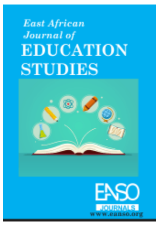

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Original Article

Propensity Score Matching Analysis of the Association between Instructor Competence and Utilization of Digital Tools in TVET Institutions of Uganda

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Online Digital Gadgets Competence, Online Teaching and Learning, TVET Institutions, Propensity Score Matching, ANOVA.

ABSTRACT

The effectiveness of online teaching in Technical and Vocational Education and Training (TVET) institutions largely depends on instructor competence in utilizing digital gadgets. This paper utilizes the Propensity Score Matching model to examine the association between instructor digital gadgets utilization competence and online teaching/learning among selected TVET institutions. This paper presents and emphasizes the critical role of digital competence among instructors as a necessary condition for online teaching. A cross-sectional survey design was employed. Univariate analysis using bar charts and histograms was done. The bivariate analysis covered an ANOVA table and scatterplot, while the Multivariate level entailed the Propensity Score Matching model. The findings showed that instructor competence in digital gadget utilization enhances online teaching, but rural residences and poor infrastructure limit engagement. Internet access remains a major hindrance, requiring government intervention for free connectivity. Practical fields face significant challenges in integrating online teaching, necessitating hefty investments in digital learning tools and simulators. Financial constraints among instructors, due to limited income-generating activities, further reduce online teaching adoption in TVET institutions.

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INTRODUCTION

During the COVID-19 lockdown in Uganda, which occurred between March 2020 and January 2022, universities swiftly transitioned to online learning, ensuring a smooth continuation of academic activities (MUTEBI, 2023). However, TVET institutions faced significant challenges in implementing online teaching due to the inability of some TVET instructors to effectively adapt to digital learning strategies, as most TVET programs rely heavily on hands-on, physical training (Majumdar, 2021; Mutebi et al., 2023). The closure of TVET institutions during pandemics and other crises, resulting from instructors' inability to effectively utilize digital teaching tools, not only poses a serious threat to the quality of TVET education but also reduces the legitimacy of TVET as a sector. This paper capitalizes on the instructor's digital competence and how it impacts online teaching and learning. This is significant because despite the digital transformations and SDG4, which emphasizes digital transformation in education, including Technical and Vocational Education and Training (TVET), this has not come to fruition, especially in Uganda, due to numerous factors relating to the unreadiness of TVET institutions in terms of infrastructure and low internet usage (Asuman et al., 2021). However, even with low adoption of online teaching, some minimal competencies are needed to be possessed by an instructor for successful delivery in online teaching, such as pedagogical, which articulates how an instructor strategizes to transmit information to the learners effectively. Asuman et al. (2021) added that HEIs are promoting faculty integration of web technologies in blended and online teaching practices due to increasing demand for blended and online learning.

The transition to digital learning has necessitated a shift in instructional methods and strategies. According to Chen and Chan (2024), the digital pedagogies in TVET enhance flexibility and effectiveness, offering richer and more personalized learning experiences, but challenges persist. In China, TVET teachers' digital competence effectively influenced their instructor competence (Xin et al., 2024). A digital competence model customized for TVET educators is crucial for enhancing teaching and learning outcomes, supporting digitization initiatives, and preparing students for the challenges of the modern workforce (Hani et al., 2024). In developed countries, TVET educators are highly competent in using most e-learning technologies, though they need more training on using smart boards and a gender-specific approach to e-learning (Lawal et al., 2021). Conversely, TVET college educators showed positive attitudes towards virtual learning during COVID-19, but challenges like a lack of support, connectivity, and training hindered their permanent transition to virtual learning (Aina & Ogegbo, 2022). Despite the challenges, the digitalization of teaching and learning in TVET programs can enhance graduates' competitiveness and sustainability in the workplace, job market, and society (Ugwoke et al., 2021). In Malaysia, a framework for digital learning in TVET was needed due to the high lecturers' knowledge, faculty readiness, and infrastructure needed to create high-quality online teaching and learning content (Razak et al., 2022). Among the commonwealth countries, a blended learning model in TVET, despite the huge investment, would improve teaching competencies through intense training of instructors (Waters et al., 2023). However, in sub-Saharan Africa, ICT integration in TVET education is low, particularly in monitoring, evaluation, career guidance, assessment, and teacher training (Hassan et al., 2021). Therefore, a competency-based whole-institution approach introduced in most East African countries' education systems calls for the development of digital competence in technical and vocational education and training, empowering all stakeholders (Zhong & Juwaheer, 2024). In Uganda's TVET institutions, digital competence among instructors remains a crucial factor in ensuring effective learning. This study explores the relationship between instructor competency in digital tools and the quality of online teaching and learning.

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LITERATURE REVIEW

The Role of Digital Competence in Online Teaching

Several studies have examined the impact of digital competence on online instruction. For example, **Almulla (2022)** examined the online teaching abilities and competencies needed to teach online courses in Saudi Arabia's higher education system. As a result, the goal of this study was to examine and expand the technology acceptance model (TAM) to assess online teaching abilities and competencies utilizing digital technologies in higher education during the COVID-19 epidemic. Therefore, it aimed to develop a new model to measure and explore critical factors that influence online teaching skills, competencies, and the actual use of digital tools in higher education. The participants in the study were 350 lecturers at King Faisal University. The research data were analyzed using structural equation modelling (AMOS-SEM). The findings revealed that: (a) perceived ease of use and perceived usefulness of using digital tools during the COVID-19 pandemic has a direct positive impact on perceived teaching self-efficacy, perceived enjoyment, online teaching skills, and digital tools access; (b) perceived ease of use and perceived usefulness of using digital tools have a direct positive impact on lecturers' attitude toward use and lecturers' behavioural intention to use digital tools during the COVID-19 pandemic; and (c) perceived ease of use. As a consequence of the findings, a validated instrument was designed to assess and investigate crucial elements that impact lecturers' real usage of digital technologies for teaching and learning in Saudi Arabia's higher education.

