The Contribution of Instructors' Usability of ICT Infrastructure on Students Learning Outcomes: The Case of Selected Higher Learning Institutions in Tanzania

Marystella Baynit, Cosmass Mnyanyi & Mohamed Msoroka
Faculty of Education
The Open University of Tanzania
marystellabaynit@gmail.com

Abstract
Higher learning institutions in Tanzania are undergoing a paradigm shift in the delivery of academic programs, transitioning from traditional face-to-face instruction to digital platforms. In this context, instructors' ability to effectively utilize ICT infrastructure is a critical determinant of successful education delivery and enhanced student learning outcomes. This study investigates the extent to which instructors' ICT usability influences students' academic performance. The study adopted a mixed-methods approach with a cross-sectional design, focusing on two higher learning institutions in Tanzania: The Open University of Tanzania (OUT) and the Institute of Accountancy Arusha (IAA). A total of 237 instructors were randomly selected to participate in the study. Data were collected using self-administered questionnaires, key informant interviews, and focus group discussions. Descriptive statistics and binary regression analysis were employed for data analysis. The findings indicate that instructors' proficiency in using ICT infrastructure significantly influences students' learning outcomes. The usability of ICT tools by instructors was said to account for up to 29% of the variation in learning outcomes. Key usability parameters such as operating smart screens/projectors, setting up audio equipment, and using online response clickers for quizzes and surveys showed a statistically significant and positive impact on student learning. The study concludes that instructors' effective use of ICT infrastructure plays a vital role in enhancing student learning outcomes, particularly when core ICT functionalities are well understood and applied. It is recommended that higher learning institutions in Tanzania strengthen instructors' competencies in ICT tools and software to optimize their impact on student learning. Additionally, education policies should mandate ICT training for instructors to align with the ongoing digital transformation in the education sector.

Keywords*: Instructors, ICT infrastructure, learning outcomes, usability*

INTRODUCTION

The accessibility and usability of ICT infrastructure have increasingly attracted scholarly attention in the context of the global shift from face-to-face to blended and fully online modes of teaching and learning. (Mambile & Mwogosi, 2024; Zhou et al., 2019). How ICT infrastructure is effectively utilized to achieve the desired learning outcomes is of significant concern because learners are no longer experiencing such direct physical experiences with instructors in the face-to-face delivery mode. In blended or fully online modes, learners interact with their instructors exclusively through ICT infrastructure. A key question this study seeks to address is whether instructors' effective use of these ICT tools supports the achievement of student learning outcomes especially given that, in a blended-learning context, instructors simultaneously act as course designers, facilitators, motivators, and evaluators.

Nevertheless, universities particularly in developing countries face growing pressure to offer flexible learning environments, ensure round the clock access to educational resources, and develop robust software infrastructures that support distributed, anytime access for students (Sims & Solomonides, 2009). However, in mapping of the ICT infrastructure availability, Alenezi (2023) found that basic equipment such as computers and projector systems, were generally accessible; while videoconferencing and interactive whiteboards were more sparsely available. Angeli et al. (2022) observed that institutions are increasingly outsourcing the development and management of their digital infrastructure including server hardware and services such as email, shared storage, and video conferencing.

In this context, infrastructure usability denotes the ease with which instructors employ ICT infrastructure to facilitate instruction and achieve desired learning outcomes. It encompasses several key dimensions, including learnability, efficiency, memorability, error frequency, and subjective satisfaction. El-Aasar and Farghali (2022) further identify four core elements of ICT usability: perceptibility, operability, understandability, and robustness.

Conversely, learning outcomes have been defined by Adam (2004), Kennedy et al. (2006), and Semlambo et al. (2022) as the personal changes or benefits resulting from learning, or as explicit statements of what a learner is expected to know, understand, and demonstrate at the

end of a course. In this study, learning outcomes refer to students demonstrated knowledge, skills, and behavioral attributes acquired via digital platforms.

Several recent studies highlight both progress and persistent challenges in ICT-enabled education. Derder et al. (2023) report positive gains in digital pedagogical skills, although perceptions of technical support and infrastructure maintenance remain moderate. Boateng et al. (2016) and Webb et al. (2020) find that e-learning confidence and readiness among academic staff improve significantly when moderated by targeted e-learning training. However, Alhubaishy and Aljuhani (2021) identify fear of change, lack of experience, and privacy concerns as primary inhibitors of instructors' digital adoption. Similarly, Okoye et al. (2023) emphasize insufficient training, inadequate infrastructure and resources, and limited internet access as major barriers to effective teaching and learning.

