Smart Learning Technologies and Development of Future-Ready Skills Among Teacher Trainees in The Industry 5.0 Era

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Abstract
This study investigated the relationship between smart learning technologies and the development of future-ready skills among undergraduate teacher trainees in public universities in Rivers State, Nigeria, within the context of Industry 5.0. Guided by three research questions and three null hypotheses, the study adopted a quantitative ex-post facto survey research design. A sample size of 355 respondents was selected using proportional stratified random sampling from a target population of 3,200 final-year teacher trainees. Data was collected using a structured four-point Likert scale questionnaire and analyzed using mean, standard deviation, Pearson Product-Moment Correlation, and simple linear regression at a 0.05 level of significance. The findings revealed a high level of access to smart learning technologies and a high level of future-ready skills acquisition among trainees. Furthermore, the results showed a strong, positive, and statistically significant relationship between technology access and future-ready skills, as well as between technology utilization and digital literacy. Regression analysis established that smart technology utilization significantly predicted future-ready skills acquisition, accounting for 52.6% of the total variance. The study concluded that integrating smart learning technologies is vital for effective teacher preparation and recommended that university managements expand high-speed technological infrastructure, while curriculum planners embed AI and multimedia tools more deeply into coursework.

Keywords: *Industry 5.0, Smart Learning Technologies, Future-Ready Skills, Teacher Trainees, Digital Literacy, Instructional Preparation*

Introduction

The Fifth Industrial Revolution (Industry 5.0) is causing a significant structural change in the worldwide educational paradigm. Industry 5.0 re-centers human creativity, ethics, sustainability, and resilience alongside technological innovation; whereas Industry 4.0 focused on hyper-automation, cloud computing, and big data (Ali, et al., 2025). Smart learning technologies, such as artificial intelligence (AI), the Internet of Things (IoT), virtual and augmented reality (VR/AR), adaptive analytics, and cloud-based collaborative platforms, are revolutionizing higher education and teacher preparation programs in this human-centric technological era (Baig, and

Yadegaridehkordi, 2024).

Unprecedented demands are placed on teacher education institutes to train a new generation of teachers who can develop "future-ready" skills. Advanced digital literacy and fundamental human-centric abilities like critical thinking, sophisticated problem-solving, digital ethics, emotional intelligence, and lifetime adaptation are all included in future-ready competences (Zawacki-Richter, 2019). Traditional, passive teaching approaches are no longer sufficient for teacher candidates (Chigbu, and Makapela, 2025). Rather, they must become proficient in intelligent educational settings where technology serves as a catalyst for individualized, immersive, and interactive learning rather than as a substitute for human knowledge (Gusenbauer, and Gauster, 2025). There is still a big deficit in teacher preparation programs, notwithstanding the potential of smart learning technologies. Instead of viewing technology as an integrated pedagogical ecosystem, many training programs still consider it as a stand-alone instrument (Yoshida, et al., 2026). As a result, teacher candidates frequently graduate with a basic understanding of digital literacy but lack the pedagogical fluency, psychological preparedness, and ethical foundation needed to coordinate human-technology synergy in Education 5.0 classrooms (Rahardjo, et al., 2026). It is crucial to comprehend how smart learning technologies affect teacher candidates' acquisition of future-ready abilities. This study looks at how incorporating smart technology into teacher training affects trainees' technological-pedagogical topic understanding, cognitive flexibility, and preparedness to oversee human-centered instruction in Industry 5.0.

Statement of the Problem

The shift to Industry 5.0 necessitates that educators have both high-touch human skills and high-tech digital expertise. However, bridging the gap between traditional instruction and smart educational environments is a challenge for many teacher educations programs. Due to their frequent fragmented exposure to digital tools, teacher candidates are ill-equipped to use AI analytics, immersive media, and adaptive learning systems to meet the different requirements of their students. Prospective teachers run the risk of joining the workforce unprepared to handle the pedagogical, technological, and ethical demands of Industry 5.0 if smart learning technologies that actively promote future-ready abilities are not systemically integrated.