Aidoo et al. (2022) determined Ghanaian teachers' competencies in delivering online lessons. Transitioning face-to-face instructions to an online environment presents difficulties for instructors, particularly teachers and students doing so for the first time. The researchers explore how teachers in disrupted schools use information and communications technology (ICT) in their classrooms that differ in several ways from the regular classroom. The researchers investigated the factors influencing teachers' online instruction competence. A questionnaire was used to collect data from teachers in three teacher training colleges in Ghana in the 2021 academic year. Results showed that teachers had adequate knowledge of ICT. Also, ICT knowledge was strongly correlated to ICT usage. Regression analysis revealed that teachers could become competent and effectively teach online courses by having adequate knowledge, regularly using ICT, and receiving technical support from the institution. These findings suggest that teachers need sufficient knowledge and support to use computers to become competent in integrating ICT into their online course delivery.

According to **Martin et al. (2021),** online instructors adopt various roles and perform various competencies in the design and delivery of online courses. In this study, online instructor roles are categorized into eight types, including Subject Matter Expert, Course Designer and Developer, Course Facilitator, Course Manager, Advisor/Mentor, Assessor/Evaluator, Technology Expert, and Lifelong Learner. Through survey-based research with 141 online instructors, this study examines competencies that online instructors perform based on various roles. When rating competencies, overall categorical means for all the roles were rated above 4.00, which showed that they used all these roles. The highest-rated items and lowest-rated items are discussed in addition to the connection between research and practice in online teaching. Online instructors who participate in training and who collaborate with instructional designers rated the frequency with which they perform the competencies to be higher. This study has implications for online instructors, instructional designers, and administrators who design and deliver online learning and offer professional development for online instructors.

As **Al-Hunaiyyan et al. (2023)** put out, the foundational pillars of the digital economy are digital skills, which are defined as the ability to find, evaluate, use, share, and create digital content. In the field of education, most people

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agree that digital technology can enhance teaching and learning by creating more engaging and interactive learning environments, which motivates students to learn. Human resource management (HRM) practices are largely responsible for maintaining a positive environment for the effective use of technology in teaching and learning. This new digital age has vastly improved citizens' access to information. In the context of online learning delivery, instructors with digital skills play a crucial role in creating immersive learning spaces that offer students new ways to learn and play a pivotal role in guiding students to become ethical and responsible digital citizens. By reviewing relevant literature and conducting a qualitative analysis in the form of a focus group, this study employed a mixed methodology. The authors then proposed a new competency model for instructors, labelled the "Digital Instructor Model," within the context of innovative and virtual learning, encompassing five aspects: strategic, pedagogical, technical skills, human resource management, and technological readiness. The objective is to assist in the development of digital instructor skills and to meet the needs of digital-age students. The model will serve as a guide for carrying out effective digital instructions supporting successful implementations of e-learning systems.

Albrahim (2020) sheds light on the skills and competencies required for teaching online courses in higher education. The paper started with an overview of the issues related to online learning and teaching. Reviewing and analyzing literature on this topic were performed to refine skills and competencies that instructors need to effectively teach in online learning environments. These skills and competencies are classified into six categories: (a) pedagogical skills, (b) content skills, (c) design skills, (d) technological skills, (e) management and institutional skills, and (f) social and communication skills.

Wannapiroon et al. (2022) investigated the vocational instructors' satisfaction with the online instructional management developed using the synchronous online learning with 2,233 vocational instructors from the Office of the Vocational Education Commission, Ministry of Education, from five regions of Thailand, namely the Central, the Northern, the Northeastern, the Southern, and the Eastern Regions and Bangkok. The research findings revealed that the vocational instructors' digital competence consisted of the following abilities: (1) analysis of course content; (2) application of video conference systems; (3) management of online classes; (4) management of online learning resources; (5) management of online learning activities; (6) development of tests; (7) development of instructional media; (8) development of instructional videos; (9) arrangement of active-learning activities; and (10) online evaluation and assessment of instruction. The vocational instructors' digital competence in online instructional management after the synchronous online learning was found to be significantly higher than before the learning, at the p-value rate of 0.01. "Overall," 93.19% of the vocational instructors were reported to pass the evaluation of online instructional management. The vocational instructors were found to be satisfied with their digital competence in online instructional management at the highest level.

Ugur et al. (2021) designed an online professional development program and evaluated the developed course in light of the implementation results. This course provided teachers with the opportunity to develop an ICT-enhanced lesson plan and apply it in their classes. The current study was conducted using design-based research. Of the 171 teachers registered, 47 participated, and 36 completed the full course and received certificates. The self-assessment of the 36 teachers on their ICT-enhanced classroom practices was used in the evaluation of the course. Second, teacher opinions were also solicited via the Teachers’ End-of-Course Evaluation Questionnaire. Third, the course was evaluated using a rubric by the instructors. According to the results, the self-assessments of teachers on ICT integration were high. The satisfaction of the teachers with the open online course was also very high, with 97% recommending the course. The course was evaluated as “exemplary” in terms of Learner Support & Resources, Online

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Organization & Design, and Instructional Design & Delivery categories, and as "effective" in the rubric's Assessment & Evaluation of Student Learning, Innovative Teaching with Technology, and Faculty Use of Student Feedback categories. Future implementations could be revised by increasing interaction and feedback and providing additional implementation opportunities for the teachers.