In the Tanzanian context, the integration of ICT in higher learning institutions faces additional hurdles. Mahenge and Sanga (2016) note inadequate funding for ICT infrastructure, limited internet access, and a lack of technical support. Slow technological adaptation among some instructors further undermines the effectiveness of ICT tools. For instance, Mtebe et al. (2011) found that many instructors in Tanzanian universities struggle to use learning management systems (LMS) and other ICT-based tools due to insufficient training and support.

These challenges underscore the need to examine how instructors' ICT infrastructure usability contributes to student learning outcomes in Tanzanian higher learning institutions. By focusing on both usability dimensions and measurable learning gains, this study aims to inform policy and practice that will strengthen digital teaching and learning.

LITERATURE REVIEW

Information and Communication Technology (ICT) has become integral to modern education, with its adoption steadily increasing in higher learning institutions across Africa, including Tanzania. Kalyani (2024) argues that effective utilization of ICT infrastructure enhances teaching effectiveness and learning outcomes by providing access to diverse educational resources, fostering interactive learning, and improving communication between students and instructors.

In Tanzania, ICT infrastructure in universities and colleges has expanded through investments by the government and international development partners. Nevertheless, the degree of its utilization largely depends on instructors' capacity and readiness to integrate technology into their pedagogical practices (Mahenge & Sanga, 2016). Studies show that when instructors are proficient with ICT tools, they are more likely to engage students through virtual classrooms, online assessments, and multimedia content (Martin et al., 2020). In particular, Frank and James (2024) found that instructors' usability of ICT infrastructure significantly impacts student engagement and academic performance in Tanzanian higher learning institutions.

Despite these gains, many instructors in Tanzania continue to face barriers to effective ICT use, including inadequate training, limited technical support, and insufficient access to essential hardware and software (Ponera & Madila, 2024). Such constraints hinder the potential benefits of ICT-integrated teaching and restrict students' opportunities to engage fully with digital learning environments.

Training interventions play a critical role in enhancing ICT usability among instructors. Hoti and Shatri (2023) and Puteh et al. (2017) emphasize that targeted ICT training not only builds technical competence but also boosts instructors' confidence in deploying technology-driven pedagogies. This increased confidence fosters more innovative teaching strategies, which in turn positively influence student learning outcomes.
Mwakyusa and Mwalyagile (2016) report that, while Tanzanian university students generally view ICT integration positively, they frequently encounter frustrations arising from inconsistent infrastructure availability, poor internet connectivity, and varying levels of instructor preparedness. Student performance tends to improve when ICT-enabled instruction aligns with their learning preferences—for example, Frank and James (2024) found that learners in blended environments (combining face-to-face sessions with online resources) achieved higher assessment scores. Conversely, Atmazaki and Indriyani (2019) demonstrated that inconsistent or poorly integrated ICT use correlates with lower student engagement and reduced academic achievement.

The question of whether instructors' ICT usability contributes directly to learning outcomes is therefore as vital as the choice of delivery technique. Angeli et al. (2022b) emphasize that usability intertwines with content

design (notably content visibility), delivery methods, and assessment quality. Instructors who co-design digital instructional materials frequently report increased teaching effectiveness, stronger student engagement, and higher-quality student work. However, English (2016) highlights that disparities in instructors' access to digital resources can produce unequal learning experiences and variable work quality among students.

Moreover, Asif et al. (2022) identified four key findings: poor institutional investment in ICT negatively affects student results; university-provided ICT training often fails to translate into improved performance; innovative and collaborative ICT use enhances student achievement; and students' acquisition of digital skills correlates positively with academic success. To maintain these gains, higher learning institutions must continuously update instructors on evolving digital platforms. Mpungose (2020) notes that while Moodle LMS provides a useful foundation, it must be supplemented with other software tools and social media to deliver fully online lectures. Finally, Muntu et al. (2023) found that digital literacy alone does not significantly influence classroom management or learning effectiveness unless supported by reliable ICT infrastructure.

