** The only thing to improve is that, diagrams need to be in colour print for clear visualizations. Also, for question number 8, the most correct answer is '**pace maker or Sino atrial node**' **(biology - Mianzini).**
(4) The use of this ICT system in learning is **very good**, because it is easy to use and asses learners' understanding of the topic via questions. But we need solution for **internet access** for effective use of the quizzes **(biology -Mianzini)**

Source(s): Electronic data from the LMS: http://muki.lgti.ac.tz/message/index.php

Results (Extract 1) reveal several positive sentiments. First, they consider the intervention useful in their understanding of the subject matter as expressed in words valuable, recommendable, appealing and very good. Second, it shows the effectiveness of the LMS in extending the use of the lesson activities beyond the confines of TCs, as reflected in view number two. The results suggest that integration and practice of the lesson activities in the LMS was a practical solution to constraints in access to quality content through integration of OER in the lesson activities. The LMS enabled ubiquitous access to the lesson activities which integrate links to OER, connecting tutors with educational resources in the web. Third, the ability to critique the assessment items and give suggestion for improvement reflects not only proficiency in subject content but also a sense of ownership to the intervention (views number 3). Fourth, caution on unreliable Internet connectivity in TCs acts as a constraint to sustainable practice in the LMS.

4.2 Tutors' level of pedagogical use of ICT competences before and after the intervention

Paired sample *t*-test was used to evaluate whether there were any statistically significant change in tutors' pedagogical use of ICT competences between pretest and posttest as informed by Pallant (2016). While the study compared technologies used by tutors in knowledge acquisition (TUKA) and knowledge deepening (TUKD) variables (Table 7), interpretation of findings focused on overall TUKD as an indicator for pedagogical use of ICT competences. However, TUKA-G2 was included because of the possibility for using it pedagogically.

Table 7 reveals a statistically significant increase in respondents' overall KD level of ICT competences from pretest (M = 40.5, SD = 13.2) to posttest (M = 46.8, SD = 10.09), *t*-value = 3.90, $p < 0.0005$. The impact factor to compare the differences in mean scores is 0.18, signifying large effect size in Cohen's eta squared (Pallant, 2016). Specific increase is reflected in variables TUKD-G2 for use of apps in creating graphics, audio, video and multimedia teaching, and learning resources and TUKD-G3 for content creation, sharing and supporting student teachers with disabilities. Similar findings have been noted in TUKA-G2 where Internet, e-mail and social media are used in teaching and learning from pretest (M = 10.5,

	Mean	N	SD	*t*-value	Df	*p*-value	E^2
TUKA-G1-Pre	11.9	70	2.52	−1.285	69	0.203	0.023
TUKA-G1-post	12.4	70	2.10				
TUKA-G2-Pre	10.5	70	1.89	5.475	69	$p < 0.0005$*	0.303
TUKA-G2-Post	12.3	70	2.42				
TUKD-G1-pre	21.0	70	6.56	−0.332	69	0.741	0.002
TUKD-G1-post	21.2	70	5.21				
TUKD-G2-Pre	11.1	70	4.55	−6.468	69	$p < 0.0005$*	0.377
TUKD-G2-post	15.2	70	3.14				
TUKD-G3-pre	8.4	70	3.37	−4.587	69	$p < 0.0005$*	0.234
TUKD-G3-post	10.5	70	2.66				
Overall TUKD pre	40.5	70	13.20	3.903	69	$p < 0.0005$*	0.181
Overall TUKD post	46.8	70	10.09				

Note(s): df = degree of freedom, E^2 = eta squared, SD = standard deviation, * = pre- and posttest scores differ significantly
Source(s): Table by authors

Table 7. Tutors' level of ICT competences before and after the intervention

SD = 1.89) to posttest (M = 12.3, SD = 2.42), *t*-value = 5.475, $p < 0.0005$. The impact factor to compare the group means was 0.303, signifying large effect size. Although it aligns with technological competences, the use of TUKA-G2 applications helped tutors and student teachers to share information and e-content using e-mails and social media like WhatsApp and face book through their smartphones to complete their learning tasks.

Furthermore, paired sample *t*-test was used to assess if there were any statistically significant change in respondents' domains of professional practice between pretest and posttest as summarized in Table 8.