Kordrostami and Seitz (2022) aimed to address the gap in the literature about the instructor's role in increasing students' affective engagement (with their peers and instructor) in an online class. Since marketing students will eventually fulfil roles that engage consumers with the firm's communication mediums, it is important to understand the impact of student engagement and peer-to-peer communication in marketing classes in building this skill. Additionally, because of the pandemic, the majority of higher education migrated to online and virtual formats, and investigating techniques that can improve the quality of online teaching is more important than ever. The impact of instructor competence in designing and facilitating online classes has been studied before. However, this paper establishes that instructor online competence indirectly positively affects students' impression of the quality of their online learning experience. Further, this relationship is mediated by how students are engaged in class through communication with peers and instructors. This research clarifies the effect of instructor affective engagement skills as a contributor to marketing students' perceptions of quality and offers several recommendations that act as guidelines for instructors delivering online courses.

Grabowski et al. (2016) selected rigorously developed and internationally validated standards from the International Board of Standards for Training Performance and Instruction (IBSTPI) to use as a framework for discussing competencies and currency in learning technology. Technology is continuing to emerge as an integral tool for living and learning, fuelled largely by the passion for social connection made possible by the Internet and the ever-expanding availability of ever-smaller mobile devices. Then, the foundational instructional designer competencies informed by changes in society, learning processes, and technology are identified and then discussed in terms of how they change the tactics and decisions designers make. An understanding of evolving learning processes applies most appropriately to the instructional methods and strategies domain.

As in many countries worldwide, schools in Germany closed in March 2020 and only partially re-opened in May as part of the consequences of the COVID-19 pandemic lockdown. Teachers were confronted with the need to adapt to online teaching. **König et al. (2020),** presented the results of a survey of early career teachers conducted in May and June 2020. First, analysed the extent to which they maintained social contact with students and mastered core teaching challenges. Secondly potential factors (school computer technology, teacher competence such as their technological pedagogical knowledge, and teacher education learning opportunities of digital teaching and learning). Findings from regression analyses show that information and communication technologies (ICT) tools, particularly digital teacher competence and teacher education opportunities to learn digital competence, are instrumental in adapting to online teaching during COVID-19 school closures. Implications are discussed for the field of teacher education and the adoption of ICT by teachers.

Key Competences for Digital Teaching in TVET

Vast studies suggest that key competencies for digital teaching in TVET include a digital mindset and attitude, digital knowledge and skills, digital education and teaching, digital care and support, digital collaboration and development, and the ability to integrate technology effectively into teaching practices. A detailed synthesis of the mentions and arguments on the vital competencies needed for digital teaching in TVET includes the following.

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According to **Xin et al. (2024)**, there are different suggestions that are put forward to train the digital competence of TVET teachers. This study was based on the development characteristics of China's standard TVET system for digital competence, focusing on digital mindset and attitude, digital knowledge and skills, and digital education and teaching.

Hani et al. (2024) explored the current state of digital competencies among TVET educators in Malaysia as well as identified the key factors contributing to developing these competencies. The study employed the exploratory sequential mixed methods approach. It was found that there is a need for a structured digital competence model for TVET educators to integrate digital technologies into teaching and learning effectively.

Zhong and Juwaheer (2024) adopted a qualitative research method to examine the anticipated digital competencies of these three stakeholder groups through an analysis of existing digital competence frameworks for leaders, educators, and individuals. The study synthesized the digital competency areas of TVET leaders, teachers, and learners. Findings showed that a competency-based whole-institution approach is vital for developing digital competence in TVET. **Falloon (2020)** advocates for digital competence by promoting a holistic understanding of digital skills and preparing students for ethical, safe, and productive use in diverse digital environments. Additionally, instructors need ICT skills, information literacy, and problem skills, but are optimal in communication and collaboration of digital content **(Garzón-Artacho et al., 2021).**

Challenges in Adopting Digital Teaching

Despite the benefits of digital learning, instructors face multiple challenges, including inadequate technical skills, lack of institutional support, and limited access to digital resources. **König et al. (2020)** found that teacher education and digital competence significantly influenced the adaptation to online teaching during COVID-19. Similarly, **Grabowski et al. (2016)** highlighted the evolving nature of instructional design and the need for continuous professional development. **Mesuwini and Mokoena (2024)** hinted at technical difficulties, limited interaction, and collaboration as key hindrances. **Chen and Chan (2024)** amplified this by citing disparities in technological resources and knowledge fragmentation among instructors. Additionally, low faculty readiness and infrastructural needs were noted as key limitations. Most importantly, South African trainees, as well as those in Uganda, face a shortage of smartphones, laptops, data, and poor communication from instructors **(Mesuwini, 2024).**

METHODOLOGY

Research Design

This study employed a cross-sectional survey design. This design was identified as the most appropriate design for examining associations, correlations, and relationships between variables, providing a snapshot of their perceptions and attitudes at a specific time without the need to make a follow-up. A purely quantitative approach was adopted in this paper.

Data Collection

A structured questionnaire was administered to 184 instructors and 406 trainees, assessing instructor competencies and online teaching/learning using a 5-point Likert scale. Stratified sampling was used for trainees and instructors, while purposive sampling targeted administrators.

Data Analysis Techniques

Stata version 18 software was used to complete the statistical analysis. The bar charts and histograms represented univariate analysis to observe the data distribution. The bivariate level analysis covered box plots, scatter plots, and analysis of variance tables (ANOVA) to examine any possible associations and assess mean differences. The multivariable level looked at the Propensity Score Matching model (PSM). The PSM function is not preinstalled in Stata version 18. However, this was made possible with the

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installation of a foreign package "pasmatch2" with its functions. psmatch2 implements full Mahalanobis matching and a variety of propensity score matching methods to adjust for pre-treatment observable differences between a group of treated and a group of untreated.