The studies reviewed above suggest that the extent to which instructors' ICT infrastructure usability influences student learning outcomes ranges from negligible to substantial. This variability is shaped by factors such as the type of ICT infrastructure (hardware versus software), the quality and frequency of usability training, the accessibility of the broader ICT ecosystem, and instructors' intrinsic motivation to adopt new technologies. Consequently, there is a clear imperative to investigate, in the specific context of Tanzanian higher learning institutions, how instructors' ICT usability contributes to the attainment of desired student learning outcomes.

Theoretical framework

The study is guided by two theoretical models aligned with its objectives. The first is the Technology Acceptance Model (TAM), developed by Davis (1989). TAM focuses on two key beliefs: Perceived Usefulness (PU) and Perceived Ease of Use (PEU). Perceived Usefulness refers to the user's subjective belief that using a particular system will enhance their performance, while Perceived Ease of Use refers to the extent to

which the user believes the system will be free of effort. These beliefs are influenced by external variables such as infrastructure availability, training, and organizational support. In the context of this study, TAM informs the understanding of how instructors perceive the usefulness and ease of employing digital technologies in their teaching practices.

The second theoretical model employed is the Technological Pedagogical Content Knowledge (TPACK) framework developed by Mishra and Koehler (2006). This model outlines the types of knowledge instructors need for effective technology integration in teaching. TPACK emphasizes the dynamic relationship between three core domains: content knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK). It highlights the importance of instructors understanding not only what to teach and how to teach it, but also how to effectively use technology to support the teaching and learning process. In the context of higher education, the TPACK framework is particularly relevant for aligning course content with appropriate digital tools to enhance instructional delivery.

METHODS AND MATERIALS

The study employed a cross-sectional design, which was selected for its practicality in allowing data collection from multiple cases at a single point in time, particularly when time and resources are limited (Shiferaw et al., 2022). This design was deemed appropriate for the study as data were collected simultaneously from two higher learning institutions offering digital training (online programmes) located in different regions. Moreover, cross-sectional designs are recognized for their effectiveness in estimating the prevalence of behaviors and characteristics within a population (Sedgwick, 2014). This is especially useful when the objective is to identify patterns, explore statistical relationships, and make generalizations to a larger population based on a snapshot of data collected at one moment in time.

The study was conducted in the United Republic of Tanzania (URT), a sovereign nation formed from the union of Tanganyika and Zanzibar. Tanzania is one of the five East African countries and is geographically situated between latitudes 1° and 12° south of the equator and longitudes 29° and 41° east of Greenwich. According to the Tanzania Commission for Universities (TCU) Guidebook (2022), the country hosts approximately 12 public and 24 private higher learning institutions.

Additionally, the National Council for Technical and Vocational Education and Training (NACTVET) reports approximately 537 registered higher learning institutions under its regulation (NACTVET Guidebook, 2023).
Two institutions were purposively selected for this study: The Open University of Tanzania (OUT), one of the 12 public universities under TCU, and the Institute of Accountancy Arusha (IAA), one of the institutions registered under NACTEVET. These institutions were chosen due to their active implementation of blended learning modes and their extensive experience in delivering digital training. Notably, despite their adoption of digital practices, instructor engagement in digital training remains relatively low, and the extent to which such training contributes to student learning outcomes remains unclear. OUT offers its courses predominantly through a blended mode, while IAA has adopted a similar approach for several of its programmes.

The study population comprised all academic staff employed at the two selected institutions who were involved in online teaching, regardless of academic rank or area of specialization. Combined, the two institutions have an estimated total of over 583 academic staff members, ranging in designation from tutorial assistants to full professors, who are actively engaged in teaching and research. The distribution of academic staff across the two institutions is presented in Table 1.