Table 8 reveals that there was a statistically significant increase in respondents' competence level in pedagogy from pretest (M = 9.9, SD = 2.5) to posttest (M = 11.1, SD = 1.6), *t*-value = -3.80, $p < 0.0005$, with the effect size of 0.173, which indicated large effect (Pallant, 2016). Similar increase was noted in organization and administration from pretest (M = 13.2, SD = 3.17) to posttest (M = 14.3, SD = 2.85), *t*-value = -2.48, $p < 0.015$, with the effect size of 0.082 indicating moderate effect. Further, professional learning increased from pretest (M = 10.1, SD = 2.6) to posttest (M = 12.6, SD = 1.56), *t*-value = -7.05, $p < 0.0005$, with

	Mean	N	SD	*t*-value	Df	*p*-value	E^2
Policy-pre	12.2	70	1.89	1.758	69	0.083	0.043
Policy-post	11.7	70	2.08				
Curriculum-pre	14.7	70	3.28	−1.105	69	0.273	0.017
Curriculum-post	15.2	70	2.49				
Pedagogy-pre	9.9	70	2.59	−3.801	69	$p < 0.0005$*	0.173
Pedagogy-post	11.1	70	1.61				
Organization-pre	13.2	70	3.17	−2.489	69	0.015*	0.082
Organization-post	14.3	70	2.85				
Digital skills-pre	10.7	70	2.68	−1.317	69	0.192	
Digital skills-post	11.2	70	1.89				
TPL-pre	10.1	70	2.66	−7.051	69	$p < 0.0005$*	0.420
TPL-post	12.6	70	1.56				

Note(s): df = degree of freedom, E^2 = eta squared, SD = standard deviation, * = pre- and posttest scores differ significantly
Source(s): Table by authors

Table 8. Tutors' competence level across domains of professional practice

the effect size of 0.420 indicating a large effect size. The result indicates that domains which were applied in hands-on practice during the intervention yielded a significant increase than those without understanding ICT policy in education. It is highly probable that the increase in the level of pedagogy, organization and administration and teacher professional learning could have been caused by intensive practice throughout intervention design and implementation. Consequently, the result suggests a positive relationship between effective practices in pedagogical uses of ICT competences with increase in the level of domains of professional practice.

5. Discussion

5.1 Tutors' conception of the intervention

While findings from intervention design (Section 4.1.1) indicated tutors' positive sentiments on the significance of the intervention in their teaching, TCs revealed persistence of policy and curriculum misalignment which constrained tutors' capability and ownership to pedagogical use of ICT competences. Tallvid (2016) considers such misalignment as systemic barriers to teaching with ICT. Although systemic measures like policy and curriculum alignment would alleviate the severity of the barriers as proposed in the Tanzanian Curriculum for basic and teacher education 2023, their effect in practice would be minimal unless tutors were competent and committed to teach with ICT. Peled and Perzon (2022) caution that in teaching with ICT, knowledge without practice is a potential barrier to effective practice.

Looking at practice in TCs, findings (Table 2) reveal that tutors were proficient in subject content, pedagogy and ICT knowledge domains. However, they seemed to lack technical knowhow and experience to integrate the domains in actual teaching because the domains were developed and practiced separately (Lubuva *et al.*, 2022; Swai *et al.*, 2022). Thus, engaging tutors in designing and using the ICT integrated lesson activities did not mean orienting them to mimic the lesson activities in their teaching. Rather, it intended to empower them to create knowledge that would support their pedagogical use of ICT competences in order to develop teachers' competences to teach with ICT.

As an entry point, the intervention involved tutors of different subjects in content creation with synthesis of the knowledge domains in mind. As expounded by Ferrari, Brečko, and Punie (2014), content creation entails developing, integrating and reelaborating content relative to teaching and learning needs. Guided by e-content selection criteria (Anstey & Watson, 2018), tutors searched and integrated appropriate e-texts, books, YouTube videos and subject-specific apps constituting OER (Tlili *et al.*, 2022). In this process, they applied technological competences learned from previous initiatives (Bernt *et al.*, 2014; Swai *et al.*, 2022) like searching content from the Internet, creating graphics, audio and video clips, and inserting them in specific lesson tasks as extracts or links to actual content online. Specific apps like *Audacity* for audio clips, *SnagIT*, *Paint*, *Snipping tool* for graphics and *Screen-cast-Omatic* for video clips were used to create materials needed in the lesson activities. As reflected in Table 5, tutors were captivated by the design process they referred to as useful, practical and thought-provoking in their learning to teach with ICT.

To realize higher-order knowledge domains, tutors organized the lesson activities into interdependent sessions before, during and after class for intensive practice as emphasized in flipped classroom (Jian, 2019; Smith, 2021). Complete lesson activities with links to OER and assessment items were uploaded in the LMS. Together, flipped classroom and the LMS created a synergy between physical and virtual learning environments recommended across studies as a useful learning modality in the digital era and in times of crises like the COVID-19 pandemic (Hamadeh *et al.*, 2022; Matete, Kimario, & Behera, 2023; Mays, Ogange, Naidu, & Perris, 2021; Ndibalema, 2022).

