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DIGITAL INSTRUCTIONAL STRATEGIES AND PRACTICAL SKILL ACQUISITION AMONG TECHNICAL AND VOCATIONAL EDUCATION AND TRAINING (TVET) LEARNERS IN RESOURCE-CONSTRAINED ENVIRONMENTS IN NIGERIA: A MIXED-METHODS STUDY

BY

Falade, Ayotunde Atanda (PhD): Department of Educational Technology, Faculty of Education, University of Ilorin, Ilorin, Nigeria; E-mail: falade.aa@unilorin.edu.ng/ ORCID: https://orcid.org/0000-0003-1517-9552

Adedapo, Adeyemi (PhD): Faculty of Education, National Open University of Nigeria, Abuja; E-mail: aadedapo@noun.edu.ng/ORCID: https://orcid.org/0000-0002-2638-4491

Sani, Sanusi Danmali: Department of Educational Technology, University of Ilorin, Ilorin, Nigeria; E-mail: 22-68xk005pg@students.unilorin.edu.ng/ ORCID: https://orcid.org/0009-0008-1419-8288

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Yusuf, Mudasiru Olalere: Department of Educational Technology, University of Ilorin, Ilorin, Nigeria; E-mail: moyusuf@unilorin.edu.ng

Abstract

Technical and Vocational Education and Training (TVET) has become increasingly important for workforce development, employability, entrepreneurship, and sustainable economic growth in the digital age. This study therefore investigated digital instructional strategies and practical skill acquisition among TVET learners in resource-constrained environments in Nigeria using a mixed-methods approach. The study adopted an explanatory sequential mixed-methods design involving quantitative survey and correlational approaches complemented with qualitative interviews, focus group discussions, and classroom observations. A total of 320 participants, comprising TVET learners and instructors, were selected from a target population of 2,635 participants, including 2,450 learners and 185 instructors across selected vocational institutions in three states in North-Central Nigeria, through multistage sampling procedures from selected vocational institutions across three states in North-Central Nigeria. Quantitative data were analysed using descriptive statistics, Pearson Product Moment Correlation, and multiple regression analysis, while qualitative data were analysed thematically. The findings revealed that instructional videos, mobile learning applications, WhatsApp instructional groups, blended learning approaches, and digital collaborative tools were the most commonly utilised digital instructional strategies. The study further revealed a significant positive relationship between digital instructional strategies and practical skill acquisition ($r = 0.682$, $p < 0.05$, 95% CI [0.617, 0.739]). Teacher digital competence also significantly predicted instructional technology utilisation ($\beta = 0.593$, $p < 0.05$). However, poor electricity supply, inadequate internet connectivity, insufficient digital devices, and limited institutional support remained major barriers affecting effective implementation. The study contributes to the growing scholarly discourse on digital transformation in developing-world TVET by offering mixed-methods empirical evidence from Nigeria's resource-constrained vocational education environments. The study recommends increased governmental investment in digital infrastructure, continuous teacher digital capacity development, and institutional support mechanisms to enhance technology-enhanced vocational learning within resource-constrained TVET environments.

Keywords: Instructional technology, TVET, Practical skill acquisition, Digital learning, Resource-Constrained environments, Teacher digital competence- and Mixed-Methods

Introduction

Technical and Vocational Education and Training (TVET) has increasingly assumed a strategic position in global educational and economic development due to its critical role in preparing learners with practical competencies, employable skills, entrepreneurial capacity, and workforce readiness required for participation in rapidly changing

labour markets. In the twenty-first century knowledge economy, nations are increasingly judged not only by the quantity of their educational provision but also by the extent to which their educational systems can produce technologically competent, innovative, and adaptable human capital capable of responding to industrial transformation and digital economic realities. Consequently, governments, international organisations, and development agencies have continued to emphasise the importance of strengthening TVET systems as instruments for sustainable development, youth empowerment, poverty reduction, and economic competitiveness (UNESCO-UNEVOC, 2022).

Globally, the demand for skilled labour continues to increase due to technological advancement, automation, artificial intelligence, digital transformation, and the emergence of Industry 4.0. However, despite this increasing demand, many countries continue to experience a persistent skills gap characterised by a mismatch between the competencies possessed by graduates and those required within contemporary workplaces. The World Economic Forum (2023) observed that technological disruption and digital transformation are rapidly reshaping labour markets, thereby increasing the need for workers with practical, digital, problem-solving, and adaptive competencies. Similarly, the International Labour Organization (2023) reported that many educational systems are struggling to equip learners with industry-relevant skills necessary for productivity and employability in modern economies. Haleem et al. (2022) further noted that digital technologies are fundamentally transforming instructional practices, assessment methodologies, and learning outcomes across educational contexts, reinforcing the urgent need for digital integration within vocational education. These concerns have intensified global attention on the need to reform TVET systems through innovative instructional approaches capable of enhancing practical learning outcomes and workforce preparedness.

