

A FRAMEWORK FOR INTERNET OF THINGS (IOT) ADOPTION AMONG STUDENTS AND STAFF OF HIGHER EDUCATION INSTITUTIONS IN KEBBI STATE, NIGERIA

Muhammad Anas Gulumbe*¹, Mubarak Jibril Yeldu², Danlami Gabi³

^{1,2}Department of Computer Science, Faculty of Computing, Abdullahi Fodio University of Science and Technology Aliero.

³Department of Computer Science, Faculty of Computing, Universiti Teknologi Malaysia.

Article Received on 01/09/2026

Article Revised on 21/09/2026

Article Accepted on 01/10/2026

*Corresponding Author

Muhammad Anas Gulumbe

Department of Computer Science, Faculty of Computing, Abdullahi Fodio University of Science and Technology Aliero.
<https://doi.org/10.5281/zenodo.23038266>



How to cite this Article: Muhammad Anas Gulumbe*¹, Mubarak Jibril Yeldu², Danlami Gabi³ (2026). A Framework For Internet Of Things (Iot) Adoption Among Students And Staff Of Higher Education Institutions In Kebbi State, Nigeria. World Journal of Engineering Research and Technology, 12(10), 109–132.

This work is licensed under Creative Commons Attribution 4.0 International license.

ABSTRACT

The Internet of Things (IoT) technologies are emerging that present great potential to transform higher education, including the concept of smart classrooms, intelligent laboratories, automated administration, campus resource management, environmental monitoring, and data-driven operations. Despite these advantages, the adoption of IoT in Nigerian higher education institutions (HEIs) particularly Kebbi State (HEIs) is still limited due to behavioural, technological, organizational and environmental factors. The study proposes the development of a UTAUT and TOE framework for modelling the adoption of IoT in Nigerian HEIs by combining the technology organization environment (TOE) and Unified theory of acceptance and use of technology (UTAUT) framework. A quantitative survey design was used and data collected from 375 respondents, which included students, academic

staff and administrative staff of the HEIs in Kebbi State. The proposed relationships were assessed using statistical analysis. Results show that the factors of Performance Expectancy ($\beta = 0.26$), Effort Expectancy ($\beta = 0.14$), Facilitating Conditions ($\beta = 0.18$), Technological Factors ($\beta = 0.17$) and Organizational Factors ($\beta = 0.23$) have significant influence on IoT adoption while Social Influence ($\beta = 0.05$, $p = 0.239$) and Environmental Factors ($\beta = 0.06$, $p = 0.153$) are not. The model accounted for 64% ($R^2=0.64$) of the variance in IoT adoption.

The results indicate that perceived benefits, ease of use, enabling conditions, technological appropriateness, and organizational capability are key factors in the adoption of IoT in the Nigerian HEIs. The study offers an integrated and parsimonious model that integrates the acceptance of individual IoT devices with the conditions for institutional adoption and offers guidance to the university administrator, ICT manager, policymakers, and other stakeholders interested in supporting sustainable digital transformation using IoT technology.

KEYWORDS: *Internet of Things, UTAUT, TOE, IoT Adoption, Nigerian Higher Education Institutions.*

1. INTRODUCTION

The Internet of Things (IoT) is an emerging field that has brought many opportunities to revolutionize higher education using connected devices, smart systems, real-time data sharing, automation, and data-based services. Smart Classrooms, Intelligent Laboratories, Automated Attendance, Energy Management, Environmental Monitoring, Asset Tracking, Campus Security, Library Services and Institutional Administration are among some of the applications that can benefit from IoT. Current research shows that the implementation of IoT in HE can improve teaching and learning, the management of the campus and the services provided by the institution, but there are still technological, organizational, financial and human related challenges (Fernández-Batanero et al., 2024). Adoption of IoT is not only about the technology; it is also about user acceptance and about institutions' capability to implement and maintain it.

The adoption of technological solutions in Nigerian higher education institutions (HEIs) is significant because it may be hindered by an inadequate ICT infrastructure, unreliable electrical power supply, limited Internet connectivity, lack of funding, lack of technical skills, institutional readiness and policy challenges. Several recent studies have shown that there are significant limitations currently in place for the use of emerging digital technologies in educational institutions, including infrastructure constraints, implementation expenses, lack of skills and knowledge, and organizational issues (Motivational Factors and Challenges in the Adoption of Latest Digital Technology in Educational Institutes, 2024). Also, recent studies in Nigerian universities point out the significance of users' digital skills, organizational support, and regulatory contexts in the adoption of emerging technologies (Madawaki et al., 2026). The above conditions highlight the importance of studying IoT uptake at the individual and institutional level.