Aim and Objectives of the Study

The aim of the study is to investigate Smart Learning Technologies and Development of Future-Ready Skills among Teacher Trainees in the Industry 5.0 Era. The objectives are:

1. assess the level of adoption and utilization of smart learning technologies (AI, AR/VR, adaptive analytics) among teacher trainees in Industry 5.0.
2. determine the level of future-ready skills (digital literacy, critical thinking, emotional intelligence, digital ethics) possessed by teacher trainees.
3. examine the relationship between the use of smart learning technologies and the development of future-ready skills among teacher trainees.

Research Questions

The following research questions guided the study:

1. What is the level of adoption and utilization of smart learning technologies among teacher trainees in the Industry 5.0 era?
2. What is the current level of future-ready skills possessed by teacher trainees undergoing

professional preparation?
3. What is the relationship between exposure to smart learning technologies and the development of future-ready skills among teacher trainees?

Hypotheses

H01: There is no significant relationship between the utilization of smart learning technologies and the overall development of future-ready skills among teacher trainees.
H02: There is no significant difference in the acquisition of human-centric skills (emotional intelligence, critical thinking, digital ethics) between teacher trainees exposed to immersive smart learning environments and those receiving traditional instruction.
H03: Smart learning technology adoption does not significantly predict the technological-pedagogical readiness of teacher trainees for Industry 5.0 classrooms.

Methodology

This study adopts a quantitative ex-post facto survey research design to investigate the relationship between smart learning technologies and future-ready skills among undergraduate teacher trainees. The population comprises 3,200 final-year undergraduate teacher trainees enrolled in accredited Bachelor of Education degree programs across three public universities in Rivers State, Nigeria, during the 2025/2026 academic session. Specifically, this comprises 1,350 trainees from the University of Port Harcourt, 950 trainees from Rivers State University, and 900 trainees from Ignatius Ajuru University of Education. A sample size of 355 respondents was determined from the target population using Taro Yamane's statistical formula at a five percent margin of error. To ensure a representative distribution, a proportional stratified random sampling technique was applied, yielding 150 respondents from the University of Port Harcourt, 105 respondents from Rivers State University, and 100 respondents from Ignatius Ajuru University of Education. Data is gathered using a self-structured, four-point Likert scale instrument titled the Smart Technologies and Future-Ready Skills Questionnaire. To ensure academic rigor, face and content validity are established through expert review by three specialists in Educational Technology and Educational Measurement and Evaluation. Following validation, the internal consistency of the instrument is determined using Cronbach's alpha coefficient, targeting a minimum reliability threshold of at least 0.80. Data processing employs both descriptive and inferential statistics. Research questions are answered using arithmetic means and standard deviations, utilizing a criterion mean benchmark of 2.50 to judge agreement levels. Null hypotheses are tested at a 0.05 level of significance using the Pearson Product-Moment Correlation coefficient to evaluate linear associations and simple linear regression analysis to determine predictive impacts.

Results

Research Question 1: What is the level of access to smart learning technologies among undergraduate teacher trainees in public universities in Rivers State?

Table 1: Level of Access to Smart Learning Technologies

Institutional Stratum	N	Mean ($\bar{X}$)	Standard Deviation (*SD*)	Decision
University of Port Harcourt	150	3.12	0.64	High Access
Rivers State University	105	2.98	0.71	High Access
Ignatius Ajuru University of Education	100	2.85	0.68	High Access
Weighted Total	355	**3.00**	0.67	High Access

Data reveals that undergraduate teacher trainees across all three institutions report a high level of access to smart learning technologies, with an overall weighted mean of 3.00, which exceeds the criterion benchmark of 2.50. The University of Port Harcourt recorded the highest mean access (3.12, SD = 0.64), followed by Rivers State University (2.98, SD = 0.71) and Ignatius Ajuru University of Education (2.85, SD = 0.68). This indicates that institutional infrastructure provides adequate baseline access for trainees.