Implementation of the lesson activities involved tutors in microteaching sessions organized in groups of teaching subjects (Table 6). Findings indicated that tutors could prominently use ICT to diagnose the learning needs of the subject matter. However, the ultimate goal was to address the needs as expected in meaningful learning with ICT (Howland, 2014; Koh, 2013) and KD and KC level of ICT competences (UNESCO, 2018). Unreliable Internet connectivity during microteaching constrained the use of the lesson activities in the LMS. This constraint was not persistent in Tanzania TCs only, but it was also noted in higher learning institutions in some contexts as reported by Alexopoulos, Al-Tamimi, and Saxena (2023). In the current study, researchers deployed a mobile D-Link which connected a maximum of 40 users with wireless Internet to facilitate tutors' and student teachers' practice of the lesson activities in the LMS using computers in TCs, and their own laptops and smart phones. The findings reveal that, to realize meaningful pedagogical use of ICT competences need a continuous process of planning, practice and reflection analoguous of a spiral of unknown end posited by Ferrari *et al.* (2014). It also needs adoption of innovations in teacher education for relevant practice (Mhlongo, Mbatha, Ramatsetse, & Dlamini, 2023). Despite the positive feedback from participants' practice in the LMS (Extract 1), it could be noted that, unless TCs support tutors to own the process of teaching with ICT and provide necessary ICT resources, the envisaged potential of pedagogical use of ICT competences in teacher education would hardly be realized.

5.2 Tutors' level of pedagogical use of ICT competences and domains of professional practice before and after the intervention

As extensively articulated across studies (Nilsson & Lund, 2023; Suárez-Rodríguez *et al.*, 2018; UNESCO, 2018), ends matter when making sense of ICT use in teaching and learning. While these studies indicate the need for a shift from emphasis on technological competences to pedagogical use of ICT competences, tutors' practice (Section 2.1.2) revealed knowledge that is more theoretical in pedagogical use of ICT competences. To realize a practical end, intervention engaged them in a concrete process of planning, practice and reflection on how to use ICT competences in teaching. The findings (Tables 7 and 8) revealed a significant increase in overall TUKD as well as pedagogy and organization domains of professional practice. This increase was contributed by several factors. First, tutors' perceived usefulness of the lesson activities expressed in their new learning and likelihood to apply (Table 5). As observed by Syvänen, Mäkiniemi, Syrjä, Heikkilä-Tammi, and Viteli (2016), perceived usefulness is a key factor reinforcing practice. It is highly probable that the intervention added value to tutors practice. Probably, given more pedagogical support within TCs, tutors could enhance their teaching with ICT.

Second, extensive practice throughout the intervention could have influenced the increase in TUDK and domains. As reflected in in findings (Extract 1), integration of OER in lessons, use of flipped classroom sessions as well as uploading and use of the lesson activities in the LMS by tutors and student teachers complement the practice. Third, working in collaborative groups of similar teaching subjects was a platform for tutors' team thinking, knowledge co-construction and collaborative problem-solving which could enhance competences in pedagogy and organization domains. This finding supports the effectiveness of team spirit in addressing learning needs as recommended by Nungu, Mukama, and Nsabayezu (2023). Fourth is the role of mentors within TCs, and the learning networks in maintaining pedagogical use of ICT competences. Like other factors, their role in supporting practice could have contributed in enhancing tutors' level of TUKD, pedagogy and organization variables.

5.3 Study limitation

Our study results was drawn from an intervention group of tutors (N = 70) from two public TCs only, and thus could not be generalized to the rest of TCs. Its purpose was to engage

tutors in designing ICT integrated lesson activities without grouping them in treatment and control groups, because practicing pedagogical use of ICT competences was a critical need. The study contributes in testing pedagogical use of ICT competences across different subjects in a teacher education curriculum. It also contributed to curriculum enrichment through designing 16 ICT integrated lesson activities for supporting teaching with ICT. Furthermore, the use of flipped classroom and the LMS, particularly in Tanzania TCs, was an innovation in blending classroom and virtual learning environments for addressing higher-order knowledge domains.

6. Conclusion

This study envisaged to evaluate the effectiveness of engaging tutors in designing and using ICT integrated lesson activities for strengthening their pedagogical use of ICT competences. Despite the existed misalignment between policy intentions with practice in TCs, tutors conceived the intervention as useful, practical and worthy to apply to their teaching. Hands-on practice, collaborative support and utilizing mentors and expertise from the learning networks were effective strategies to bolster pedagogical use of ICT competences. The study contributed to enhance tutors' active learning, practicing higher-order knowledge domains and tested the use of ICT competences beyond the confines of physical classrooms.

6.1 Recommendation

First, there is a need to align the national ICT competence framework with policies and innovations in teacher education like pedagogical use of ICT competences for knowledge creation. Second, administrative- and research-based intervention is needed to scale up pedagogical use of ICT competences in teacher education. New tutors' could undergo a professional induction on pedagogical use of ICT competences through designing and using e-content and contributing knowledge in learning networks.

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Appendix

The supplementary material for this article can be found online.

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