DIGITAL SKILLS AND INNOVATIVE TECHNOLOGIES AS DETERMINANTS OF EFFECTIVE E-LEARNING AMONG DISTANCE LEARNING STUDENTS IN POLYTECHNICS IN KWARA STATE, NIGERIA

BY

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Abstract

E-learning is an evolving mode of learning, making knowledge acquisition accessible and available to people regardless of geographical locations. Existing studies have reported different factors, including the availability of digital technologies, digital skills, and quality of content as the catalysts for e-learning. The need to ascertain the determinants of e-learning in polytechnics underscores why this study investigates digital skills and access to innovative technologies as determinants of effective e-learning among distance learning students in polytechnics in Kwara State, Nigeria. A descriptive correlational survey design was employed, with a population of 3,197 distance learners across Federal Polytechnic, Offa, and Kwara State Polytechnic, Ilorin. Using a multi-stage sampling, 341 respondents were selected, and data were collected with a validated self-designed questionnaire whose reliability coefficients were .810 for digital skills, .758 for access to innovative technologies, and .794 for effective e-learning. Data were analysed using Pearson Product–Moment Correlation (PPMC) and multiple regression. Findings showed a very strong positive relationship between digital skills and effective e-learning **(**$r = .820$**,** $p = .000$**),** leading to the rejection of H_{01}**.** Similarly, access to innovative technologies exhibited a very strong positive correlation with effective e-learning **(**$r = .836$, $p = .000$**),** resulting in the rejection of H_{02}**.** The joint influence of digital skills and access to innovative technologies on effective e-learning was also significant, with regression results indicating $R = .900$**,** $R^2 = .810$, $F(2,272) = 579.734$, $p = .000$**,** thereby rejecting H_{03}**.** Coefficient analysis further revealed that both predictors significantly contributed to effective e-learning (digital skills: $\beta = .464$, $p = .000$; access to technologies: $\beta = .515$**,** $p = .000$). The study concludes that digital skills and technological access are strong determinants of effective e-learning, with access to innovative technologies exerting a slightly greater influence. It recommends targeted institutional investments to strengthen students' digital capacity and improve technological infrastructure.

Keywords: Digital skills, Innovative technologies, E-learning, Polytechnics, Kwara State, Nigeria

Introduction

Learning is a continuous process through which individuals acquire new knowledge, skills, and expertise necessary to perform tasks effectively. It involves systematic exposure to procedures, processes, and techniques that enable individuals to develop competence in various domains (Chigbundu & Oluwabiyi, 2023). Historically, learning was confined to manual interaction with information sources. However, the emergence of Information and

Communication Technologies (ICTs) has transformed learning into a more dynamic and accessible process. As society evolves, so does the concept of learning, making its evaluation essential in understanding how effectively it supports educational objectives. Technological advancements have significantly influenced instructional delivery, prompting educators to shift from traditional classroom-based instruction to technology-driven learning modes. This transformation has given rise to e-learning, a system that integrates electronic resources and digital platforms into the teaching and learning process (Adenekan et al., 2023). E-learning, often described as web-based learning, enables users to access instructional content without the limitations of geographical proximity, relying on computer systems and Internet networks for interaction and knowledge acquisition.

As technology continues to advance, e-learning has gained prominence as a dependable instructional method across different levels of education. Its flexibility, interactivity, and customisable features have made it increasingly attractive to learners who seek convenient and adaptable learning experiences (Avelino, 2025; Romi, 2024). The growing recognition of these benefits has intensified interest in understanding the factors that support the effective adoption of e-learning, especially given the ongoing debates on what constitutes e-learning within educational and technological communities (Igboroodowo & Chukwuemeke, 2022). One of the core strengths of e-learning lies in its ability to provide self-paced instruction, personalised learning paths, and flexible schedules. These features offer an alternative for individuals unable to attend traditional classroom settings while enabling learners to participate from any location using digital devices (Bouchrika, 2025; Baber, 2022). Because various e-learning models seek to enhance learning outcomes, assessing the effectiveness of e-learning has become crucial. Learning outcomes, such as grades, course completion, and skill acquisition, serve as indicators of how well instructional objectives are achieved (Müller & Wulf, 2022; Lockman & Schirmer, 2020; Salem et al., 2024). The effectiveness of e-learning is influenced by several factors, among which digital literacy skills are prominent. Digital literacy skills entail the ability to critically navigate, evaluate, and utilise digital tools, information, and online services (Abah et al., 2025; Olatoye & Oyewumi, 2025). Scholars argue that an individual's ability to use e-learning facilities effectively depends on their digital skills, which range from basic abilities, such as connecting to the Internet or downloading digital documents, to more advanced competencies (Chigbundu & Oluwabiyi, 2023; Ng, 2022). The COVID-19 pandemic further highlighted the importance of digital literacy, expanding research interests toward digital competencies required specifically for online learning (Baber et al., 2022; Zan et al., 2021; Kryukov & Gorin, 2024).

In addition to digital skills, access to innovative technologies has become fundamental to enhancing learning experiences. ICT integration in tertiary education facilitates accessibility and quality learning while fostering cognitive development and creativity (Kryukov & Gorin, 2024; Wagwu & Okoro, 2025). Innovative technologies, including social networking tools, blogs, wikis and interactive e-books, enable collaboration and enrich learning environments through multisensory engagement (Ukubeyinje et al., 2025; Andrew et al., 2021). However, the availability of such technologies depends on functional digital infrastructure, including video-conferencing tools, reliable networks, and user-friendly interfaces (Nwadi et al., 2023; Iswahyudi et al., 2023; Obim & Izuakolam, 2025). Despite the benefits associated with digital skills and innovative technologies, disparities in access persist among Nigerian undergraduates. Research reveals that while some students possess high levels of digital literacy, others, particularly those in public institutions, struggle with limited digital skills and inadequate technological access (Ilori et al., 2023). These inequalities are more pronounced among distance learning students who often depend heavily on digital infrastructure for their academic progress. Although technologies such as MOOCs have shown potential in improving academic performance, many innovative tools in Nigerian distance learning environments remain non-functional or insufficient (Adelowo et al., 2023; Oyebowale et al., 2024).