Table 1
The study population in the selected institutions

S/No	Institution Name	Population
1	Institute of Accountancy Arusha	260
2	Open University (Dodoma, Dar es Salaam, Manyara and Arusha)	323
	Total	583

Source: Prospectus 2023

Sample size and sampling procedure

A sample size of 237 academic staff was derived from an estimated population of 583 employed academic staff from two selected higher learning institutions based on the Yamane formula of 1967.

$$= \frac{n}{1 + N e^2} \quad \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots (1)$$

Where n is the sample size, N population size e is the level of precision. The formula assumes that p=.05 (maximum variability). The desired

confidence level is 95%, and the degree of precision/sampling error accepted is 5%. Therefore;

$$n = \frac{583}{1 + 583\ (\ 0.0025)} \approx 237$$

Each element in the sample was selected using simple random sampling, whereby a proportional representation from each selected institution was drawn randomly from employment records through the lottery method. The procedure considered the sampling elements to have homogeneous characteristics since they were all employed academic staff. However, the key informants and focus group participants were purposively selected. The sampling proportion as per the institution is indicated in Table 2.

Table 2
Sampling distribution as per selected institutions

S/No	Institution Name	Population	Sample Size
1	Institute of Accountancy Arusha	260	$\frac{260}{583} \times 237 = 106$
2	Open University	323	$\frac{323}{583} \times 237 = 131$
Total		583	237

Source: Field data (2023)

Data collection methods

Three data collection techniques were employed in this study: questionnaire survey, interviews, and focus group discussions. These methods were used to gather both quantitative and qualitative data, including socio-demographic characteristics of respondents and instructors' perspectives on the usability of ICT infrastructure in higher learning institutions.

Questionnaire survey: A total of 237 self-administered questionnaires comprising both open- and closed-ended questions were distributed to selected academic staff. The questionnaires were designed to assess instructors' perspectives on the usability of digital ICT infrastructure within higher learning institutions. The content and structure of the questionnaire were informed by the Technology Acceptance Model (TAM) (Davis, 1989) and the Technological Pedagogical Content Knowledge (TPACK) framework (Mishra & Koehler, 2006). A standard five-point Likert scale was used to collect data related to the first specific objective, with additional customized items reflecting the TPACK domains. The instrument was pre-tested on at least 5% of the target

sample to ensure clarity, relevance, and reliability before full-scale data collection. The choice of questionnaires as a data collection method was driven by several advantages. Questionnaires are cost-effective and time-efficient, allowing the researcher to collect data from a large number of participants simultaneously, an essential consideration given resource and time constraints (Gomm, 2008).

Interviews: Interviews were particularly valuable to the researcher as they aimed to explore in-depth information, especially participants' opinions, perceptions, and views that may not be easily captured through questionnaires (Gomm, 2008; Sarakikya & Kitula, 2024). Face-to-face interviews were conducted with a total of eight key informants selected for this study. Four key informants were purposively chosen from each institution, making a total of eight participants. This number was deemed sufficient to ensure both data triangulation and thematic saturation. The key informants included heads of departments and deans of faculties who are directly involved in ICT usability and digital training within their respective institutions.

Focus Group Discussions: According to Morgan (2004), Duevel (2019), and Millward (2012), well-managed focus group discussions can generate richer and more nuanced insights into a topic, as the group interaction often stimulates memories, debate, and disclosure among participants. For this study, four focus group discussions were conducted, two per institution, comprising academic staff members who did not participate in the questionnaire survey. This was done for triangulation purposes. Research by Guest et al. (2017) has shown that focus groups with 4–6 participants can be sufficient to reach data saturation when the group has homogeneous characteristics.

In this study, each focus group comprised four members selected through a nomination strategy by their peers, based on their subject knowledge, gender representation, and confidence to actively contribute to discussions. Gender inclusion was proportionally considered based on the availability of male and female participants at each institution.

Data analysis

Field data for this study were analysed quantitatively and qualitatively. Quantitative data were analysed using descriptive statistics, specifically percentages and means, to examine the socio-demographic characteristics of respondents and general patterns of ICT infrastructure usage among

instructors. To assess the contribution of instructors' ICT infrastructure usability to student learning outcomes, binary logistic regression was employed. Before conducting the regression analysis, key assumptions were tested to ensure the robustness of the model. The assumption of no extreme outliers was assessed using Cook's Distance, which yielded a maximum value of 1.0602, well below the threshold of 5, indicating the absence of excessively influential data points. Additionally, the linearity of the logit was evaluated using the Box-Tidwell test, while the independence of errors was assumed based on the cross-sectional study design. Multicollinearity among predictor variables was examined using collinearity tolerance and Variance Inflation Factor (VIF). All predictors had tolerance values ranging from 0.353 to 0.578 and VIF values between 1.73 and 2.835, satisfying the acceptable thresholds (tolerance > 0.1 and VIF < 10). These results confirm that none of the variables were excessively correlated, ensuring model stability and interpretability. Moreover, the assumption of linearity in the logit was confirmed as all independent variables showed significant F-values with p-values less than 0.05, indicating a statistically significant linear relationship with the outcome variable. Specifically, all predictors had p-values at or below 0.001, providing strong evidence of linearity. An adequate sample size was also maintained, adhering to the guideline of a minimum of 10 events per predictor variable, further validating the model's reliability.