The growing digitalisation of workplaces and industries has further intensified the need for technology-enhanced instructional approaches in TVET. Across the world, instructional technology is increasingly being integrated into vocational education to support practical demonstrations, simulations, collaborative learning, learner engagement, self-paced instruction, virtual experimentation, and competency-based training. Digital instructional strategies such as learning management systems, mobile learning, digital simulations, instructional videos, blended learning, virtual laboratories, augmented reality, and online collaborative platforms have demonstrated considerable potential for improving practical skill acquisition and enhancing learner participation in vocational education (Kintu et al., 2022; Radianti et al., 2020). Such technologies enable learners to visualise procedures, repeat demonstrations, interact with simulated tools, and access instructional content beyond the limitations of conventional classrooms and physical workshops.

Instructional technology also provides opportunities for addressing learning deficits associated with resource scarcity and instructional limitations in developing educational environments. In situations where workshop equipment is unavailable or insufficient, digital simulations and instructional videos can support conceptual understanding and procedural learning. Similarly, mobile and online learning platforms can provide flexible access to instructional materials, enabling learners to continue learning beyond the physical classroom. UNESCO-UNEVOC (2024) notes that digital transformation in TVET has become important for improving instructional quality, expanding access to learning opportunities, strengthening teacher competencies, and supporting skills development in resource-limited contexts. Furthermore, technology-enhanced instruction aligns with contemporary learner-centred pedagogies that emphasise participation, interaction, collaboration, and experiential learning. Instructional technology has evolved beyond the traditional use of audiovisual aids to encompass the systematic design, development, implementation, and management of technology-enhanced learning processes aimed at improving instructional effectiveness and learner performance. Within Technical and Vocational Education and Training (TVET), instructional technology involves the integration of digital tools, multimedia resources, mobile applications, simulations, virtual demonstrations, and online collaborative platforms that support practical teaching and competency-based learning. Such technologies are increasingly important because vocational education depends heavily on demonstration, experimentation, repeated practice, and learner

engagement, all of which can be enhanced through interactive and technology-supported instructional approaches (Januszewski & Molenda, 2018; Kintu et al., 2022).

Globally, digital transformation has become a defining feature of contemporary TVET reform due to rapid technological advancement, automation, artificial intelligence, and Industry 4.0 innovations that continue to reshape labour-market expectations. Consequently, educational systems are increasingly expected to integrate digital pedagogies capable of preparing learners for technology-driven workplaces and emerging occupational realities. Research evidence increasingly supports the effectiveness of digital instructional strategies such as blended learning, instructional videos, virtual simulations, mobile learning, and collaborative online platforms in improving learner participation, practical understanding, and experiential learning within vocational education environments (Radianti et al., 2020; Brolpito et al., 2021). The Technology Acceptance Model (TAM) developed by Davis (1989) further explains that learners' and instructors' willingness to utilise instructional technologies depends largely on perceived usefulness and ease of use, while Universal Design for Learning (UDL) emphasises the importance of flexible and inclusive instructional environments capable of accommodating diverse learner needs and learning preferences.

Learner diversity further strengthens the need for flexible and technology-enhanced instructional approaches within TVET environments. Vocational learners differ in terms of socioeconomic background, digital literacy, learning preferences, prior educational experiences, and access to technological resources. Technology-enhanced instruction can therefore support inclusive participation by providing multiple means of representation, engagement, interaction, and repeated learning opportunities consistent with UDL principles (CAST, 2018). However, unequal access to technology and digital infrastructure continues to create significant educational disparities within many developing-country TVET systems, thereby limiting the full instructional potential of digital learning environments (UNESCO, 2023). Despite the growing global interest in digital transformation within TVET, the integration of digital instructional strategies into Nigerian TVET institutions remains inconsistent and inadequate. Many institutions still rely heavily on traditional instructional approaches that inadequately support practical engagement, collaborative learning, and digital competency development. In several cases, instructors lack adequate digital pedagogical skills required for meaningful technology integration, while institutional infrastructure remains insufficient for supporting effective digital learning environments. These deficiencies contribute significantly to weak practical skill acquisition, reduced learner motivation, low instructional effectiveness, and poor alignment between vocational training and labour-market expectations.

Although previous studies have examined ICT integration, e-learning adoption, and digital literacy within educational settings, there remains limited empirical evidence specifically investigating how digital instructional strategies influence practical skill acquisition among TVET learners in resource-constrained environments in Nigeria. Existing studies have often focused on general technology acceptance, institutional readiness, or theoretical discussions without adequately examining learners' practical skill outcomes and lived experiences within vocational learning contexts. Furthermore, limited studies have adopted mixed-methods approaches capable of generating both quantitative evidence and qualitative insights into the effectiveness, challenges, and contextual realities of technology-enhanced TVET instruction.