The utilization of digital tools and gadgets by institutions at varying levels of development and structure, as well as the year of initiation, introduces a self-selective behaviour that is random, given that ICT has spilled all over the TVET institutions. This introduces the element of endogeneity. If not effectively mitigated, the influence of the utilization of online devices and gadgets may lack internal validity in the regression analysis potentially leading to spurious results. The PSM can overcome this problem by estimating possible matching and comparisons with reduced bias and confounding.

In this paper, the average treatment effect (ATT) for the participants was derived through the modelling of the following.

- One-to-One Matching: This method pairs each treated unit with the nearest untreated unit based on the propensity score. The simplest form of matching ensures a direct comparison between similar observations but can lead to data loss if there are unmatched treated units. The ATT is estimated as:

$$ATT = E[Y(1) - Y(0)|D = 1)]$$

Where $Y(1)$ and $Y(0)$ are outcomes for the treated and untreated groups, respectively. $D = 1$

Indicates treatment.

- k-Nearest Neighbours (k-NN) Matching: Instead of matching each treated unit with only one untreated unit, k-NN selects the k closest untreated units based on the propensity score. The ATT is given by:

$$ATT = \frac{1}{Nt}\sum_{i\in T}\left(Y_i - \frac{1}{k}\sum_{j\in C(i)} Y_j\right)$$

Where Nt is the total number of treated units, $C(i)$ represents the set of k-nearest neighbours for treated unit i, Y_i and Y_j are the outcomes for treated and untreated units, respectively.

- Radius Matching: This approach matches treated units to control units within a predefined radius around their propensity score. The ATT is estimated as:

$$ATT = \frac{1}{N_t}\sum_{i\in T}\left(Y_i - \sum_{j\in C(i)} w_{ij}Y_j\right)$$

Where w_{ij} is a weighting function ensuring that only control units within the radius contribute to the estimation.

- Kernel Matching: This nonparametric method assigns weights to all control units based on their distance from the treated unit in terms of the propensity score. The ATT is calculated as:

$$ATT = \frac{1}{N_t}\sum_{i\in T}\left(Y_i - \sum_{j\in C} K(h^{-1}|P_i - P_j|)Y_j\right)$$

Where K(.) is a kernel function, P_i. h is the bandwidth parameter.

- Bootstrap Model: To improve the robustness of the estimated treatment effects, bootstrapping was applied. Bootstrapping involves repeatedly resampling the dataset with replacement and recalculating the ATT to obtain more accurate standard errors and confidence intervals. The bootstrap estimation is as follows:

$$ATT^b = \frac{1}{B}\sum_{b=1}^{B} ATT^b$$

Where B is the number of bootstrap replications and ATT^b is the treatment effect estimated from the bootstrap model.

The PSM model was employed to address selection bias by comparing treated and control groups. Qualitative data were transcribed,

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categorized into meaningful themes, and analyzed textually, with triangulation enhancing validity.

Ethical Considerations

This study was conducted in accordance with the ethical principles outlined by the Uganda Christian University Research Ethics Committee (REC) and the Uganda National Council for Science and Technology (UNCST). Prior to participation, informed consent was obtained from all participants through the respective heads of department, deputy principals, and principals of the visited TVET institutions. All data collected was handled with strict confidentiality, with unique identification codes assigned to ensure anonymity. The authors declare no conflicts of interest. This study did not receive any external funding; all resources used during data collection were provided solely by the corresponding author. K.M.A. did the conceptualization of the study, he wrote the introduction, the background, and the methodology. R.W. supported the data analysis using Stata version 18. K.H. and J.M. provided the supervision and editing roles in this publication.

RESULTS AND DISCUSSIONS

This paper performed univariate, bivariate, and multivariable analyses levels using visualizations, an ANOVA table summary, and the Propensity Score Matching model as seen below.

Univariate Level Data Analysis

A clear observation of the histograms shows an uneven distribution of the scores for both online teaching/learning and digital gadgets utilization by the instructors.

Figure a: Distribution of Online Learning Scores

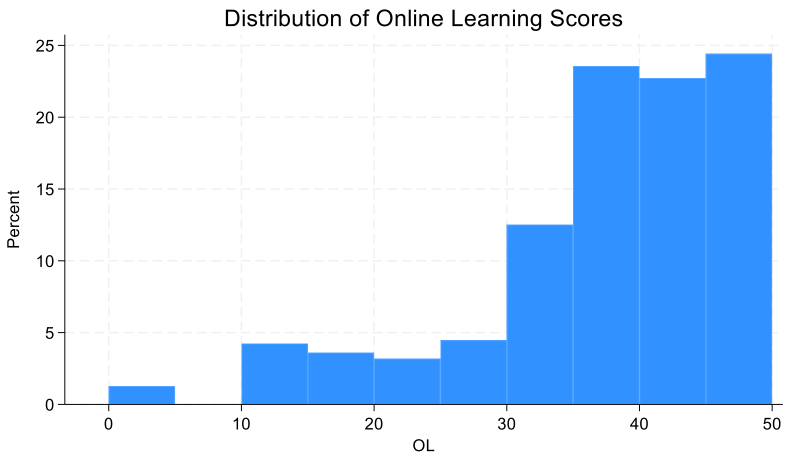
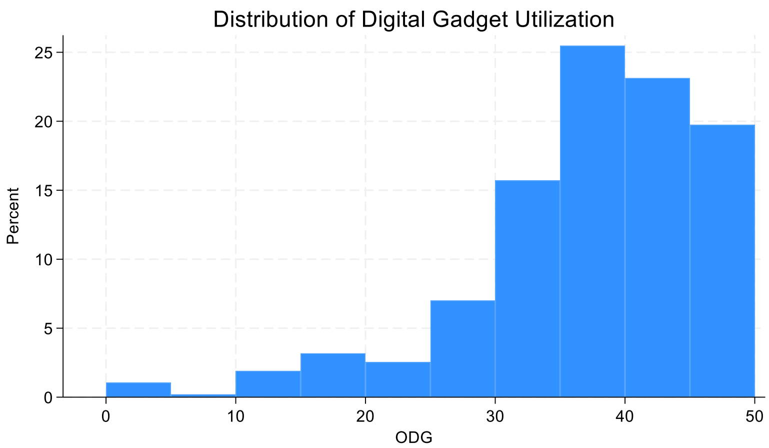