Given the expanding reliance on e-learning in Nigeria's tertiary education sector and the mixed findings regarding the influence of digital skills and technological access on learning outcomes, it becomes necessary to examine these factors within specific educational contexts. The polytechnic system in Nigeria represents a critical environment where distance learners increasingly depend on digital technologies for instruction. However, empirical evidence regarding how digital skills and access to innovative technologies shape effective e-learning in this setting remains limited.

Although e-learning has become a vital component of contemporary education, its effectiveness remains uneven, particularly among distance learners who rely heavily on digital platforms for academic engagement. Studies show that the success of e-learning depends significantly on learners' digital literacy skills and their confidence in navigating digital environments (Chigbundu & Oluwabiyi, 2023; Vaszkun & Szakacs, 2025). However, Nigerian undergraduates, especially those in public institutions, continue to experience varying levels of digital competence, with many lacking even the basic operational skills needed to fully benefit from online learning systems (Ilori et al., 2023). These disparities pose critical challenges for distance learning students in polytechnics, who must independently navigate digital tools, evaluate online resources and complete tasks without direct physical support. Despite evidence that digital literacy positively influences e-learning effectiveness (Falloon, 2020; Sarfraz et al., 2022), little is known about how these skills specifically affect distance learners in polytechnics in Kwara State, Nigeria. Compounding the challenges of digital literacy is the issue of unequal access to innovative technologies and functional digital infrastructure. While innovative technologies such as interactive e-books, 3D animation tools, and MOOCs have the potential to enhance learning outcomes (Iswahyudi et al., 2023; Obim & Izuakolam, 2025; Adelowo et al., 2023), many Nigerian tertiary institutions continue to struggle with non-functional platforms, poor Internet connectivity, and inadequate ICT facilities (Oyebowale et al., 2024; Nwadi et al., 2023). Distance learners are particularly disadvantaged, as their learning is almost entirely dependent on the availability and reliability of these technologies. Despite the increasing shift towards technology-mediated learning, empirical evidence specifically linking digital skills and access to innovative technologies with e-learning effectiveness among polytechnic distance learners in Kwara State remains limited. This gap highlights the need for a systematic investigation into how these factors influence effective e-learning within this educational context. Therefore, *this study investigates* digital skills and access to innovative technologies as determinants of effective e-learning among distance learners in polytechnics in Kwara State, Nigeria.

Objectives of the Study

The main objective of this study is to investigate digital skills and access to innovative technologies as determinants of effective e-learning among distance learning students in polytechnics in Kwara State, Nigeria. The specific objectives of the study are to:

1. establish the relationship between digital skills and effective e-learning among distance learning students in polytechnics in Kwara State, Nigeria;

2. establish the relationship between access to innovative technologies and effective e-learning among distance learning students in polytechnics in Kwara State, Nigeria; and,

3. establish the significant relationship among digital skills, access to innovative technologies, and effective e-learning among students in polytechnics in Kwara State, Nigeria.

Research Hypotheses

The following null hypotheses guide the conduct of this study and would be tested at 0.05 level of significance:

H_{o1}: There is no significant relationship between digital skills and effective e-learning among distance learning students in polytechnics in Kwara State, Nigeria.

H_{o2}: There is no significant relationship between access to innovative technologies and effective e-learning among distance learning students in polytechnics in Kwara State, Nigeria.

H_{o3}: There is no significant relationship among digital skills, access to innovative technologies, and effective e-learning among distance learning students in polytechnics in Kwara State, Nigeria.