It is against this background that this study investigates digital instructional strategies and practical skill acquisition among TVET learners in resource-constrained environments in Nigeria. The study seeks to examine how digital instructional strategies influence practical skill development, learner engagement, and instructional effectiveness within vocational education settings characterised by infrastructural and technological limitations. Through a mixed-methods approach, the study is expected to generate empirical evidence capable of informing policy decisions, instructional practices, curriculum innovation, and digital transformation strategies within Nigerian TVET institutions. The remainder of this paper is organised as follows: the Literature Review examines conceptual definitions, theoretical frameworks, and existing scholarship; the Methodology section describes the

research design, sample, instruments, and analytical procedures; the Results section presents quantitative and qualitative findings; the Discussion interprets findings in relation to theory and literature; and the Conclusion provides a summary, limitations, recommendations, and directions for further research.

Purpose of the Study

The main purpose of this study is to investigate the influence of digital instructional strategies on practical skill acquisition among TVET learners in resource-constrained environments in Nigeria.

The study specifically:

1. identified the digital instructional strategies commonly used in TVET instruction within resource-constrained environments in Nigeria;
2. examined the relationship between digital instructional strategies and practical skill acquisition among TVET learners;
3. determined the influence of teacher digital competence on the effective use of digital instructional strategies in TVET delivery;
4. explored learners' and instructors' experiences regarding the use of digital instructional strategies for practical skill development; and
5. identified barriers affecting the effective integration of digital instructional strategies in Nigerian TVET institutions.

Research Questions

The following research questions guided the study:

1. What digital instructional strategies are commonly used in TVET instruction within resource-constrained environments in Nigeria?
2. What relationship exists between digital instructional strategies and practical skill acquisition among TVET learners?
3. To what extent does teacher digital competence influence the use of digital instructional strategies in TVET delivery?
4. What are the experiences of learners and instructors regarding the use of digital instructional strategies for practical skill development?
5. What barriers affect the effective integration of digital instructional strategies in Nigerian TVET institutions?

Methodology

This study adopted a mixed-methods research design involving the integration of quantitative and qualitative approaches to obtain a comprehensive understanding of digital instructional strategies and practical skill acquisition among TVET learners in resource-constrained environments in Nigeria. Specifically, the study employed an explanatory sequential mixed-methods design in which quantitative data were collected and analysed first, followed by qualitative data collection and analysis to explain, elaborate, and deepen the quantitative findings. The choice of a mixed-methods approach was informed by the complex nature of instructional technology integration within vocational education environments. The quantitative component adopted a descriptive survey and correlational design to examine the extent of digital instructional strategy utilisation and its relationship with practical skill acquisition among TVET learners. The qualitative component employed a phenomenological approach involving semi-structured interviews, focus group discussions, and classroom/workshop observations to explore participants' lived experiences regarding technology-enhanced TVET instruction. The study population comprised all Technical and Vocational Education and Training (TVET) learners and instructors in selected technical colleges, vocational training centres, and Colleges of Education (Technical) across three states in North-Central Nigeria. The target population consisted of 2,635 participants, comprising 2,450 TVET learners and 185 instructors involved in vocational and technical education programmes within the selected institutions.

A multistage sampling procedure was employed for the study. At the first stage, purposive sampling was used to select institutions located within resource-constrained environments based on the operational indicators described above. At the second stage, stratified sampling was employed to ensure representation across different vocational disciplines and institutional types. The population was stratified according to programme areas (Electrical/Electronics, Building Technology, Computer Studies, Agricultural Education, Home Economics, and Business Education) and institutional category (technical colleges, vocational training centres, and Colleges of Education Technical). At the third stage, simple random sampling was used to select respondents from each stratum. Based on Krejci and Morgan's (1970) sample size determination table, a minimum sample of 305 participants was indicated for a total population of approximately 2,635. A sample of 320 TVET learners and instructors were therefore selected for the quantitative component to account for anticipated attrition and non-response. For the qualitative component, purposive sampling was used to select participants who possessed direct experience with digital instructional strategies within vocational learning environments, resulting in a total of 15 instructors and 24 learners participating in semi-structured interviews and focus group discussions.

Five instruments were used for data collection in this study:

Digital Instructional Strategies Questionnaire (DISQ): The Digital Instructional Strategies Questionnaire was developed to obtain quantitative data regarding the types, frequency, and perceived effectiveness of digital instructional strategies used within TVET instruction. The Digital Instructional Strategies Questionnaire (DISQ) consisted of 28 items divided into two sections. Section A contained 6 demographic items, while Section B contained 22 Likert-scale items measuring the availability, frequency, and perceived effectiveness of digital instructional strategies. Responses were structured on a five-point Likert scale ranging from Strongly Agree (5) to Strongly Disagree (1).