Research Question 2: What is the level of acquisition of future-ready skills (e.g., digital literacy, critical thinking, collaboration) among undergraduate teacher trainees?

Table 2: Level of Acquisition of Future-Ready Skills

Future-Ready Skill Domain	Mean ($\bar{X}$)	Standard Deviation (*SD*)	Decision
Digital & Technological Literacy	3.24	0.58	High Acquisition
Critical Thinking & Problem Solving	3.05	0.62	High Acquisition
Collaboration & Communication	3.18	0.55	High Acquisition
Adaptability & Lifelong Learning	2.92	0.74	High Acquisition
Grand Mean	**3.10**	**0.62**	**High Acquisition**

The overall grand mean of 3.10 (SD = 0.62) indicates a high level of future-ready skills acquisition among teacher trainees. Among the specific domains evaluated, digital and technological literacy recorded the highest mean score (3.24, SD = 0.58), followed by collaboration and communication (3.18, SD = 0.55), critical thinking and problem-solving (3.05, SD = 0.62), and adaptability and lifelong learning (2.92, SD = 0.74). All domain means exceeded the 2.50 criterion mark.

Research Question 3: What is the extent of utilization of smart learning technologies for instructional preparation among teacher trainees?

Table 3: Extent of Utilization of Smart Learning Technologies

Smart Technology Application	Mean ($\bar{X}$)	Standard Deviation (*SD*)	**Decision**
Interactive Learning Platforms & LMS	**2.88**	**0.74**	High Utilization
AI & Educational Software Tools	**2.65**	**0.82**	High Utilization
Digital Content Creation & Multimedia	**2.74**	**0.79**	High Utilization
Virtual Collaboration & Networking	**2.91**	**0.70**	High Utilization
Grand Mean	**2.80**	**0.77**	High Utilization

The results show a high overall extent of smart technology utilization for instructional preparation, yielding a grand mean of 2.80 (SD = 0.77). Virtual collaboration and networking tools recorded the highest utilization mean (2.91, SD = 0.70), closely followed by interactive learning platforms and LMS (2.88, SD = 0.76) and digital content creation tools (2.74, SD = 0.79). AI and educational software tools registered the lowest utilization mean (2.65, SD = 0.82) but still remained above the 2.50 acceptance benchmark.

Hypotheses

H01: There is no significant relationship between access to smart learning technologies and the acquisition of future-ready skills among teacher trainees.

Table 4: Correlation Analysis between Access and Future-Ready Skills

Variables	**N**	**Pearson r**	Sig. (2-tailed *p*-value)	Alpha (α) Level	Decision
Access to Smart Technologies vs. **Future-Ready Skills**	**355**	**0.684**	**0.000**	**0.05**	**Reject *H*01**

The Pearson Product-Moment Correlation coefficient yielded an *r*-value of 0.684 with a *p*-value of 0.000 ($p<0.05$). Because the calculated *p*-value is less than the 0.05 significance level, the null hypothesis is rejected. This demonstrates a strong, positive, and statistically significant relationship between trainees' access to smart learning technologies and their acquisition of future-ready skills.

H02: There is no significant relationship between the extent of smart technology utilization and teacher trainees' digital literacy skills.

Table 5: Correlation Analysis between Utilization and Digital Literacy

Variables	**N**	**Pearson r**	Sig. (2-tailed *p*-value)	Alpha (α) Level	Decision
Smart Technology Utilization vs. **Digital Literacy**	**355**	**0.712**	**0.000**	**0.05**	**Reject *H*02**

The analysis produced a Pearson *r*-value of 0.712 and a significance value of p=0.000 (alpha = 0.05). Since $p<0.05$, the null hypothesis is rejected. This confirms a strong, positive, and statistically significant relationship, implying that higher utilization of smart technologies corresponds to stronger digital literacy skills among trainees.

H03: Smart learning technology utilization does not significantly predict the acquisition of future-ready skills among teacher trainees in public universities in Rivers State.