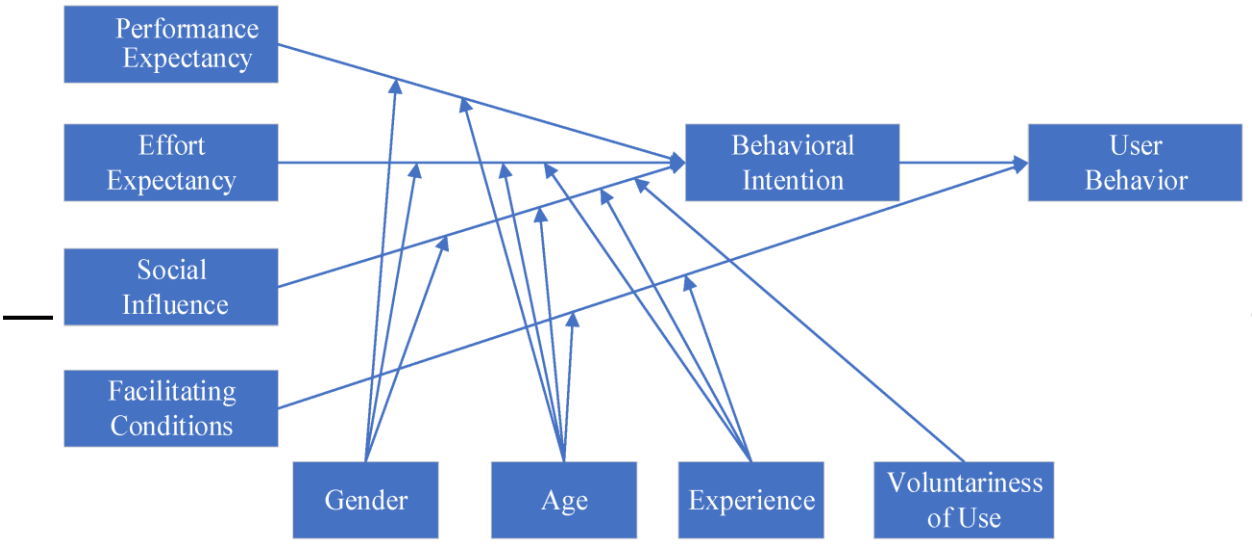
Literature Review

Theoretical Framework: Unified Theory of Acceptance and Use of Technology (UTAUT)

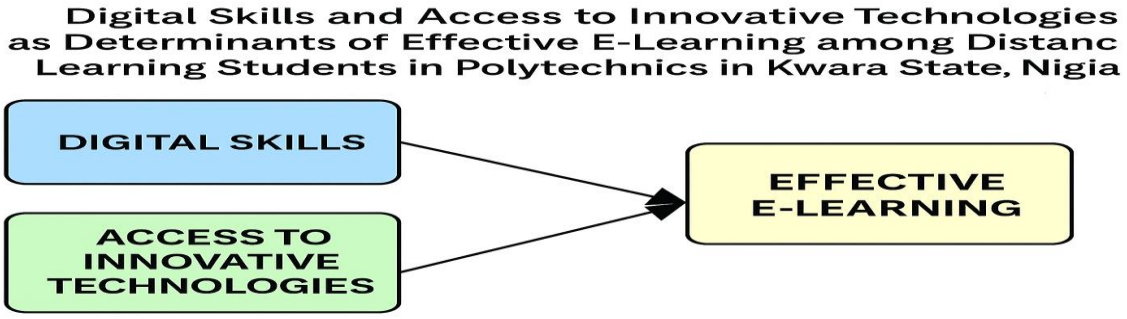
The Unified Theory of Acceptance and Use of Technology **(**UTAUT) is a model that provides a basic conceptual framework by combining models that explain the individual acceptance of IT by analysing eight competing models trying to explain the users' technology acceptance and usage intention. It has been used to evaluate the use of information systems and information technology for diverse purposes (Ayaz & Yanartas, 2020). UTAUT comprises four main factors, including: Performance expectancy, social influence, effort expectancy, and facilitating conditions. The proponents of UTAUT believed that there are determining factors that directly affect intention to use or adoption of technologies. From the identified four factors of UTUAT, only two (2), which are facilitating conditions (FC) and performance expectancy (PE), are considered applicable to this study. The FC represents both digital skills and access to innovative technologies, while the PE represents the effectiveness of e-learning among undergraduates in polytechnics.

Figure 1: Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh *et al.* 2003)

Conceptual Framework



This study adopts an intuitive conceptual model to present the ideas or variables: digital skills (IV 1), access to innovative technologies (IV 2), and e-learning (DV). Digital skills address abilities to connect electronic devices to learning platforms, identify the software needed for e-learning, install e-learning software, and navigate different e-learning platforms. Also, access to innovative technologies includes access to Google facilities (Classroom, Meet, Forms), Moodle, MOOCs, Coursera, Zoom, AI, and others, while e-learning comprises blended, virtual, video-based, game, social, and the like.



Digital Skills, Access to Innovative Technologies, and Effective E-learning

Global research on digital learning environments demonstrates that e-learning has become a mainstream component of contemporary higher education, although levels of readiness and technological maturity vary significantly across regions. In Europe, for instance, a comprehensive study of 249 universities across 38 countries reported widespread institutional adoption of blended learning (91%) and online courses (82%), supported by robust digital infrastructure such as learning management systems, online repositories, high-speed Internet, and student portals (Kryukov & Gorin, 2024). However, despite this infrastructural maturity, only a minority of institutions (12%) independently developed MOOC platforms, indicating continued reliance on external technological innovations. These findings highlight the feasibility of large-scale e-learning in well-resourced contexts but also point to challenges in adapting such models to regions where infrastructural and financial constraints are more apparent, such as Nigeria. Within the Nigerian context, empirical studies consistently show that the most significant barrier to effective e-learning adoption is the limited availability of digital resources. Igboroodowo and Chukwuemeke (2022), for example, found that business education students held favourable views about the pedagogical value of e-learning but expressed concerns about inadequate institutional provision of digital tools and platforms. Comparative evidence from public and private universities during the COVID-19 lockdown further underscores inequities in access. Adelowo et al. (2023) reported that private-university students utilised a wider range of platforms, including Moodle, Coursera, Zoom, and WebEx, and predominantly relied on laptops for online learning. By contrast, students in public universities were constrained by unstable Internet connectivity, limited access to laptops, and lower digital competence, often resorting to smartphones as a primary learning device. These findings are particularly relevant for distance learners in polytechnics, who often study outside campus environments and therefore face heightened infrastructural challenges.