Practical Skill Acquisition Assessment Scale (PSAAS): The Practical Skill Acquisition Assessment Scale was designed to measure learners' perceived practical competence and vocational skill development across dimensions including procedural understanding, technical competence, task performance, confidence in practical operations, and application of vocational skills. The Practical Skill Acquisition Assessment Scale (PSAAS) consisted of 20 items measuring learners' perceived practical competence, procedural understanding, technical performance, confidence in practical operations, and application of vocational skills. Responses were measured using a five-point Likert response format ranging from Very High Extent (5) to Very Low Extent (1).

Semi-Structured Interview Guide:

The interview guide was used to obtain qualitative information from instructors regarding their experiences, perceptions, challenges, and instructional practices relating to digital instructional strategies within TVET settings. The Semi-Structured Interview Guide consisted of 12 open-ended questions organised into three sections covering instructors' experiences, perceptions, instructional practices, and challenges relating to digital instructional strategy integration within TVET environments.

Focus Group Discussion Guide:

The focus group discussion guide was designed to obtain learners' perspectives regarding the effectiveness, accessibility, challenges, and learning experiences associated with digital instructional strategies. The Focus Group Discussion Guide consisted of 10 discussion prompts designed to explore learners' experiences, accessibility concerns, engagement levels, and perceptions regarding the effectiveness of digital instructional strategies in practical skill development.

The instruments were subjected to face and content validation by three experts in Educational Technology, TVET, and Measurement and Evaluation from Nigerian tertiary institutions. The validators examined the instruments in terms of clarity, relevance, appropriateness, content coverage, language suitability, and alignment with the study objectives and research questions. Their observations, corrections, and recommendations were carefully incorporated into the final versions of the instruments before administration. A pilot study was conducted using respondents outside the selected study area but with similar characteristics to the target population. Data obtained

from the pilot study were analysed using Cronbach's Alpha reliability technique to determine the internal consistency of the instruments. The reliability coefficients obtained are presented in Table 1.

Table 1: ***Reliability Coefficients of Research Instruments***

Instrument	Cronbach Alpha	Interpretation
Digital Instructional Strategies Questionnaire (DISQ)	0.87	High reliability
Practical Skill Acquisition Assessment Scale (PSAAS)	0.84	High reliability
Observation Checklist	0.81	High reliability

The reliability coefficients indicated that the instruments possessed acceptable internal consistency (all > 0.80) and were therefore considered reliable for the study.

The researcher obtained introductory letters from relevant authorities before proceeding to the selected institutions. Permission was obtained from institutional administrators and heads of departments within all participating institutions. The quantitative phase involved administering the questionnaires to learners and instructors within their respective institutions. Respondents were briefed regarding the purpose of the study and were assured of confidentiality and voluntary participation. Following the quantitative phase, qualitative data were collected through semi-structured interviews, focus group discussions, and classroom/workshop observations. Interviews with instructors were conducted face-to-face and audio-recorded with participants' informed consent. Focus group discussions involving learners were conducted in conducive learning environments to encourage active participation and free expression of opinions. Classroom and workshop observations were carried out during instructional sessions involving digital instructional strategies, with detailed field notes recorded throughout the observation process.

Quantitative data collected from the questionnaires were coded and analysed using the Statistical Package for Social Sciences (SPSS) version 26. Descriptive statistics such as frequency counts, percentages, means, and standard deviations were used to answer research questions relating to types and utilisation of digital instructional strategies. A criterion mean of 3.00 (midpoint of the five-point scale) was adopted as the decision rule for acceptance or rejection of items. Inferential statistics including Pearson Product Moment Correlation and multiple regression analysis were employed to examine the relationship between digital instructional strategies and practical skill acquisition, as well as the influence of teacher digital competence on instructional technology integration. Qualitative data obtained from interviews, focus group discussions, and observations were transcribed verbatim and analysed using Braun and Clarke's (2006) thematic analysis framework, involving familiarisation, initial coding, theme development, review, definition, and write-up. Integration of quantitative and qualitative findings occurred during the interpretation stage.

Ethical principles guiding educational research were strictly observed throughout the study. Participants were adequately informed about the purpose, procedures, and significance of the study before participation. Participation was voluntary, and respondents were informed of their right to withdraw from the study at any stage without penalty. Confidentiality and anonymity were maintained by ensuring that no identifying information was disclosed in the research report. Informed consent was obtained from all participants prior to data collection. Audio recordings and research data were securely stored and used strictly for academic purposes, consistent with data privacy principles outlined by Tiefenthaler and Schumacher (2021). The study also ensured that participants were not exposed to physical, emotional, or psychological harm during the research process.

Results

A total of 320 questionnaires were administered to TVET learners and instructors across the selected institutions. Out of these, 301 were correctly completed and returned, representing a response rate of 94.1%. Nineteen

questionnaires were excluded due to incomplete responses or inconsistent rating patterns, rendering the final sample N = 301.

Research Question One: **What digital instructional strategies are commonly used in TVET instruction within resource-constrained environments in Nigeria?**

Respondents' responses regarding the availability and utilisation of various digital instructional strategies were analysed using mean and standard deviation scores. A criterion mean of 3.00 was adopted as the decision rule. Table 3 presents the findings.