Figure b: Distribution of Digital Utilization



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Firstly, online teaching and learning scores are very high, though there are a few low scores. The negative skewness of online teaching and learning suggested that most of the participants rated online teaching as an effective addition to the TVET institutions, with a few revealing it was unsatisfactory. Similarly, the utilization of online digital gadgets was found to be left-skewed, an indication that most of the instructors interviewed reported high scores for utilizing digital gadgets and equipment. In summary, most of the instructors found online teaching as a better approach to learning, even though the practical nature of TVET institutions would require a huge investment in installing simulator classrooms for the instructors to stretch and transmit information to a wider audience remotely.

As seen in the figures below, the median scores for online teaching and learning were found to be higher for those who had ever participated in online teaching. Also, institutions in Central and Western Uganda appeared to have a higher median score for instructor utilization of digital gadgets as compared to the instructors in Eastern and Northern Uganda.

Figure c: Box Plots for Online Learning/Teaching

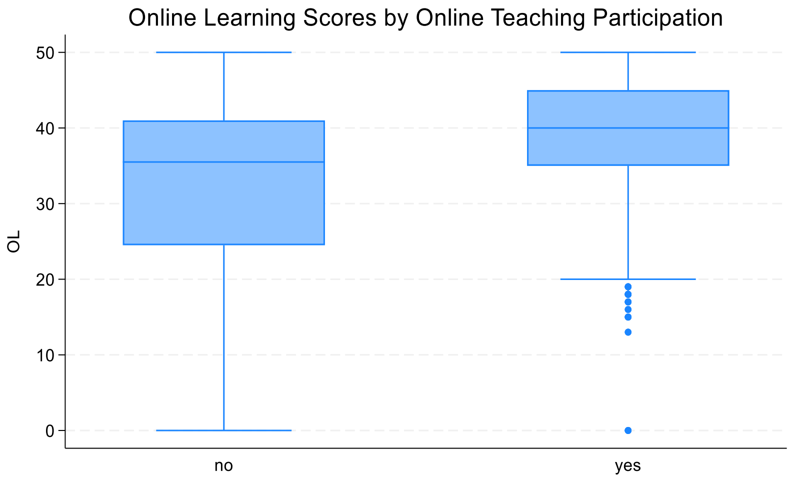
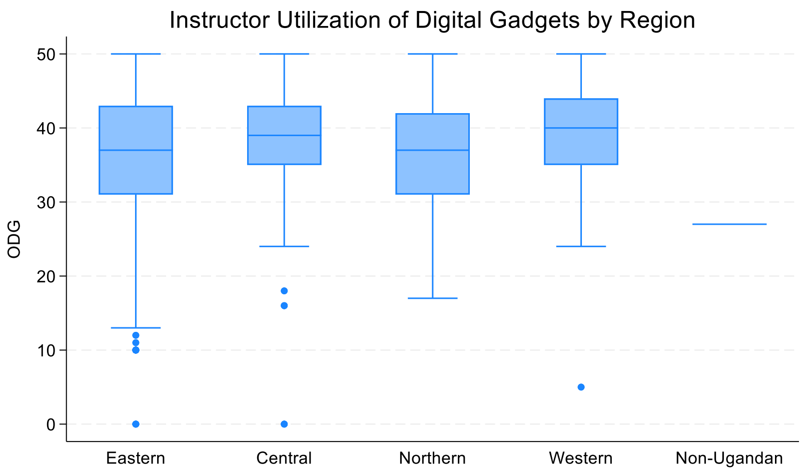


Figure d: Box Plots for Digital Utilization



Bivariate Level Data Analysis

The figure below is a scatterplot showing the association between online teaching and digital gadgets utilization. The figure displays two potential pieces of information: the steeper positive relationship between online teaching/learning and digital gadgets competence

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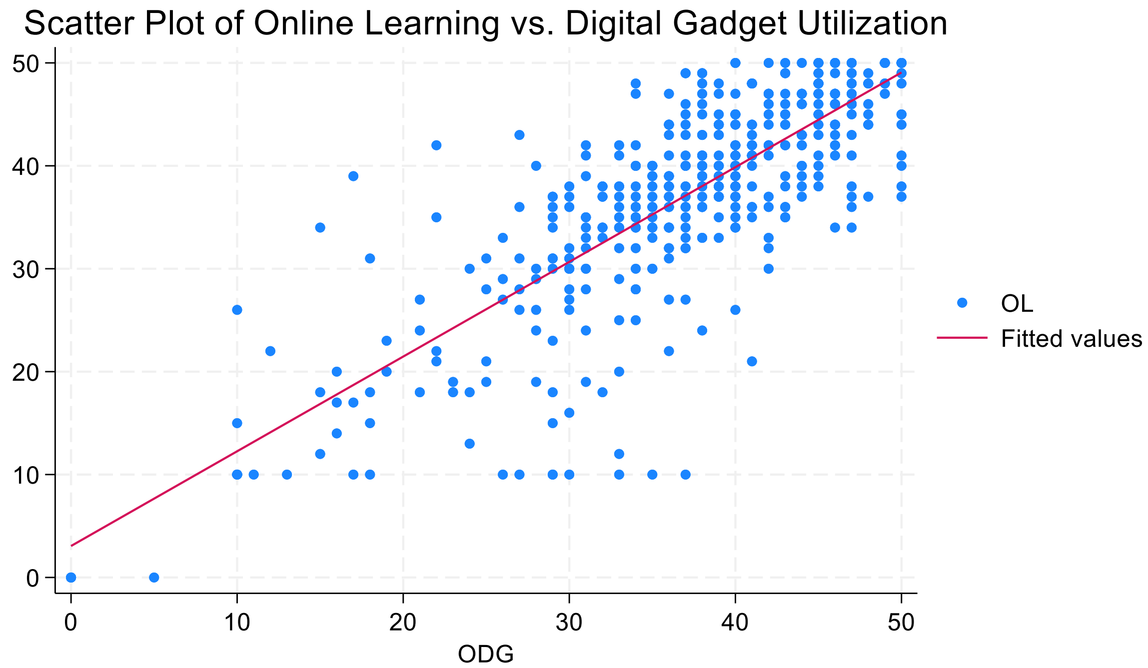
and the concentration of the scores to the line of best fit. This illustrates that there is a positive significant relationship between the utilization of digital gadgets competence and online teaching and learning in TVET. This suggests that if TVET institutions desire to have an effective online teaching/learning environment, efforts need to be directed to digital gadgets utilization competence.