In terms of tool awareness and utilisation, existing studies indicate substantial variability even within single institutional settings. Nwadi et al. (2023) observed high levels of student engagement with e-learning websites

(84.8%) and Google Classroom (75.6%), yet a notable proportion of learners remained unaware of widely used systems such as Moodle and Canvas. This suggests inconsistencies in institutional communication, training, and platform onboarding, raising questions about the extent to which learners in polytechnic distance-learning programmes are adequately introduced to the digital systems necessary for successful e-learning. A strong body of evidence emphasises the centrality of digital skills in shaping learners' engagement, satisfaction, and academic outcomes in online environments. Training-based interventions have demonstrated that learners, even those initially unfamiliar with digital tools, can rapidly acquire skills such as whiteboard animation, 3D video creation, simple graphic design, and interactive media production when provided with structured instruction (Obim & Izuakolam, 2025). Studies from Jordan similarly reveal that e-learning can foster digital thinking skills, though often at moderate levels, underscoring the need for deliberate curricular integration of digital-skills development (Al-Ghammaz, 2025). More advanced analyses, such as Romi (2024), link a wide range of digital competencies, including communication, educational problem-solving, information processing, digital safety, application of emerging technologies, and database management, to improved academic effectiveness and performance in e-learning settings. Supporting this, Ilori et al. (2021) found that digital literacy significantly predicted undergraduates' use of electronic resources, demonstrating the strong relationship between skill proficiency and e-learning engagement.

Quality-related studies reveal that learners often find e-learning platforms convenient and easy to navigate, but still confront structural constraints. Wolniak and Stecula (2024) reported high user satisfaction with platform usability among Polish students, yet Nigerian research shows that cyberbullying, poor electricity supply, and high participation costs continue to hinder learners' preference for online learning (Chigbundu & Oluwabiyi, 2023). These findings suggest that even where digital skills and platform usability are adequate, broader social and infrastructural conditions can undermine adoption—conditions that are particularly salient for distance learners in Kwara State, whose learning depends heavily on self-managed digital access. Research on MOOCs and emerging technologies further illustrates the expanding role of innovative platforms in digital learning. MOOCs have been shown to positively influence academic performance among distance learners in Nigerian universities (Ohanyelu & Nwauwa, 2025), while studies in Ibadan indicate substantial adoption rates and strong links between MOOC utilisation and UTAUT constructs such as performance expectancy, effort expectancy, social influence, and facilitating conditions (Otitoju & Nwagwu, 2024). Nevertheless, unexpected negative associations between certain expectancy variables and MOOC usage point to possible misalignments between learner expectations and institutional support. Meanwhile, the growing use of AI technologies among e-tutors highlights the expanding technological landscape of e-learning, although utilisation is hindered by the absence of clear policy frameworks (Usman, 2025). This gap may be even more pronounced in polytechnic systems, where institutional policy and training structures may be less developed than in established distance-learning universities.

Studies focusing on faculty readiness reinforce these concerns. Adenekan et al. (2023) found that academic librarians generally possess adequate technological competencies and perceive e-learning tools as easy to use, but their skills tend to remain at average levels rather than advanced proficiency. This underscores the importance of continuous professional development, especially in polytechnic environments where instructors must integrate practical, skill-based content with digital delivery. Large-scale research further identifies digital literacy, motivation, cognitive skills, and e-learning habits, including time and task management, as significant predictors of e-learning effectiveness (Vaszkun & Szakacs, 2025). For distance learners, who are required to manage learning autonomously, such factors are particularly consequential. Across these studies, two determinants emerge

consistently**:** digital skills, encompassing basic, intermediate, and advanced competencies; and access to innovative technologies and enabling conditions, such as reliable Internet, functional devices, stable electricity, platform infrastructure, and institutional support. While these determinants have been explored extensively in university contexts, there is a notable absence of focused research on distance learners in polytechnics, particularly in Kwara State, Nigeria. Polytechnics have distinct curricular orientations, learner demographics, and infrastructural realities that differ from universities. Moreover, distance learners in these institutions may face additional constraints arising from self-paced study, off-campus reliance on personal technologies, and limited institutional support. These gaps justify the present investigation, which seeks to examine how digital skills and access to innovative technologies shape e-learning practices among polytechnic distance learners in Kwara State, Nigeria.

Methodology

This study employed a descriptive survey of correlational type to establish the digital skills and access to innovative technologies as determinants of effective e-learning among distance learning students in polytechnics in Kwara State, Nigeria. 3,197 distance learners of Federal Polytechnic, Offa, and Kwara State Polytechnic, Ilorin, constituted the population of this study. LIS educators and professional librarians working in the libraries of the six institutions with LIS schools under investigation made up the study's actual population. A multi-stage sampling that combines stratified and simple random samplings were used to select 341 respondents. A self-developed questionnaire, which was subjected to face and content validities was used for data collection. After the pilot survey, Crobach's Alpha was used to determine the questionnaire's reliability for the variables: Digital skills (.810); Access to innovative technologies (.758), and Effective e-learning (.794). The hypotheses were tested using inferential statistics that combined regression analysis and Pearson Product-Moment Correlation (PPMC).