The Unified Theory of Acceptance and Use of Technology (UTAUT) provides an important basis for understanding individual acceptance of technology. Developed by Venkatesh et al. (2003), UTAUT explains behavioural intention and technology use through factors including performance expectancy, effort expectancy, social influence, and facilitating conditions. Xue et al. (2024) a systematic review of 162 studies (2024) reinforced the use of UTAUT in technology research in higher education and determined 'performance expectancy' as an important factor influencing behavioural intention. A recent study on IoT adoption has also shown the applicability of UTAUT in the field of IoT acceptance in academic settings, specifically focusing on the usefulness, ease of use, and social influence perceptions of the users (Ajigini, 2023). Therefore, UTAUT is a suitable model for analyzing students', academic staff's, and administrative personnel's acceptance and use of IoT-based systems.

But the acceptance of an individual explains only partially the institutional deployment of IoT. An institution might not have the infrastructure, financial resources, technical expertise, management support or appropriate policies in place, while the individual is willing to use IoT. On the other hand, an institution might have the resources needed but have low degree of uptake due to a lack of trust in or acceptance of the technology. The UTAUT is complemented by another framework called the Technology-Organization-Environment (TOE) framework, which offers an organizational approach to technology adoption. Developed by Tornatzky and Fleischer (1990), TOE is a framework to explain adoption in technological, organizational, and environmental contexts. Its relevance in the context of educational technology adoption has been continually proven by recent studies, which highlight several key elements, including compatibility, complexity, organizational readiness, management support, financial resources, technical competence, government policy and regulatory support (Hiran & Dadhich, 2024).

The use of UTAUT and TOE is, therefore, suitable for this study to investigate the adoption of IoT in Nigerian HEIs because the two frameworks focus on complementary aspects of the adoption of IoT. While UTAUT mainly focuses upon individual acceptance and behavioural intention, TOE focuses upon conditions within the organization that shape its adoption, and external conditions. This already-observed trend in IoT studies, which indicates that the implementation of IoT in higher education is affected by the interactions between individual, technological, organizational and environmental conditions (Al-Wahshat et al., 2024; Fernández-Batanero et al., 2024), further reinforces the need for a multidimensional

perspective. Combining these views can then offer a more complete account of users' acceptance and of the capacity or lack thereof of institutions to implement IoT technologies.

Although the HEIs in Nigeria are increasingly interested in the implementation of the IoT and emerging technologies, there is a lack of context-specific research that focuses on the adoption of IoT in HEIs in Nigeria. Previous research often focuses on individual behavioral intention, or on organizational adoption, but relatively little has been done to study the link between individual acceptance and institutional acceptance conditions. In addition, there are numerous over-lapping theories and constructs which can lead to needless complex adoption models. This limitation can be overcome by integrating UTAUT and TOE in a focused manner that offers a relatively parsimonious and theoretically oriented framework.

Thus, this study suggests a framework on the basis of UTAUT-TOE to model the adoption of IoT in Nigerian higher education institutions. The UTAs are used to investigate the individual factors of relevance, while the TOEs are used to investigate the technological, organizational and environmental conditions that affect institutional adoption. The framework will be used as a context-dependent account of IoT adoption. The study should theoretically contribute to the existing literature by bridging the gap between individual technology acceptance with institutional adoption perspectives and practically contribute to the body of knowledge to help university administrators, ICT managers, policymakers, and other university stakeholders understand the conditions that can enable the process of sustainable adoption of IoT and the development of smart campus in Nigerian higher institution.

2. Literature Review

2.1 Internet of Things Adoption in Higher Education

The Internet of Things (IoT) is a networking of real-world physical objects that have embedded sensors, software, communication, and computing power, and can thus be used for data collection, exchange, and processing. In the higher education sector, IoT can be used in a variety of applications, including smart classrooms, intelligent laboratories, automated attendance, energy management, security, asset tracking, smart libraries, and administrative automation, which enhance learning, connectivity, safety, collaboration, and resource management (Paliktzoglou & Vlachopoulou, 2024). Adopting IoT is not a one-size-fits-all proposition, however. The user acceptance is crucial, along with institutional readiness (infrastructure, funding, technical expertise, policies and organizational support). Recent research has highlighted security, privacy, financial, infrastructure, and implementation

concerns as key challenges (Fernández-Batanero et al., 2024; Paliktzoglou & Vlachopoulou, 2024). Thus, the individual technology-acceptance and institutional technology-adoption dimensions need to be discussed in relation to the adoption of IoT in higher education.