On the other hand, qualitative data, obtained through interviews and focus group discussions, were analysed using thematic analysis. Audio recordings were transcribed, and the data were coded and organized into themes following the six-phase approach recommended by Braun and Clarke (2006), as adapted by Jack (2019). This involved familiarization with the data through repeated reading, generating initial codes by labeling significant sections, identifying and reviewing emerging themes, and refining them to ensure clarity and accuracy. Themes were named and defined to represent recurring patterns in participants' responses, particularly around their experiences, challenges, and perspectives on ICT infrastructure usability in digital teaching environments. Thematic analysis was chosen due to its suitability for exploratory research, enabling an in-depth understanding of instructors' digital practices. This method is particularly effective for identifying meaningful patterns, accommodating inductive theme development, and offering rich, contextual insights into the perceived impact of ICT infrastructure usability on student learning outcomes.

Validity and reliability of the study

To ensure that the instrument covers all the components and valid information, the entire process of developing the questionnaire was guided by content validity. This type of validity was ensured through reviewing the previous studies in assessing the adequacy and accuracy of what it measures. Multiple data collection methods were employed to enhance the construct validity of the qualitative information. Triangulation through the use of interviews, focus group discussions, and document reviews helped ensure the credibility and depth of the findings. Additionally, the validity of the qualitative data was reinforced by sourcing information from credible references, including official government reports and peer-reviewed publications from reputable academic publishers. For interview-based data, particular attention was given to the relevance and expertise of the selected participants, ensuring that only individuals with substantial knowledge and experience in ICT usability and digital teaching were included in the study.

On the other hand, reliability for this study was achieved through several strategies. For the quantitative data collected via self-administered questionnaires, internal consistency was assessed using Cronbach's alpha coefficient as defined in the formula below. This statistical measure evaluates how well the items within each scale measure the same underlying construct. A Cronbach's alpha value of 0.70 or higher was considered acceptable, indicating satisfactory internal reliability of the instrument. In addition, the questionnaire was pre-tested on a sample representing 5% of the target population to refine ambiguous items and ensure clarity and consistency. For the qualitative data, reliability was supported by maintaining a systematic coding process, consistent interview protocols, and audio recording of all sessions to ensure accurate transcription and analysis.

Fami (2000) $\propto = K/K - 1 \times S_T^2 - \sum S_I^2$ ..... (1)

Where α (alpha) coefficient, K is the number of items; S_T^2 is the total variance of the sum of the items and the variance of individual items. The reliability of variable analysis indicated by a Cronbach Alpha (α) value all exceeded 0.70. This allowed the analysis of the data for further use. Data reliability of the items for both hardware ICT infrastructure and software components was first tested. The results of the test in terms of Cronbach

alpha coefficients were both above 0.005 of the required coefficients (8 items for hardware =0.89, 9 items for students' learning outcome 0.936; - items for software).

RESULTS AND DISCUSSION

Socio-demographic characteristics of the respondents

Three socio-demographic characteristics concerning respondents who participated in the study were established. These include age, sex, and the name of the institution. The attributes were considered to influence the variables under this study. The findings are indicated in Table 3 below.

Table 3

Socio-demographic characteristics of the respondents

Variable	Attribute	Frequency	Percent
Sex	Male	160	67.5
	Female	77	32.5
Age category	Below 30	22	9.3
	30 to 39	105	44.3
	40 to 49	85	35.9
	50 to 59	23	9.7
	Above 59	2	0.8
Name of the higher learning institution	OUT	115	48.5
	IAA	122	51.5

Source: Field data (2023)

The findings presented in Table 3 indicate that male participants outnumbered female participants in this study. This reflects the broader gender distribution among academic staff in higher learning institutions in Tanzania, where male instructors tend to dominate. This disparity can be attributed to historical gender imbalances in educational access and enrollment, particularly for women, within the Tanzanian socio-cultural context. These findings are consistent with the Tanzania Commission for Universities (2022) report on the status of university education, which highlights the continued predominance of male instructors in higher education institutions.