Data Analysis

Table 1: Respondents' Demographic Information

Options		**F**	**%**
Gender	Male	168	61.1
	Female	107	38.9
	Total	**275**	**100**
Polytechnic	Federal Polytechnic, Offa	102	37.1
	Kwara State Polytechnic, Ilorin	173	62.9
	Total	**275**	**100**
Discipline	Applied Science	86	31.3
	Finance and Management	82	29.8
	Information and Communication Technology	107	38.9
	Total	**275**	**100**
Age range	16 – 20 years	72	26.2
	21 – 25 years	117	42.5
	26 – 30 years	54	19.6
	31 years and above	32	11.6
	Total	**275**	**100**
Marital status	Single	195	70.9
	Married	76	27.6
	Divorced	3	1.1
	Widow	1	0.4

Total	**275**	**100**

Table 1 reveals that the majority of respondents were male, accounting for 61.1% (168 respondents), while females constituted 38.9% (107 respondents). This indicates a gender imbalance among the respondents, which may reflect broader enrollment patterns in polytechnic education or the specific disciplines surveyed. Interestingly, respondents were drawn from two polytechnics: Federal Polytechnic, Offa, and Kwara State Polytechnic, Ilorin. A larger proportion (62.9%) of respondents were affiliated with Kwara State Polytechnic, Ilorin, compared to 37.1% from Federal Polytechnic, Offa. This disparity suggests either a higher student population at Kwara State Polytechnic or greater accessibility during data collection. Also, three academic disciplines were represented in the study: Applied Science, Finance and Management, and Information and Communication Technology (ICT). ICT had the highest representation, with 38.9% (107 respondents), followed by Applied Science at 31.3% (86 respondents) and Finance and Management at 29.8% (82 respondents). This distribution highlights the prominence of ICT-related programs among the respondents, which may influence the technological orientation of the study findings. Furthermore, the age profile of respondents shows that the largest group (42.5%) fell within the 21–25 years category, followed by 16–20 years (26.2%), 26–30 years (19.6%), and 31 years and above (11.6%). This pattern suggests that the majority of respondents are young adults, consistent with the typical age range of polytechnic students. The relatively small proportion of respondents aged 31 and above may indicate limited participation of mature students in the surveyed programs. An overwhelming majority of respondents (70.9%) were single, while 27.6% were married. Only a negligible proportion reported being divorced (1.1%) or widowed (0.4%). This finding aligns with the age distribution, as younger respondents are more likely to be unmarried. The demographic profile indicates that the respondents are predominantly young, single, and male, with a strong representation from Kwara State Polytechnic and ICT disciplines. These characteristics may have implications for the study, particularly in areas related to technology adoption, career aspirations, and social dynamics within polytechnic education.

Hypotheses Testing

Ho_1: There is no significant relationship between digital skills and effective e-learning among distance learning students in polytechnics in Kwara State, Nigeria.

Table 2: PPMC results showing the relationship between digital skills and effective e-learning among distance learning students in polytechnics in Kwara State, Nigeria

S/N	Variables	Mean	SD	Df	Correlations ®	Sig. P	Remark
1.	Digital skills	19.05	5.01	275	.820**	.000	Significant
2.	Effective e-learning	26.55	6.04	275			

**. Correlation is significant at the 0.05 level (2-tailed).

Decision Rule: Reject Ho_1 if the p-value is ($p<0.05$). If otherwise, do not reject (i.e., if the p-value is greater than (or equal to 0.05).

Table 2 presents the results of a Pearson Product-Moment Correlation (PPMC) analysis examining the relationship between digital skills and effective e-learning among distance learning students in polytechnics in Kwara State, Nigeria. The descriptive statistics indicate that the mean score for digital skills was 19.05 (SD = 5.01), while effective e-learning recorded a higher mean of 26.55 (SD = 6.04). These values suggest that, on average, students demonstrated moderate digital proficiency and relatively higher engagement in effective e-learning practices.

The correlation coefficient (r = 0.820) reveals a very strong positive relationship between digital skills and effective e-learning. This implies that students with higher levels of digital competence are more likely to experience effective e-learning. The significance level (p = 0.000) is well below the 0.05 threshold, confirming that the observed relationship is statistically significant and unlikely to have occurred by chance. With a degree of freedom (df) of 275, the sample size is sufficiently large to lend credibility to these findings. Based on the decision rule, the null hypothesis (H_0), which posits no significant relationship between digital skills and effective e-learning, is rejected. Consequently, the study establishes that digital skills are a critical determinant of effective e-learning among distance learners in Kwara State polytechnics.

Ho_2: There is no significant relationship between access to innovative technologies and effective e-learning among distance learning students in polytechnics in Kwara State, Nigeria.

Table 3: PPMC results showing the relationship between access to innovative technologies and effective e-learning among distance learning students in polytechnics in Kwara State, Nigeria

S/N	Variables	Mean	SD	Df	Correlations ®	Sig. P	Remark
1.	Access to innovative technologies	28.65	6.73	275	.836**	.000	Significant
2.	Effective e-learning	26.55	6.04	275			

**. Correlation is significant at the 0.05 level (2-tailed).

Decision Rule: Reject Ho_2 if the p-value is ($p<0.05$). If otherwise, do not reject (i.e., if the p-value is greater than (or equal to 0.05).

Table 3 presents the Pearson Product-Moment Correlation (PPMC) analysis of the relationship between access to innovative technologies and effective e-learning among distance learning students in polytechnics in Kwara State, Nigeria. The descriptive statistics indicate that the mean score for access to innovative technologies is 28.65 with a standard deviation of 6.73, while effective e-learning has a mean score of 26.55 and a standard deviation of 6.04. These values suggest that respondents generally reported a relatively high level of access to innovative technologies and effective e-learning experiences, with moderate variability in their responses. The correlation coefficient (r) of 0.836 demonstrates a very strong positive relationship between the two variables. This implies that as access to innovative technologies increases, the effectiveness of e-learning also improves significantly. Furthermore, the p-value of 0.000, which is less than the 0.05 significance threshold, confirms that the observed relationship is statistically significant. Consequently, the null hypothesis (Ho_2), which posits that there is no significant relationship between access to innovative technologies and effective e-learning, is rejected.

Ho_3: There is no significant joint relationship among digital skills, access to innovative technologies, and effective e-learning among distance learning students in polytechnics in Kwara State, Nigeria.