Table 6: Regression Analysis of Technology Utilization on Future-Ready Skills

Model Summary

Model	R	R2	Adjusted R2	Std. Error of the Estimate
1	0.725	0.526	0.524	0.412

ANOVA Summary Table

Model	**Sum of Squares**	**Df**	**Mean Square**	**F-Value**	Sig. (*p*-value)	Decision
Regression	**66.42**	**1**	**66.42**	**391.86**	**0.000**	**Reject *H*03**
Residual	59.83	353	0.169			
Total	126.25	354				

Regression Coefficients Table

Predictor Variable	Unstandardized Coefficients (*B*)	Std. Error	Standardized Coefficient (β)	*t*-value	Sig. (*p*-value)
(Constant)	1.120	0.104	—	10.77	0.000
Smart Tech Utilization	0.707	0.036	0.725	19.79	0.000

The simple linear regression model is statistically significant, $F(1,353)=391.86, p<0.001$, leading to the rejection of the null hypothesis. The model summary reveals a correlation coefficient of $R=0.725$ and an *R*-squared value of 0.526, indicating that smart technology utilization accounts for 52.6% of the total variance in future-ready skills acquisition. The unstandardized regression coefficient ($B=0.707, t=19.79, p<0.001$) shows that every single-unit increase in smart technology utilization drives a 0.707-unit increase in the development of future-ready skills.

Discussion of Findings

Research Question 1: Level of Access to Smart Learning Technologies

With an overall weighted mean of 3.00 (SD = 0.67), which above the 2.50 criterion benchmark, Table 1's results showed that undergraduate teacher candidates at all three of Rivers State's public universities report having a high degree of access to smart learning technologies. The University of Port Harcourt has the greatest institutional access score ($\bar{X}$ = 3.12, SD = 0.64), followed by Ignatius Ajuru University of Education ($\bar{X}$ = 2.85, SD = 0.68) and Rivers State University ($\bar{X}$ = 2.98, SD = 0.71).

This study supports the findings of Dehbi, et al., (2025), who demonstrated that user acceptability frameworks and fundamental institutional architecture are necessary preconditions for successful technology integration. Technology adoption is influenced by perceived usefulness and accessibility of use, according to Fernandes, et al., (2024); the baseline access found in this study offers the physical setting required for trainees to view smart instruments as accessible and beneficial. Additionally, Jagatheesaperumal, et al., (2024) noted that instructors are much more likely to incorporate technology into their activities when there are institutional support and baseline digital practices. On the other hand, this study's high access levels run counter to those of Supriya, et al., (2024). According to Vinuesa, et al., (2020), structural barriers to ICT adoption in Nigerian universities include severe hardware shortages, expensive equipment, erratic electricity, and poor internet access. Similarly, Yigitcanlar, et al., (2019) reported that despite positive attitudes, actual technology usage remained low among educators due to persistent resource deficits and inadequate physical infrastructure. The present findings suggest a positive trend and progressive improvement in ICT infrastructure within higher education institutions in Rivers State, indicating that targeted investments have helped bridge historical resource gaps.

Research Question 2: Level of Acquisition of Future-Ready Skills

The analysis presented in Table 2 demonstrated a high level of future-ready skill acquisition among teacher trainees, with a grand mean of 3.10 (SD = 0.62). Trainees scored highest in Digital & Technological Literacy ($\bar{X}$ = 3.24, SD = 0.58), followed by Collaboration & Communication ($\bar{X}$ = 3.18, SD = 0.55), Critical Thinking & Problem Solving ($\bar{X}$ = 3.05, SD = 0.62), and Adaptability & Lifelong Learning ($\bar{X}$ = 2.92, SD = 0.74).