Table 3: ***Digital Instructional Strategies Commonly Used in TVET Instruction (N = 301)***

S/N	Digital Instructional Strategy	Mean	SD	Decision
1	Instructional videos	3.87	0.82	Accepted
2	Mobile learning applications	3.65	0.91	Accepted
3	PowerPoint presentations	4.01	0.76	Accepted
4	Online learning platforms	3.12	1.04	Accepted
5	Learning management systems (LMS)	2.84	1.11	Rejected
6	Virtual simulations	3.21	0.98	Accepted
7	Blended learning approaches	3.58	0.89	Accepted
8	Virtual laboratory demonstrations	2.95	1.02	Rejected
9	WhatsApp instructional groups	4.14	0.71	Accepted
10	Digital collaborative tools	3.34	0.95	Accepted

Note. Criterion Mean = 3.00.

The findings in Table 3 revealed that instructional videos, PowerPoint presentations, WhatsApp instructional groups, mobile learning applications, blended learning approaches, virtual simulations, and digital collaborative tools were among the most commonly utilised digital instructional strategies. WhatsApp instructional groups recorded the highest mean score (M = 4.14, SD = 0.71), indicating widespread use attributable to accessibility and low data requirements. Learning Management Systems (LMS) and virtual laboratory demonstrations recorded mean scores below the criterion mean (M = 2.84 and M = 2.95 respectively), indicating limited utilisation. Qualitative findings supported these results. Instructors reported that WhatsApp groups and instructional videos were preferred because they function effectively even under limited connectivity conditions. One instructor stated: "Most of us rely on WhatsApp and videos because they are easier to use and students can access them through their phones. Full online systems are difficult because of poor internet and inadequate institutional support." A learner similarly explained: "We learn many practical steps through videos shared by our teachers because sometimes the workshop equipment is not enough for everybody."

Research Question Two: **What relationship exists between digital instructional strategies and practical skill acquisition among TVET learners?**

To answer this question and test H_{o1}, Pearson Product Moment Correlation analysis was conducted. Table 4 presents the results.

Table 4: ***Correlation between Digital Instructional Strategies and Practical Skill Acquisition (N = 301)***

Variables	N	Mean	SD	R	p-value	95% CI
Digital Instructional Strategies	301	3.57	0.74	0.682	0.000	[0.617, 0.739]
Practical Skill Acquisition	301	3.71	0.69			

The results in Table 4 revealed a strong positive relationship between digital instructional strategies and practical skill acquisition among TVET learners ($r = 0.682$, $p = 0.000$, 95% CI [0.617, 0.739]). The confidence interval, which does not include zero, further confirms the statistical significance and practical relevance of this relationship. Decision on H_{o1}: Since $r = 0.682$ ($p = 0.000 < 0.05$), H_{o1} is rejected. There is a significant positive relationship between digital instructional strategies and practical skill acquisition among TVET learners in

resource-constrained environments in Nigeria. Increased utilisation of digital instructional strategies is significantly associated with improved practical skill acquisition.

Qualitative findings strongly corroborated this result. Many learners reported that digital instructional strategies improved their understanding of practical procedures, enhanced repeated learning opportunities, and increased confidence during workshop activities. A participant explained: "Watching practical demonstrations repeatedly through videos helps us understand the procedures better before trying them physically." Another learner remarked: "Simulations make difficult tasks easier to understand because you can practise virtually before doing the real work."

Research Question Three: **To what extent does teacher digital competence influence the use of digital instructional strategies in TVET delivery?**

To answer this question and test H_{o2} and H_{o3}, multiple regression analysis was conducted. Multicollinearity diagnostics (VIF and Tolerance) were computed to verify regression assumptions. Table 5 presents the results.

Table 5: ***Multiple Regression Analysis of Teacher Digital Competence and Digital Instructional Strategy Utilisation***

Variable	B	Beta (β)	t	Sig.	Tolerance	VIF
Teacher digital competence	0.614	0.593	11.427	0.000	0.541	1.847
ICT training exposure	0.284	0.271	5.318	0.001	0.616	1.623
Institutional support	0.196	0.184	3.912	0.003	0.707	1.412

R	R^2	Adjusted R^2	F	Sig.
0.734	0.539	0.531	74.628	0.000

Note. Dependent Variable: Digital Instructional Strategy Utilisation. All VIF values < 2.0, indicating acceptable multicollinearity.