Table 4: Model Summary results showing the joint significant relationship among digital skills, access to innovative technologies, and effective e-learning among distance learning students in polytechnics in Kwara State, Nigeria

Model	R	R Square	Adjusted R-Square	Std. Error of the Estimate
1	.900[a]	.810	.809	2.64175

a. Predictors: (Constant), Access to innovative technologies, Digital skills

Table 4 presents the model summary of a regression analysis examining the joint relationship among digital skills, access to innovative technologies, and effective e-learning among distance learning students in polytechnics in Kwara State, Nigeria. The model yielded a correlation coefficient (R) of 0.900, indicating a very strong positive association between the independent variables (digital skills and access to innovative technologies) and the dependent variable (effective e-learning). This suggests that improvements in digital competencies and technological access are strongly linked to enhanced e-learning outcomes. The coefficient of determination (R^2) is 0.810, implying that approximately 81% of the variance in effective e-learning can be explained by the combined influence of digital skills and access to innovative technologies. This high explanatory power underscores the critical role these factors play in shaping e-learning effectiveness. Furthermore, the adjusted R^2 value of 0.809, which accounts for the number of predictors and sample size, shows minimal deviation from the R^2 value, confirming the robustness and reliability of the model. The standard error of the estimate is 2.64175, indicating the average deviation of observed values from the predicted values. While this figure suggests some variability, it remains within an acceptable range for social science research, signifying that the model provides reasonably accurate predictions. In summary, the findings demonstrate a significant and strong joint relationship between digital skills, access to innovative technologies and effective e-learning.

Table 5: ANOVA results showing the joint significant relationship among digital skills, access to innovative technologies and effective e-learning among distance learning students in polytechnics in Kwara State, Nigeria

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	8091.742	2	4045.871	579.734	.000[b]
	Residual	1898.243	272	6.979		
	Total	9989.985	274			

a. Dependent Variable: Effective e-learning
b. Predictors: (Constant), Access to innovative technologies, Digital skills

Table 5 presents the results of an Analysis of Variance (ANOVA) conducted to examine the joint effect of digital skills and access to innovative technologies on effective e-learning among distance learning students in polytechnics in Kwara State, Nigeria. The dependent variable in the model is effective e-learning, while the predictors include access to innovative technologies and digital skills. The ANOVA results indicate that the regression model is statistically significant, with an F-value of 579.734 and a corresponding significance level (p-value) of .000, which is less than the conventional threshold of 0.05. This implies that the combined influence of digital skills and access to innovative technologies on effective e-learning is highly significant. In other words, these predictors jointly explain a substantial proportion of the variance in effective e-learning outcomes. The sum of squares for regression (8091.742) is considerably higher than the residual sum of squares (1898.243), suggesting that the model accounts for a large portion of the variability in the dependent variable. The mean square for regression (4045.871) also far exceeds that of the residual (6.979), reinforcing the strength of the predictors in explaining the observed differences in effective e-learning. Overall, the findings demonstrate that digital skills and access to innovative technologies are critical determinants of effective e-learning among distance learning students. This underscores the need for polytechnic institutions to prioritize the development of students' digital competencies and ensure adequate access to modern technological resources to enhance the quality and effectiveness of e-learning programs.

Table 6: Coefficients[a] results showing the joint significant relationship among digital skills, access to innovative technologies, and effective e-learning among distance learning students in polytechnics in Kwara State, Nigeria

Model		Unstandardised Coefficients		Standardised Coefficients		
		B	**Std. Error**	**Beta**	**t**	**Sig.**
1	(Constant)	2.675	.723		3.699	.000
	Digital skills	.559	.044	.464	12.657	.000
	Access to innovative technologies	.462	.033	.515	14.050	.000

a. Dependent Variable: Effective e-learning

Table 6 presents the coefficients of a multiple regression analysis examining the influence of digital skills and access to innovative technologies on effective e-learning among distance learning students in polytechnics in Kwara State, Nigeria. The dependent variable in the model is effective e-learning, while the independent variables are digital skills and access to innovative technologies. The constant term has an unstandardised coefficient (B) of 2.675, indicating the baseline level of effective e-learning when both predictors are held at zero. This coefficient is statistically significant ($t = 3.699$, $p < .001$), suggesting that the model has a meaningful intercept. Digital skills exhibit a positive and significant effect on effective e-learning, with an unstandardized coefficient of 0.559 and a standardized beta of 0.464. This implies that for every one-unit increase in digital skills, effective e-learning improves by 0.559 units, holding other factors constant. The t-value of 12.657 and a significance level of $p < .001$ confirm that this relationship is highly significant. The standardized beta further indicates that digital skills contribute substantially to the model, though not as strongly as access to innovative technologies. Access to innovative technologies also demonstrates a positive and significant influence on effective e-learning, with an unstandardized coefficient of 0.462 and a standardized beta of 0.515. This suggests that a one-unit increase in access to innovative technologies leads to a 0.462-unit improvement in effective e-learning. The t-value of 14.050 and $p < .001$ reinforce the robustness of this effect. Notably, the standardized beta for access to innovative technologies is slightly higher than that of digital skills, indicating that access to innovative technologies is the stronger predictor of effective e-learning in this model. Overall, the findings reveal that both digital skills and access to innovative technologies are critical determinants of effective e-learning among distance learning students. However, access to innovative technologies exerts a marginally greater influence than digital skills. These results underscore the importance of equipping students with adequate digital competencies while ensuring they have access to modern technological resources to optimize e-learning outcomes.