In terms of age distribution, the majority of instructors fall within the 30 to 39-year age group, suggesting a relatively young academic workforce. This age group is considered to be more technologically inclined, having been born and raised during the ICT revolution, and is therefore more likely to adopt and utilize digital tools in teaching and learning.

Regarding institutional representation, participation from the two selected institutions—Open University of Tanzania (OUT) and the Institute of Accountancy Arusha (IAA)—was nearly equal, with IAA showing slightly higher figures based on available employment records. Both institutions have documented efforts to integrate ICT into their training delivery systems, making them relevant contexts for studying the usability of ICT infrastructure by instructors.

The instructors' usability of ICT infrastructure contributes to students' learning outcomes

The usability of ICT infrastructure was assessed by categorizing it into hardware and software components, with a focus on their relationship to students' learning outcomes. The results from the binary logistic regression analysis of hardware infrastructure provide valuable insights into how instructors' use of digital tools influences educational performance. Table 4 presents a detailed summary of the key ICT hardware usability variables that significantly predict students' learning outcomes, including the use of various digital hardware devices and their application in instructional methods. These findings highlight not only the extent to which instructors are able to effectively utilize ICT hardware in higher learning institutions but also offer practical implications for educators and policymakers. Specifically, the results underscore the importance of targeted investment and training in hardware infrastructure to enhance the delivery of instruction and ultimately improve student learning outcomes.

Table 4
The instructors' usability of hardware ICT infrastructure

ICT hardware infrastructure usability	β	S.E.	Mean	Wald	Odds Ratio	Sig.
Setting up and using a Laptop/ Computer for presentation or lectures	-0.08	0.33	3.95	0.06	0.92	0.80
Connecting and operating a projector or smart screen	0.56	0.29	4.05	3.79	1.75	0.05*
Using an interactive whiteboard for teaching and collaboration	-0.12	0.19	4.05	0.44	0.88	0.51
Setting up and using audio systems for clear sound during lectures	0.49	0.22	3.92	4.90	1.64	0.02*
Utilizing tablets and smartphones for teaching and communication with students	-0.13	0.20	3.83	0.44	0.88	0.51
Operating digital cameras/video cameras for recording lectures or creating multimedia content	-0.06	0.21	3.97	0.09	0.94	0.76
Setting up and using printers and scanners for printing or distributing materials	-0.08	0.21	3.77	0.16	0.92	0.69
Utilizing response systems (clickers) for interactive quizzes and surveys	0.36	0.18	4.02	3.96	1.44	0.04*
Constant	-2.12	1.08	3.74	3.87	0.12	0.04*

Source: Field data (2023)

The findings presented in Table 4 reveal that instructors' ability to connect and operate projectors or smart screens significantly contributes to students' learning outcomes. The binary logistic regression analysis produced a positive coefficient (β = 0.56) with a standard error of 0.29, indicating that increased proficiency in using these tools is associated with improved student performance. The mean score for this predictor was 4.05, suggesting that most instructors reported a relatively high level of competence and ease in operating such hardware. The statistical significance (p = 0.05) confirms that this relationship is unlikely to be due to chance. These results emphasize the critical role of instructors'

effective use of ICT hardware infrastructure in enhancing the quality of training delivery and, consequently, improving student learning outcomes in higher education institutions. This quantitative finding is further supported by qualitative evidence from the focus group discussions, where one of the participants remarked, "…*I have used digital technologies in teaching my class over the years and I can perform some key operations successfully*…"

This implies that the instructors have some ability to use the ICT hardware infrastructure in delivering their classes. This finding concurs with the TAM model, which stipulates that the adoption of the technology depends on perceived usefulness and perceived ease of use. Instructors expressed the ability to use computer facilities and projectors in their class sessions. This initiative needs to be embraced and up-scaled to other higher learning institutions in Tanzania. Similarly, the instructor demonstrates an intersection of technological and pedagogical knowledge, whereby digital tools such as projectors and smart boards are used to enhance instructional delivery.