The findings revealed that teacher digital competence significantly influenced the utilisation of digital instructional strategies (B = 0.614, β = 0.593, t = 11.427, p = 0.000). ICT training exposure (β = 0.271, p = 0.001) and institutional support (β = 0.184, p = 0.003) also significantly predicted digital instructional strategy utilisation. The overall regression model was significant (F = 74.628, p < 0.05), with R^2 = 0.539 indicating that approximately 53.9% of the variance in digital instructional strategy utilisation was explained by the three predictors. All VIF values were below 2.0, confirming the absence of problematic multicollinearity. Decision on H_{o2}: Since β = 0.593 (p = 0.000 < 0.05), H_{o2} is rejected. Teacher digital competence significantly influences the utilisation of digital instructional strategies in TVET delivery. Decision on H_{o3}: Since ICT training exposure (β = 0.271, p = 0.001 < 0.05) and institutional support (β = 0.184, p = 0.003 < 0.05) both significantly predicted digital instructional strategy utilisation, H_{o3} is also rejected.

Qualitative findings further revealed that although many instructors possess basic digital literacy skills, they often lack specialised competencies required for pedagogically meaningful technology integration. One instructor observed: "Most teachers know how to use phones and PowerPoint, but many are not trained in how to integrate digital tools effectively into practical teaching." Another participant stated: "Training opportunities are limited, and many institutions do not provide enough technical support for digital teaching."

Research Question Four: **What are the experiences of learners and instructors regarding the use of digital instructional strategies for practical skill development?**

Qualitative data from interviews, focus group discussions, and observations were analysed thematically. Four major themes emerged from the data:

Theme 1: Improved Understanding of Practical Procedures

Most learners reported that digital instructional strategies markedly enhanced their understanding of practical concepts and procedures. Participants indicated that instructional videos and simulations enabled them to visualise

practical tasks more effectively than conventional verbal explanations, supporting Vygotsky's (1978) notion of technology as a mediating tool for knowledge construction. A learner explained: "Sometimes when the teacher explains verbally, it is difficult to imagine the process. Videos make it clearer." Classroom observations confirmed this theme: learners were observed pausing and replaying video demonstrations during pre-workshop preparation sessions, and instructors noted noticeably improved procedural accuracy during subsequent practical activities.

Theme 2: Increased Learner Engagement and Motivation

Respondents reported that technology-supported instruction increased learner participation and interest in vocational learning activities, aligning with the engagement dimension of UDL (CAST, 2018). Observational findings showed higher learner interaction and attentiveness during technology-supported instructional sessions compared to conventional lessons. An instructor stated: "Students become more active and interested when digital materials are used during practical lessons." Learners who had initially appeared disengaged during lecture-based sessions were observed actively participating in group discussions around shared videos and simulations.

Theme 3: Flexibility and Repeated Learning Opportunities

Learners particularly appreciated the ability to revisit instructional materials outside classroom hours a characteristic aligned with both connectivist principles (Siemens, 2005) and UDL's emphasis on multiple means of engagement. A participant explained: "You can replay videos many times until you fully understand the process. This is something a teacher cannot do in one lesson." This theme was especially prominent among learners who reported lower prior ICT exposure, suggesting that the flexibility of digital strategies partially compensated for pre-existing learning gaps.

Theme 4: Persistent Infrastructural and Technical Challenges

Despite the perceived benefits, participants consistently identified infrastructural barriers affecting effective digital instructional integration. These included poor electricity supply, inadequate internet connectivity, insufficient devices, limited digital resources, and inadequate institutional support. One instructor explained: "Digital teaching is good, but without stable electricity and internet access, implementation becomes difficult. Some days we cannot use any technology at all because there is no power." These findings suggest that while digital instructional strategies positively influence vocational learning experiences, infrastructural constraints remain the dominant limiting factor within resource-constrained environments.

Research Question Five: **What barriers affect the effective integration of digital instructional strategies in Nigerian TVET institutions?**

Respondents' perceptions regarding barriers to digital instructional strategy integration were analysed using descriptive statistics. Table 6 presents the findings.

Table 6: ***Barriers Affecting Digital Instructional Strategy Integration (N = 301)***

S/N	Barrier	Mean	SD	Decision
1	Poor electricity supply	4.32	0.69	Accepted
2	Inadequate internet connectivity	4.18	0.74	Accepted
3	Insufficient digital devices	4.05	0.77	Accepted
4	Lack of teacher training	3.96	0.82	Accepted
5	Poor institutional funding	4.26	0.71	Accepted
6	High cost of data subscriptions	3.89	0.85	Accepted
7	Resistance to technological change	3.22	0.97	Accepted
8	Limited technical support personnel	3.87	0.81	Accepted

Note. Criterion Mean = 3.00. All items were accepted.

The findings in Table 6 revealed that poor electricity supply (M = 4.32), poor institutional funding (M = 4.26), inadequate internet connectivity (M = 4.18), and insufficient digital devices (M = 4.05) were the four most critical barriers. Qualitative findings strongly reinforced these results. One instructor stated: "Even when teachers are willing to use technology, the environment often makes it difficult. You plan a digital lesson and the power goes

out." Another participant observed: "Without adequate funding, institutions cannot provide the equipment and digital infrastructure needed for modern vocational teaching."