Discussion of Findings

Relationship between digital skills and effective e-learning among distance learning students in polytechnics in Kwara State, Nigeria

The result of this study, which revealed a very strong positive correlation ($r = 0.820$) between digital skills and effective e-learning among distance learning students in polytechnics in Kwara State, Nigeria, underscores the critical role of digital skills in contemporary education. The significance level ($p = 0.000$) further confirms that this relationship is statistically significant and unlikely to have occurred by chance. This finding aligns with the growing body of literature that positions digital literacy as a fundamental determinant of successful engagement in e-learning

environments. Several scholars have emphasized that digital skills are indispensable for navigating e-learning platforms effectively. For instance, Olatoye and Oyewumi (2025) describe digital literacy as encompassing technical proficiency, cognitive abilities, and socio-emotional capacities required to participate safely and ethically in digital environments. Similarly, Chigbundu and Oluwabiyi (2023) argue that the ease with which individuals utilize e-learning facilities depends largely on their digital skills. These assertions corroborate the present finding, suggesting that students with higher digital competence are better equipped to access, evaluate, and utilize online learning resources, thereby enhancing their learning outcomes. The strong correlation observed in this study is consistent with empirical evidence from Romi (2024), who reported that digital skills dimensions—such as communication, problem-solving, and data processing positively impact students' academic performance in e-learning contexts. Likewise, Ilori et al. (2023) found that undergraduates with high digital literacy exhibited greater proficiency in utilizing electronic resources, which significantly influenced their learning experiences. These studies collectively affirm that digital skills are not merely supportive but foundational to effective e-learning. However, contrasting perspectives exist in the literature. For example, Chigbundu and Oluwabiyi (2023) noted that while Nigerian undergraduates were digitally proficient, their attitude toward e-learning was not significantly influenced by these skills, suggesting that other factors such as motivation, infrastructure, and socio-economic conditions—may moderate the relationship. Similarly, Vaszkun and Szakacs (2025) argued that digital literacy may not directly affect e-learning effectiveness; rather, the confidence derived from possessing such skills plays a more decisive role. These divergent views highlight the complexity of the digital skills–e-learning nexus and suggest that while skills are critical, they operate within a broader ecosystem of enabling conditions. Contextually, the strong positive relationship observed in this study reflects the increasing reliance on technology-driven learning in Nigeria's polytechnic education system. The COVID-19 pandemic accelerated the adoption of e-learning globally, and in Nigeria, this shift exposed disparities in digital readiness among students (Adelowo et al., 2023; Oyebowale et al., 2024). While private institutions demonstrated better access to technology and higher digital competence, public institutions faced challenges such as inadequate infrastructure and limited technical proficiency (Ilori et al., 2023). Against this backdrop, the present finding underscores the urgent need for targeted interventions to enhance digital literacy among distance learners in polytechnics, as a strategy for improving the effectiveness of e-learning. This study reinforces the theoretical position advanced by the Unified Theory of Acceptance and Use of Technology (UTAUT), which identifies facilitating conditions—such as digital skills—as critical to technology adoption and performance outcomes (Ayaz & Yanartas, 2020). By establishing a strong and significant relationship between digital skills and effective e-learning, the study provides empirical support for policy initiatives aimed at integrating digital literacy training into the curriculum of Nigerian polytechnics. Such measures will not only improve students' e-learning experiences but also prepare them for the demands of a digitally-driven workforce.

Relationship between access to innovative technologies and effective e-learning among distance learning students in polytechnics in Kwara State, Nigeria

The result of this study revealed a correlation coefficient (\(r = 0.836\)) between access to innovative technologies and effective e-learning among distance learning students in polytechnics in Kwara State, Nigeria. This indicates a very strong positive relationship, suggesting that as students' access to innovative technologies improves, the effectiveness of e-learning significantly increases. Furthermore, the p-value (\(p = 0.000\)) being less than the 0.05 significance threshold confirms that this relationship is statistically significant, leading to the rejection of the null hypothesis (Ho_2), which posited no significant relationship between access to innovative technologies and effective e-learning.

This finding aligns with the position of Wagwu and Okoro (2025), who argued that innovative technologies enhance literacy skills and cognitive development by enabling learners to interact with content dynamically. Similarly, Andrew et al. (2021) emphasized that innovative technologies bridge the gap between traditional and digital learning experiences, fostering learner autonomy and engagement. These assertions corroborate the present study's result, as improved access to technologies such as interactive e-books, MOOCs, and virtual learning platforms evidently contributes to more effective e-learning experiences. Conversely, the finding contrasts with earlier studies that reported mixed or weak associations between technological access and learning outcomes. For instance, Igboroodowo and Chukwuemeke (2022) found that while students perceived e-learning technologies as beneficial for bridging theoretical and practical gaps, their availability was inconsistent, limiting overall effectiveness. Similarly, Adelowo et al. (2023) highlighted disparities in access during the COVID-19 lockdown, noting that students in public institutions faced infrastructural challenges that hindered optimal e-learning engagement. These contrasting results suggest that while access is a critical determinant, its impact may be moderated by contextual factors such as institutional support and socio-economic conditions. The strong positive correlation observed in this study can be contextualized within the broader discourse on digital transformation in education. Kryukov and Gorin (2024) asserted that access to digital technologies accelerates innovative changes in educational processes, creating competitive advantages for institutions. This perspective reinforces the argument that technological infrastructure—such as high-speed internet, adaptive learning systems, and virtual reality tools—plays a pivotal role in shaping effective e-learning environments. Moreover, Nwadi et al. (2023) reported high utilization rates of platforms like Google Classroom and video conferencing among vocational students, further supporting the notion that technological access directly influences learning effectiveness. However, it is important to acknowledge persistent challenges that may constrain the positive impact of technological access. Literature identifies issues such as inadequate funding, low bandwidth, and digital divides as barriers to effective e-learning (Ebijuwa & Oladejo, 2023; Oyebowale et al., 2024). These challenges underscore the need for holistic strategies that not only provide access but also ensure sustainability and equity in technology deployment.