The findings also indicate that instructors' ability to set up and use audio systems for clear sound delivery during lectures significantly impacts students' learning outcomes. The logistic regression analysis yielded a positive coefficient ($\beta = 0.49$) with a standard error of 0.22, suggesting that effective use of audio systems is positively associated with enhanced learning outcomes. The mean score for this skill was 3.92, indicating that many instructors possess this capability to a moderate extent. The statistical significance ($p = 0.02$) confirms that this relationship is meaningful and not due to chance. These results highlight the importance of instructors being proficient in using audio technology to ensure clarity in lecture delivery, which in turn positively influences students' comprehension and academic performance. These findings are supported by English (2016), who noted that instructors engaged in instructional design using digital infrastructure reported more effective teaching, increased student engagement, and higher-quality student work.

Furthermore, the results demonstrate that the effective use of response systems (clickers) for administering interactive quizzes and surveys significantly contributes to improved student learning outcomes. The logistic regression analysis reported a positive coefficient ($\beta = 0.36$) with a standard error of 0.18, indicating a strong relationship between the use

of interactive tools and improved student performance. The mean score for this predictor was 4.02, showing that many instructors are reasonably proficient in employing response systems in their instructional practices. A Wald statistic of 3.96 and an odds ratio of 1.44 suggest that students' learning outcomes are 1.44 times more likely to improve when instructors effectively use clickers to facilitate engagement and participation during lectures. The statistical significance ($p = 0.04$) further validates this finding. These results underscore the value of integrating interactive technologies in teaching strategies to foster participatory learning environments and enhance educational outcomes in higher learning institutions.

However, the findings also reveal that certain aspects of instructors' usability of ICT hardware do not significantly influence students' learning outcomes. Specifically, the ability to set up and use laptops or computers for presentations, operate interactive whiteboards for teaching and collaboration, utilize tablets and smartphones for instruction and communication, operate digital cameras or video equipment for recording lectures or creating multimedia content, and set up and use printers and scanners for distributing materials were not found to have a statistically significant impact. These conclusions are supported by high p-values and low Wald statistics in the regression analysis, suggesting that these hardware-related skills do not meaningfully predict student learning outcomes in the studied higher learning institutions.

This may imply limited instructor capability or access to such hardware infrastructure, possibly due to institutional constraints or lack of training. It also suggests that while certain ICT skills, such as operating projectors or using audio systems, are central to the instructional process, others may play a more peripheral role and, thus, have less direct influence on learning outcomes. Similarly, the analysis of instructors' usability of software-based ICT infrastructure indicated no statistically significant contribution to students' learning outcomes. These findings, detailed in Table 5, point to the need for more targeted support and training in software integration or a reassessment of the digital tools currently in use to determine their relevance and alignment with instructional goals.

Table 5

The instructors' usability of software ICT infrastructure contribution to students' learning outcomes in the selected higher learning institutions

ICT Software Infrastructure usability	B	S.E.	Mean	Wald	Odds	Sig.
Learning management system: A platform used for managing and delivering educational content, such as blackboard, canvas, and Moodle (Text writing, pdf, word, jpg)	0.10	0.28	4.12	0.13	1.11	0.72
Video conferencing software: tools like zoom, Microsoft teams and google meet for online classes, meetings, and webinars	0.41	0.24	3.9	2.91	1.51	0.09
Presentation software: PowerPoint, prezi and google slides.	- 0.20	0.28	4.16	0.48	0.82	0.49
Document collaboration software: google Docs, Microsoft office 365, drop box for creating and shearing.	0.15	0.26	3.81	0.36	1.17	0.55
Combined (text, audio, video)	- 0.14	0.26	3.42	0.30	0.87	0.58
Education games and simulations: Kahoot, Quizlet Minecraft for engaging students and enhancing learning	- 0.21	0.27	3.02	0.63	0.81	0.43
Special software programs e.g. SPSS, R software, ANOVA and social ups e.g. WhatsApp, accounting bills	0.41	0.19	3.35	4.83	1.51	0.03
Searching tools and ups google scholar, fire fox, and chrome	- 0.16	0.26	4.13	0.36	0.85	0.55
Transmission tools e.g. email, zimbra, outlook etc.	- 0.02	0.30	4.23	0.00	0.98	0.95
Online assessment and grading software: Turnitin, SARIS, ISMS, gradecam and odmondo for grading, assessing and providing feedback on assessment.	0.07	0.22	3.91	0.12	1.08	0.73
Education content creation software: Camtasia, audacity and adobe Creative suite for creating educational videos, Slides podcast, and other multimedia content.	0.28	0.26	3.13	1.12	1.32	0.29
Mind mapping and brainstorming software: mindmeister, google and bulb.us to visualize and organize ideas	- 0.07	0.24	3.1	0.07	0.94	0.79
Programming and cording skills: Scratch, python, java for teaching programming and coding.	0.60	0.25	3.25	5.88	1.83	0.02
Language learning software: Duo lingo, Rosetta stone and babble for language	0.05	0.25	3.21	0.05	1.06	0.83