Figure e: Scatterplot Showing Correlation between Online Learning and Digital Gadgets Utilization



The higher the online digital gadgets competence, the higher the online teaching and learning in TVET. This reveals that various instructor competencies are relevant in facilitating online teaching in TVET, but it all begins with the competence of the instructor in utilizing digital gadgets. Having TVET instructors who can barely utilize digital platforms such as laptops, smartphones, and projectors, as well as lacking soft skills, makes it impossible to integrate online teaching and learning in TVET despite the existence of the necessary infrastructure. Other associated background characteristics of the instructors were examined to see if they influence online teaching in TVET with the aid of the Pearson Chi-square test below.

Table 1: Association between Online Teaching and Learning and Background Characteristics

Variable	Background characteristics	Yes	No	Total	χ^2	p
Region	Eastern	165 (65%)	87 (35%)	252		
	Central	68 (79%)	18 (21%)	86		
	Northern	42 (76%)	13 (24%)	55	11.56	0.021
	Western	61 (81%)	14 (19%)	75		
	Non-Ugandan	1 (100%)	0 (0%)	1		
	Total	337	132	469		
Marital Status	Married	132 (80%)	32 (20%)	164		
	Single	204 (68%)	95 (32%)	299	18.67	0.000
	Widowed	0 (0%)	4 (100%)	4		
	Other	1 (50%)	1 (50%)	2		
	Total	337	132	469		

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Variable	Background characteristics	Yes	No	Total	χ^2	p
Gender	Male	252 (75%)	84 (25%)	336		
	Female	84 (64%)	48 (36%)	132	6.04	0.014
	Total	336	132	468		
Religion	Born Again Christians	58 (74%)	20 (26%)	78		
	Anglicans/Pentecostal	120 (72%)	47 (28%)	167		
	Catholics	114 (71%)	47 (29%)	161	4.37	0.497
	Muslims	28 (64%)	16 (36%)	44		
	Seventh Day Adventist	8 (89%)	1 (11%)	9		
	Other	8 (89%)	1 (11%)	9		
	Total	336	132	468		
Participant Type	Instructor	155 (80%)	39 (20%)	194		
	Trainee	181 (66%)	93 (34%)	274	11.15	0.004
	Other	1 (100%)	0 (0%)	1		
	Total	337	132	469		
Age	Under 25	181 (67%)	90 (33%)	271		
	26-35	57 (79%)	15 (21%)	72		
	36-45	59 (87%)	9 (13%)	68	13.52	0.009
	46-55	27 (71%)	11 (29%)	38		
	Over 55	12 (63%)	7 (37%)	19		
	Total	336	132	468		
Education Level	PLE	0 (0%)	2 (100%)	2		
	UCE	143 (68%)	66 (32%)	209		
	UACE	19 (58%)	14 (42%)	33	29.11	0.000
	Certificate	21 (54%)	18 (46%)	39		
	Diploma	79 (81%)	19 (19%)	98		
	Bachelor's degree	69 (87%)	10 (13%)	79		
	Master's degree	6 (67%)	3 (33%)	9		
	Total	337	132	469		
Field Program	Automotive Mechanics	76 (82%)	17 (18%)	93		
	Electrical Installation	50 (68%)	23 (32%)	73		
	Welding and Fabrication	27 (90%)	3 (10%)	30	16.74	0.033
	Fashion and Garment Design	34 (59%)	24 (41%)	58		
	Electronics	9 (64%)	5 (36%)	14		
	Building and Construction	41 (65%)	22 (35%)	63		
	Carpentry and Joinery	18 (75%)	6 (25%)	24		
	Fitting and Machining	20 (71%)	8 (29%)	28		
	Other	62 (72%)	24 (28%)	86		
	Total	337	132	469		

Source: *Author (2025)*

Regarding the association between religion and online teaching, a Chi-square value of 11.56 with 4 degrees of freedom and a *p*-value of 0.021 indicates that the religion of instructors is significantly associated with online teaching. Furthermore, the region of belonging also significantly influences online teaching, with 65% of participants from the Eastern region reporting having used and being able to conduct online teaching. A higher percentage of instructors interested in online instruction came from the Western region (81%), Northern region (76%), and Central region (79%), suggesting regional

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disparities in online teaching practices and infrastructure.

Marital status demonstrated a significant association ($\chi^2 = 18.67$, $p = 0.000$), with married participants being more likely to engage in online teaching (80%) compared to single participants (68%). Married instructors were more exposed in terms of digital transformation, increasing the desire and willingness to feature in online teaching and learning. Gender also showed a significant relationship ($\chi^2 = 6.04$, $p = 0.014$), with male participants (75%) being more likely to have online teaching experience than female participants (64%). Males are usually well-known for their desire to explore new environments and would not hesitate to have their classes conducted online as compared to females.