Significant relationship among digital skills, access to innovative technologies, and effective e-learning among students in polytechnics in Kwara State, Nigeria

The findings of this study reveal that both digital skills and access to innovative technologies are critical determinants of effective e-learning among distance learning students in polytechnics in Kwara State, Nigeria. However, access to innovative technologies exerts a marginally greater influence than digital skills. This outcome aligns with the growing consensus in literature that technological infrastructure and resource availability are foundational to the success of e-learning initiatives, particularly in developing contexts. Several scholars have emphasised the importance of digital skills in enabling learners to navigate e-learning platforms effectively. For instance, Chigbundu and Oluwabiyi (2023) argue that the ability to use e-learning facilities with ease depends largely on an individual's digital skills. Similarly, Olatoye and Oyewumi (2025) conceptualize digital literacy as encompassing technical proficiency, cognitive ability, and socio-emotional capacities necessary for safe and ethical participation in digital environments. These perspectives underscore the role of digital skills as a prerequisite for engaging with e-learning systems. Conversely, other studies suggest that while digital skills are essential, they may not directly translate into improved learning outcomes without adequate technological support. Vaszkun and Szakacs (2025) found that digital literacy does not always have a direct effect on e-learning effectiveness; rather, confidence derived from higher digital literacy levels influences outcomes. This nuanced view resonates with the present finding that digital skills, though significant, are slightly less influential than access to innovative technologies.

The marginally greater influence of access to innovative technologies observed in this study corroborates the position of Kryukov and Gorin (2024), who assert that access to digital technologies in universities is the main factor accelerating innovative changes in education. Similarly, Wagwu and Okoro (2025) argue that innovative technologies transform learning experiences by promoting interactivity, creativity, and learner autonomy. These technologies—ranging from MOOCs and learning management systems to AI-powered adaptive learning tools—enable immersive and personalized learning experiences that traditional methods cannot offer (Obim & Izuakolam, 2025; Kouser & Majid, 2021). Empirical evidence further supports this assertion. Adelowo et al. (2023) and Oyebowale et al. (2024) report that despite infrastructural challenges, access to innovative technologies such as MOOCs significantly enhances academic performance among Nigerian distance learners. This suggests that technological access not only facilitates participation but also enriches the quality of learning through diverse and interactive platforms. The Nigerian context presents unique challenges that amplify the importance of technological access. Studies indicate persistent disparities in infrastructure and resource availability between public and private institutions (Ilori et al., 2023; Adelowo et al., 2023). While private institutions often provide better access to devices and stable internet connectivity, public institutions struggle with inadequate infrastructure, thereby limiting the effectiveness of e-learning despite students' digital proficiency. This structural limitation explains why access to innovative technologies emerges as a slightly stronger determinant in this study. The interplay between digital skills and technological access tends to be more balanced due to advanced infrastructure and widespread connectivity. For example, Wolniak and Stecula (2024) highlight that in Polish higher education, both digital competence and resource availability significantly influence e-learning quality. However, in resource-constrained environments like Nigeria, technological access becomes a critical bottleneck, overshadowing the role of digital skills.

Conclusion

This study establishes that digital skills and access to innovative technologies are significant determinants of effective e-learning among distance learning students in polytechnics in Kwara State, Nigeria. Evidence from the correlation and regression analyses shows that both variables have strong positive relationships with e-learning effectiveness, with access to innovative technologies exerting a slightly stronger influence. This indicates that while students' ability to navigate digital tools is essential, their learning experiences are even more profoundly shaped by the availability and functionality of modern technological resources. Furthermore, the joint contribution of digital skills and access to innovative technologies accounts for a substantial proportion of the variance in effective e-learning, reflecting their combined importance in enhancing students' engagement and learning outcomes. These findings align with existing literature emphasizing that digital competencies and technological infrastructure must function together to support meaningful online learning. The results underscore that distance learners rely heavily on both personal competence and institutional support to thrive in digital learning environments. Overall, the study highlights the critical need for polytechnics to invest in strengthening students' digital competencies while simultaneously improving access to reliable, innovative technologies. Doing so will not only enhance the quality of e-learning delivery but also position students to succeed in an increasingly digital academic landscape.

Recommendations

Based on the findings, this study recommends the following:

1. Polytechnic management should adequately fund their ICT and distance learning centers. This will enhance the quality of the technological infrastructure available for e-learning by the students.

2. Polytechnic management should collaborate with relevant agencies and bodies for organising digital skills training for their students. This will help in equipping the students with the advanced digital skills required for a productive e-learning experience.
3. Polytechnic management should explore adopting traditional e-learning platforms such as Moodle and Easy Class for e-learning. This will enrich the students' e-learning experience beyond receiving lectures, which are offered by Zoom and Google Meet.
4. Polytechnic management should partner with digital e-learning platforms to organise sensitisation programmes for students. This will deepen the students' awareness of digital platforms they can use for their e-learning.
5. Polytechnic management should invest in cutting-edge technologies such as simulation and interactive 3D environments that will make e-learning interesting and attractive to students.
6. Polytechnic management should provide strong and reliable Internet services within their campuses. This can be done by partnering with network service providers.

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