Discussion of the Findings

This study investigated digital instructional strategies and practical skill acquisition among TVET learners in resource-constrained environments in Nigeria using a mixed-methods approach. The discussion of findings is presented in line with the study objectives, interpreted against existing literature and the three theoretical frameworks underpinning the study.

The findings revealed that instructional videos, PowerPoint presentations, mobile learning applications, WhatsApp instructional groups, and blended learning were the most commonly utilised digital instructional strategies, while Learning Management Systems and virtual laboratory environments were less frequently utilised. This finding suggests that TVET institutions within resource-constrained environments prioritise accessible, low-cost, and flexible technologies capable of functioning effectively despite infrastructural limitations. The widespread utilisation of WhatsApp instructional groups and instructional videos reflects the growing role of mobile technologies in supporting learning within developing educational environments where smartphones are more accessible than institutional digital infrastructure. This aligns with UNESCO-UNEVOC (2024), which observed that mobile-supported learning and low-bandwidth digital instructional tools are increasingly central to TVET delivery in developing countries, and with Kintu et al. (2022), who found that blended and mobile-supported learning environments significantly improve learner participation. From the perspective of the SAMR model (Puentedura, 2006), most digital tool usage observed in this study corresponds to the Substitution and Augmentation levels, suggesting that deeper Modification and Redefinition-level transformations remain aspirational goals for many Nigerian TVET institutions. The limited use of LMS and virtual laboratory systems supports the assumptions of TAM: technologies perceived as complex, requiring sophisticated infrastructure, or difficult to learn experience lower adoption rates (Davis, 1989; Scherer et al., 2021). Instructors and learners appeared to adopt digital strategies that were affordable, familiar, and relatedly easy to operate a pattern consistent with TAM's perceived ease of use construct.

The findings demonstrated a strong positive relationship between digital instructional strategies and practical skill acquisition ($r = 0.682$, $p < 0.05$, 95% CI [0.617, 0.739]), with Ho_1 rejected. Learners exposed to digital instructional strategies demonstrated improved procedural understanding, practical confidence, and vocational task performance. This finding supports Radianti et al. (2020), who reported that immersive and technology-enhanced environments improve learner engagement and experiential learning, and Adedokun-Shittu and Shittu (2021), who found that multimedia-supported vocational instruction enhances learners' understanding and practical performance. From a theoretical perspective, the finding aligns with both Social Constructivism and Connectivism. Vygotsky's (1978) concept of mediated learning is evident: digital tools serve as mediating artefacts that scaffold practical learning, enabling learners to visualise, practise, and internalise vocational procedures in ways not possible through conventional verbal explanation alone. Siemens' (2005) connectivist perspective is also supported by the widespread use of WhatsApp groups and digital platforms, which extended learning into distributed peer networks beyond formal classroom boundaries. Furthermore, the multimodal nature of technology-enhanced instruction providing visual, auditory, and interactive engagement simultaneously supports procedural memory and task retention, particularly within TVET where repeated demonstration and practice are essential for competency development. The finding further suggests that instructional technology can partially compensate for physical resource limitations: digital demonstrations and simulations may provide alternative opportunities for procedural exposure when workshop equipment is insufficient.

The findings confirmed that teacher digital competence significantly influenced digital instructional strategy utilisation ($\beta = 0.593$, $p < 0.05$), with both Ho_2 and Ho_3 rejected. The regression model ($R^2 = 0.539$) indicated that teacher digital competence, ICT training exposure, and institutional support collectively explained 53.9% of the

variance in digital instructional strategy utilisation a substantial and practically meaningful explanatory power. This finding corroborates Scherer et al. (2021), who reported that teachers' technological confidence and pedagogical readiness significantly influence technology adoption, and Yusuf and Ogunlade (2022), who observed that inadequate digital pedagogical competence remains a major barrier in Nigerian vocational education. The finding is consistent with TAM's proposition that technology utilisation is strongly influenced by users' confidence and competence. The qualitative findings revealed a critical distinction: while many instructors possess general ICT literacy, they lack specialised digital pedagogical competencies required for meaningful vocational technology integration. This suggests that institutional professional development programmes must go beyond basic ICT training to include targeted instruction in digital pedagogy, simulation-based instruction, learner engagement strategies, and technology-supported practical demonstrations. Without such targeted capacity building, digital infrastructure investments may remain underutilised regardless of availability.

The qualitative findings revealed that learners and instructors generally perceived digital instructional strategies positively, citing improved understanding, engagement, motivation, flexibility, and repeated learning opportunities. These experiences align with UDL principles (CAST, 2018), particularly UDL's multiple means of representation (instructional videos and simulations providing multimodal content) and multiple means of engagement (interactive digital activities fostering sustained participation). The ability of learners with varying levels of prior knowledge to access materials at their own pace represents a direct application of UDL's flexibility principle within vocational education. The connectivist dimension of learner experience was particularly visible in the repeated appreciation for WhatsApp groups and mobile platforms, which enabled learners to stay connected to instructional content and peer communities outside formal learning hours (Siemens, 2005). Observational findings further demonstrated that technology-enhanced sessions produced noticeably higher learner attentiveness and active participation compared to conventional lessons, reinforcing the engagement dimension of UDL (CAST, 2018). However, persistent infrastructural and institutional barriers continued to limit effective implementation, suggesting that positive attitudes toward digital instructional strategies alone are insufficient to guarantee success within resource-constrained environments. The effectiveness of digital instructional strategies is therefore not solely a function of pedagogical quality but is heavily conditioned by institutional readiness, infrastructure, and policy commitment.