Instructors were significantly more likely to engage in online teaching (80%) than trainees (66%) ($\chi^2 = 11.15$, $p = 0.004$). Most instructors viewed online teaching as a means of facilitating easiness and convenience in teaching their trainees, while a few saw it as a challenge that needed retraining. Age also played a significant role ($\chi^2 = 13.52$, $p = 0.009$), with higher participation in online teaching among somewhat older participants aged 36-45 years (87%) compared to those aged under 25 years (67%). Older participants had more experience and desire for online instruction as related to young, naive trainees.

Education level was another significant factor ($\chi^2 = 29.11$, $p = 0.000$), with participants holding bachelor's degrees (87%) or diplomas (81%) reporting the highest levels of online teaching engagement, while those with lower qualifications, such as UACE (58%) or certificates (54%), demonstrated lower participation rates. Highly educated instructors were found to have more desire, willingness, and disaggregated ability to transition to online teaching and learning than those with diplomas and UACE certificates. Lastly, the field of study was also significantly associated with online teaching ($\chi^2 = 16.74$, $p = 0.033$). For example, participants in Welding and Fabrication reported the highest participation (90%), followed by Automotive Mechanics (82%), while Fashion and Garment Design participants showed lower participation (59%).

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Table 2: Estimated Effects of Online Digital Competence and Socio-Demographic Factors on Online Teaching and Learning Using Various PSM Methods

Online Teaching & Learning	PSM common	PSM ate	PSM logit	PSM common neighbor	PSM caliper	PSM Kernel
Online Digital Gadgets Competence	0.036 (0.007)***	0.036 (0.007)***	0.061 (0.013)***	0.036 (0.007)***	0.036 (0.007)***	0.036 (0.007)***
Residence (rural)	-0.423 (0.140)**	-0.423 (0.140)**	-0.736 (0.239)**	-0.423 (0.140)**	-0.423 (0.140)**	-0.423 (0.140)**
Internet Access (no)	-1.061 (0.231)***	-1.061 (0.231)***	-1.769 (0.390)***	-1.061 (0.231)***	-1.061 (0.231)***	-1.061 (0.231)***
Field						
Electrical Installation	-0.444 (0.232)*	-0.444 (0.232)*	-0.764 (0.400)*	-0.444 (0.232)*	-0.444 (0.232)*	-0.444 (0.232)*
Welding & Fabrication	0.175 (0.375)	0.175 (0.375)	0.343 (0.701)	0.175 (0.375)	0.175 (0.375)	0.175 (0.375)
Fashion & Garment Design	-0.418 (0.247)*	-0.418 (0.247)*	-0.699 (0.436)	-0.418 (0.247)*	-0.418 (0.247)*	-0.418 (0.247)*
Electronics	-0.565 (0.409)	-0.565 (0.409)	-1.012 (0.700)	-0.565 (0.409)	-0.565 (0.409)	-0.565 (0.409)
Building & Construction	-0.618 (0.236)**	-0.618 (0.236)**	-1.044 (0.406)**	-0.618 (0.236)**	-0.618 (0.236)**	-0.618 (0.236)**
Carpentry & Joinery	-0.291 (0.342)	-0.291 (0.342)	-0.498 (0.596)	-0.291 (0.342)	-0.291 (0.342)	-0.291 (0.342)
Fitting & Machining	0.065 (0.316)	0.065 (0.316)	0.128 (0.551)	0.065 (0.316)	0.065 (0.316)	0.065 (0.316)
Other	-0.244 (0.224)	-0.244 (0.224)	-0.410 (0.394)	-0.244 (0.224)	-0.244 (0.224)	-0.244 (0.224)
IGA (no)	-0.327 (0.141)*	-0.327 (0.141)*	-0.565 (0.243)**	-0.327 (0.141)*	-0.327 (0.141)*	-0.327 (0.141)*
Constant (_cons)	0.001 (0.320)	0.001 (0.320)	-0.003 (0.558)	0.001 (0.320)	0.001 (0.320)	0.001 (0.320)
Treated	38.838806	38.838806	38.5465839	38.5465839	38.5465839	38.5465839
Controls	38.5313433	38.5940299	38.3913043	38.3913043	37.1379191	37.6663424
Difference	0.307462687	0.244776119	0.155279503	0.155279503	1.40866472	0.880241468
S.E.	2.20221882	2.09588972	2.1745455	2.1745455	1.57232845	1.62473805
T-stat	0.14	0.12	0.07	0.07	0.9	0.54