ICT Software Infrastructure usability	**B**	**S.E.**	**Mean**	**Wald**	**Odds**	**Sig.**
learning and practice.						
Constant	-2.67	1.05	3.68	6.50	0.07	0.01

Source: Field data (2023)

The key software ICT usability aspects assessed in the study included instructors' ability to use learning management systems, video conferencing platforms, document sharing tools, presentation software, educational gaming platforms, specialized educational software such as SPSS and mind-mapping tools, programming and coding skills, and the ability to use learning materials software and search engines. While the mean scores for these variables suggest some potential for positive contribution to student learning outcomes, the regression analysis showed that their p-values did not reach statistical significance, indicating no meaningful positive impact within the studied context. This outcome may have several implications. First, it may reflect instructors' limited familiarity or proficiency with these software tools. Second, it could point to restricted access to such platforms due to infrastructural challenges, particularly inadequate internet connectivity across the selected higher learning institutions. Despite the lack of statistical significance, the descriptive data suggest there is still potential for software-based ICT tools to positively influence student learning, especially if appropriate support and infrastructure are provided. These findings are reinforced by qualitative data from the focus group discussions, where internet accessibility was consistently identified as a major barrier. One of the key informants noted:

> The Internet is a problem within the institute, especially during the afternoon session and evening. Software platforms within the institute are outdated and not friendly to be used by instructors. Also, the ICT infrastructure is not enough for students. For instance, you may find one class has 180 students, but only 40 computers are working.

This quotation suggests that instructors' usability of ICT infrastructure is challenged by internet accessibility, the size of the class, and the availability of digital facilities. This, consequently, may affect the students' learning outcomes. These findings are consistent with the study conducted by Okoye (2023), which identified a lack of training, inadequate infrastructure and resources, limited internet access, and restricted availability of digital platforms as the main challenges hindering the effectiveness of the teaching learning process.

CONCLUSION

The usability of ICT infrastructure among instructors in Tanzanian higher learning institutions shows promising trends, particularly concerning hardware components. Instructors appear to be more familiar and

comfortable with hardware ICT infrastructure, such as smart screens/projectors, audio systems, and clickers for quizzes, than with software-based tools. The study concludes that the effective use of hardware ICT infrastructure significantly contributes to students' learning outcomes. This indicates that such tools play a critical role in supporting instructional delivery and enhancing the learning process.

However, the findings also reveal that instructors' usability of software ICT infrastructure remains limited. This presents a concern in an era characterized by rapid technological advancement. The results have important policy implications, particularly in the need to establish enabling environments that support both instructors and students in improving training delivery through technology. While ICT offers significant potential to enhance student learning, its successful integration into teaching largely depends on instructors' competencies and adaptability. Therefore, education policies should prioritize comprehensive capacity-building initiatives, investment in ICT infrastructure, provision of ongoing technical support, and measures to address resistance to change within academic institutions.

It is recommended that higher learning institutions actively work to improve instructors' software ICT usability by offering affordable and accessible training programs. Institutions should also strengthen internet infrastructure and prioritize continuous professional development tailored to digital instruction. At the individual level, instructors are encouraged to enroll in self-paced, freely available online training programs to enhance their digital competencies. Furthermore, national education policy should mandate ICT training for instructors, particularly through recognized free online platforms, to ensure that teaching professionals remain responsive and adaptive to the evolving demands of digital education.

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