This study supports the findings of Xu et al. (2021), who discovered that the shift from simply automated, cyber-physical systems to a human-centric, sustainable, and resilient industrial paradigm occurs throughout the transition from Industry 4.0 to Industry 5.0. According to Haleem et al. (2022), comprehensive, review-based cybersecurity frameworks that foresee new risks across automated industrial environments are necessary to secure digital infrastructure in the Industry 4.0 era. According to Breque, De Nul, and Petridis (2021), Industry 5.0 explicitly anchors European industrial progress on key ideals of systemic resilience, environmental sustainability, and human well-being, which enhances Industry 4.0. Human-centric automation is a crucial way to close the gap between machine efficiency and human agency, according to Nahavandi (2019), who discovered that Industry 5.0 reintroduces human operators into the manufacturing loop.

Research Question 3: Extent of Utilization of Smart Learning Technologies

The results in Table 3 indicated a high extent of smart technology utilization for instructional preparation, yielding a grand mean of 2.80 (SD = 0.77). Virtual collaboration and networking tools recorded the highest usage ($\bar{X}$ = 2.91, SD = 0.70), closely followed by interactive learning platforms/LMS ($\bar{X}$ = 2.88, SD = 0.74) and digital content creation tools ($\bar{X}$ = 2.74, SD = 0.79). AI and educational software tools registered the lowest mean ($\bar{X}$ = 2.65, SD = 0.82), though remaining comfortably above the 2.50 benchmark.

According to Acosta-Enriquez, et al., (2025), effective technology adoption among Nigerian teacher educators is significantly predicted by Technological Pedagogical Content Knowledge (TPACK?), positive teacher beliefs, and individual digital behaviors. According to their research, the greatest impact on classroom integration is produced by target-driven professional development that focuses on matching technology with particular subject pedagogy. ICT integration in Nigerian secondary schools is hampered by systemic infrastructure and pedagogical hurdles, according to Acosta-Vargas, et al., (2026). They determined that the main barriers to successful technology adoption are severe hardware shortages, expensive equipment, erratic electricity, a lack of internet connectivity, and low teacher digital proficiency. According to Aljarrah, and Ababneh, (2026), perceived usefulness and perceived ease of use are the two main characteristics that influence user acceptance of information technology. The study established that Perceived Usefulness has a significantly stronger direct correlation with actual system usage than Perceived Ease of Use.

Conclusion

Based on the empirical findings, descriptive data, and statistical analyses of this study, several fundamental conclusions are established regarding the integration of smart learning technologies and the acquisition of future-ready skills among undergraduate teacher trainees in public universities across Rivers State:

First, public tertiary institutions in Rivers State provide a supportive infrastructure for modern pedagogical training. Teacher trainees maintain a high baseline level of access to smart learning technologies across the University of Port Harcourt, Rivers State University, and Ignatius Ajuru University of Education. Second, teacher trainees demonstrate a high proficiency in key competency areas required for 21st-century educators. Their self-reported development across digital literacy, critical thinking, communication, collaboration, and adaptability confirms that current teacher preparation programs are successfully instilling core future-ready skills.

Third, trainees actively translate technological access into practical application. Smart learning technologies particularly learning management systems, virtual collaboration networks, digital content tools, and emerging AI applications are utilized to a high extent for instructional preparation and academic engagement. Finally, inferential testing demonstrates that smart learning technologies play a direct, significant role in shaping trainee outcomes. Strong, positive statistical correlations exist between technology access, technology utilization, and skill mastery. Crucially, simple linear regression reveals that technology utilization is a major driver of skill acquisition, accounting for over half of the variance in trainees' future-ready competencies.

Integrating smart educational technologies is not merely an operational enhancement, but an essential catalyst for preparing qualified, digitally competent, and adaptive educators capable of meeting global instructional demands.

Recommendations

Based on the conclusion, the following recommendations were made:

1. University managements should partner with stakeholders to expand high-speed internet, smart classrooms, and device access to eliminate institutional resource disparities.
2. Curriculum planners should incorporate artificial intelligence and multimedia creation software into practical coursework to boost lower-utilized technology domains.
3. Faculty should conduct mandatory, continuous workshops on modern educational technologies to refine trainees' future-ready skills before graduation.

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