**** p<0.01, ** p<0.05, * p<0.1.*
Source*: Author, 2025*

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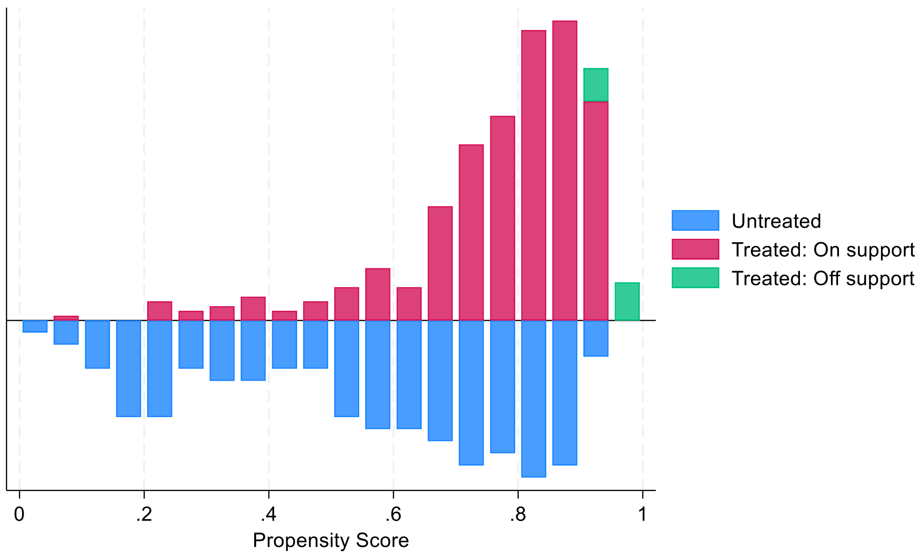
The primary distinctions across the PSM models stem from variations in coefficient magnitudes and statistical significance levels. The PSM logit model exhibits stronger effects for most factors, with online digital gadget competence (β = 0.061, $p < 0.01$), rural residence (β = -0.736, $p < 0.05$), and lack of internet access (β = -1.769, $p < 0.01$) showing more marked effects compared to other models. Additionally, technical disciplines such as Electrical Installation, Fashion & Garment Design, and Building & Construction demonstrate higher negative coefficients in the logit model, showing greater challenges in adopting online teaching. The influence of income-generating activities (IGA) is also more substantial in the logit model (β = -0.565, $p < 0.05$), suggesting that financial constraints may further limit engagement. Furthermore, the PSM Caliper and PSM Kernel models revealed greater disparities between treated and control groups, with differences of 1.408 and 0.880, respectively, compared to lower margins in other models. Despite these variations, all models consistently affirm that instructor competence in digital tools enhances online teaching, rural residence hinders participation, and internet access is a critical determinant. Therefore, a PSM common support model was deemed appropriate.

Instructor competence in using online digital gadgets had a positive and statistically significant effect on online teaching and learning (β = 0.036, $p < 0.01$). This suggests that a higher level of digital gadget proficiency increases engagement in online teaching. Instructors and trainees residing in rural areas were less likely to engage in online teaching (β = -0.423, $p < 0.05$). This could be due to poor internet connectivity and limited access to digital resources, making online interactions difficult. Lack of internet access significantly limited participation in online teaching and learning (β = -1.061, $p < 0.01$). This implies that instructors without reliable internet were far less likely to adopt online teaching compared to those with access. The findings further showed that instructors specializing in Electrical Installation (β = -0.444, $p < 0.1$), Fashion & Garment Design (β = -0.418, $p < 0.1$), and Building & Construction (β = -0.618, $p < 0.05$) were less likely to engage in online teaching. This could be attributed to the hands-on nature of these fields, which require physical demonstrations rather than digital instruction. Additionally, instructors without income-generating activities were less likely to adopt online teaching (β = -0.327, $p < 0.1$). This suggests that financial constraints may limit the ability to invest in necessary digital tools and stable internet connections. The propensity score graph illustrates the distribution of propensity scores for individuals who received online training (treated) and those who did not (untreated).

Figure f: Propensity Score Graph Displaying Benefits from Online Training



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The overlap between the treated and untreated groups suggests that the matching procedure has successfully identified comparable observations. A significant concentration of treated individuals is observed at higher propensity scores (above 0.6), indicating that instructors with experience in online training in utilizing digital gadgets are more likely to have successful online teaching and learning.

The distribution pattern suggests that individuals with high competence in using online digital gadgets, internet access, and urban residence are more likely to effectively engage in online teaching and learning. Conversely, rural residence, lack of internet access, and involvement in hands-on technical fields such as Electrical Installation and Welding appear to reduce the likelihood of participating in online training. The graph confirms that a balanced comparison is possible for most observations, supporting the reliability of the estimated effects of the instructor's online digital gadgets' competence on online teaching and learning.

The bootstrap model for the variable `_bs_1` shows an observed statistic of 0.307463 with a bias of 0.906957, indicating the online teaching and learning estimate is slightly overestimated. The standard error is 1.270039, suggesting moderate variability in the bootstrap estimates. The 95% confidence intervals calculated using normal, percentile and bias-corrected methods range from negative to positive values, with the bias-corrected interval (-1.69018, 1.617284) likely providing the most reliable estimate, adjusting for bias in the data.

Table 3: Bootstrap Model Results

Variable	Reps	Observed	Bias	Std. err.	[95% conf.	interval]	
_bs_1	50	0.307463	0.906957	1.270039	-2.24478	2.859702	(N)
					-1.33634	4.047619	(P)
					-1.69018	1.617284	(BC)

Key:
N: Normal
P: Percentile
BC: Bias-corrected

CONCLUSION AND RECOMMENDATIONS

Instructor competence in digital gadgets utilization positively influences online teaching. TVET institutions in Uganda need to revise their skilling policy, if any, to develop a strategic plan aimed at establishing TVET institutions as research-led institutions through prioritizing digital transformation by employing digitally competent instructors.

Rural residence is a disadvantage, reducing engagement in online teaching due to poor infrastructure and internet access. As indicated in Uganda’s Vision 2040, rural internet connectivity should move together with the rural transformation agenda to enhance access to learning, even for far-end learners.

Lack of internet access remains a major hindrance, significantly lowering the likelihood of online teaching and learning. Today, access to the internet is an indispensable factor in all of the educational hierarchy. Therefore, the government should work hand in hand with the Ministry of ICT and NITA to ensure free internet connectivity and access not only to the staff of TVET but to the trainees as well.

Instructors in hands-on technical fields (e.g., Electrical Installation, Fashion & Garment Design, Building & Construction) are less likely to engage in online teaching, reflecting the practical nature of their courses. This issue can be solved through a hefty investment in learning equipment and simulators for easy demonstration of the practical programs online.

TVET instructors without income-generating activities were found not to easily transition to online teaching and learning. This was also because online teaching was a cost both to the instructor and to the institution. Therefore, financial constraints among instructors limit online interaction with their trainees.

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