The findings identified poor electricity supply, poor institutional funding, inadequate internet connectivity, insufficient digital devices, and lack of teacher training as the five most critical barriers. These findings align with UNESCO-UNEVOC (2022), which identified infrastructural deficits and digital inequality as the most significant barriers to digital transformation within African TVET systems, and with Okoye and Arimonu (2021), who documented inadequate funding and weak technological support as major constraints in Nigerian TVET. Zhao et al. (2021) similarly observed that disparities in digital access create significant inequalities in learner outcomes a concern directly applicable to the resource-constrained environments examined in this study. The findings carry important policy implications. First, successful digital transformation within TVET requires substantial infrastructural investment in electricity, internet connectivity, digital devices, and technical support systems. Second, teacher professional development must prioritise digital pedagogical competence rather than general ICT literacy alone. Third, digital strategies adopted within TVET institutions should be context-sensitive, prioritising accessible and low-cost technologies such as instructional videos, mobile learning, and blended learning approaches capable of functioning effectively within constrained environments. The World Bank (2024) recommends phased and sustainability-conscious approaches toward technology integration in low- and middle-income countries, a recommendation strongly endorsed by the findings of this study.

Implications for Policy, Practice, and Pedagogy

The findings carry significant implications across policy, instructional practice, curriculum development, and TVET reform. From a policy perspective, the study demonstrates the need for stronger governmental and institutional commitment toward digital transformation within TVET, with prioritisation of infrastructural

investment, teacher capacity development, and technology-supported vocational learning environments. From a pedagogical perspective, digital instructional strategies should be integrated into vocational curricula as components of broader competency-based education reforms, with explicit attention to learner diversity, accessibility, and inclusivity consistent with UDL frameworks. From an institutional perspective, TVET administrators should develop sustainable strategies for improving digital infrastructure, supporting continuous instructor development, and promoting accessible instructional technologies. The study demonstrates that although barriers remain formidable, digital instructional strategies possess considerable potential for improving practical skill acquisition when appropriately implemented, institutionally supported, and theoretically grounded.

Conclusion

This study investigated digital instructional strategies and practical skill acquisition among TVET learners in resource-constrained environments in Nigeria using a mixed-methods approach. The study was motivated by growing concerns regarding the persistent skills gap, weak practical competency development, inadequate instructional resources, and the increasing need for digitally responsive vocational education systems capable of preparing learners for contemporary labour-market demands. The findings revealed that instructional videos, mobile learning applications, WhatsApp instructional groups, blended learning approaches, PowerPoint presentations, and digital collaborative tools constituted the most commonly utilised digital instructional strategies, while more sophisticated platforms such as LMS and virtual laboratories remained underutilised due to infrastructural constraints. The study demonstrated a significant positive relationship between digital instructional strategies and practical skill acquisition ($r = 0.682$, $p < 0.05$, 95% CI [0.617, 0.739]), leading to the rejection of H_{o1}. Teacher digital competence, ICT training exposure, and institutional support jointly explained 53.9% of the variance in digital instructional strategy utilisation, with both H_{o2} and H_{o3} rejected. Qualitatively, learners and instructors reported improved understanding, engagement, motivation, and flexible repeated learning as key benefits of technology-enhanced instruction, while infrastructural inadequacies remained the most persistent obstacles.

Recommendations

Based on the findings of this study and the conclusions drawn regarding the role of digital instructional strategies in enhancing practical skill acquisition among TVET learners in resource-constrained environments, the following recommendations are proposed to strengthen instructional effectiveness, improve digital technology integration, and support sustainable vocational education development in Nigeria.

1. The Federal Ministry of Education and relevant educational agencies should develop comprehensive national policies for digital transformation within TVET institutions, with particular attention to resource-constrained environments across all geopolitical zones.
2. TETFund, the National Board for Technical Education (NBTE), and other educational intervention agencies should provide targeted funding support specifically for digital instructional infrastructure and technology-enhanced vocational education initiatives.
3. Instructors should adopt learner-centred digital instructional strategies such as blended learning, instructional videos, simulations, collaborative learning platforms, and mobile-supported instruction, designed in accordance with UDL principles to accommodate diverse learner needs and preferences.
4. Institutions should establish dedicated technical support units responsible for assisting instructors and learners in the effective utilisation, maintenance, and management of instructional technologies within vocational education environments.

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