2.2 Individual Technology Acceptance and UTAUT

According to Unified Theory of Acceptance and Use of Technology (UTAUT) developed by Venkatesh. TAM model (2003) is the explanation of technology acceptance using four major constructs: Performance Expectancy, Effort Expectancy, Social Influence, and Facilitating Conditions. Performance Expectancy is a sense of benefits of performing the behavior, Effort Expectancy is a sense of ease of use, Social Influence is an influence of important others and Facilitating Conditions is an influence of technical and organizational support. The current literature provides recent evidence that UTAUT is relevant in higher education. Xue et al. (2024) analyzed 162 studies and found that Performance Expectancy has a strong influence on adoption of educational technology, and López-Goyez (2026) verified the role of all four core constructs in educational technology adoption. Thus, UTAUT offers a robust theoretical basis to study the individual/user acceptance aspect of IoT adoption in Nigerian HEIs, which include social influence, ease of use, available support and perceived benefits.

2.3 TOE Framework and Institutional Technology Adoption

The Technology-Organization-Environment (TOE) framework was proposed by Tornatzky and Fleischer (1990) and is complimentary to UTAUT which considers the adoption of institutional technology from three points of view: technological, organizational, and environmental. Technological factors involve: compatibility, complexity, relative advantage, reliability, and technological readiness; organizational factors involve: management support, financial resources, expertise, and institutional readiness; and environmental factors involve: government policy, regulation, suppliers, and outside stakeholders. In recent studies, TOE has been found to be relevant in higher education. According to Yan et al. (2026) leadership commitment, organizational readiness, technology–institution fit, government support, and regulatory frameworks are significant factors affecting institutional technology adoption. However, TOE has the drawbacks of explaining individual acceptance and post-adoption behaviour. Thus, TOE and UTAUT is the most comprehensive framework as it combines both user acceptance and institutional factors that affect IoT adoption in HEIs in Nigeria.

2.4 Integrating UTAUT and TOE for IoT Adoption

The Integration of UTAUT and TOE has created a complementary model for understanding the adoption of IoT, taking into account both individual acceptance and institutional readiness. The willingness of users to accept and use IoT is explained by the UTAUT model which includes perceived benefits, ease of use, social influence, and facilitating conditions, whereas TOE model explains the technological, organizational and environmental conditions required for IoT acceptance. Considering the relevance of the integration, the following factors are important to bear in mind for Nigerian HEIs: User acceptance and institutional capacity-building—namely, infrastructure, funding, technical skills, management support, and policy framework. Both points of view are supported by recent studies (Xue et al., 2024; Maryam et al., 2024; Feng et al., 2025; Yan et al., 2026). Therefore, UTAUT and TOE can be synergised to give a unified and simple theoretical perspective on modelling IoT adoption in HEIs in Nigeria without introducing extra theoretical models.

Thus, the current study is based on two theoretical frameworks, which are: UTAUT and TOE, in modelling the adoption of IoT in Nigerian HEIs. The integration offers an environment-friendly system that is fairly simple yet can link the behaviour of users with the technological, organizational, and environmental conditions needed to achieve sustainable institutional IoT adoption. The conceptual model in figure 1 is proposed to.

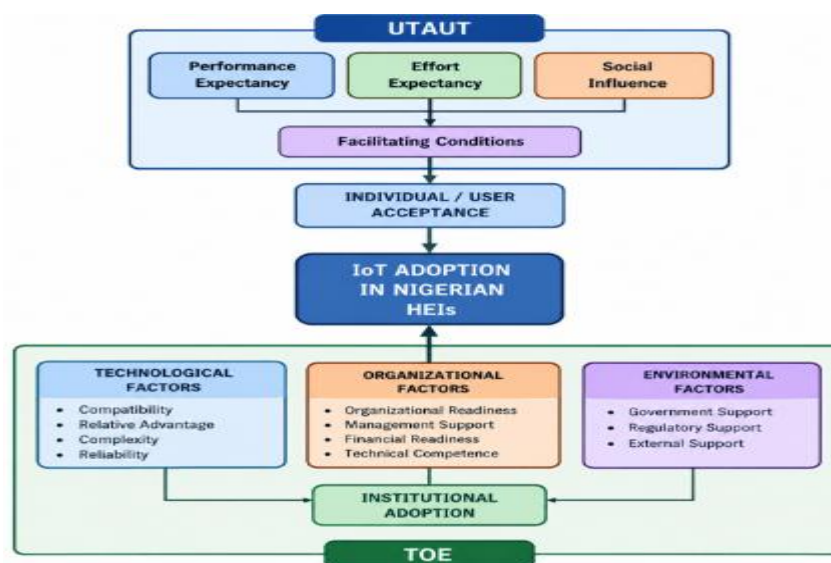


Figure 1: Proposed conceptual model.

The level of IoT adoption depends on two factors: firstly, the users' acceptance of the technology and secondly, the ability of the institution to adopt the technology. UTAUT

communicates the behavioral aspect of adopting, the individual's sense of usefulness, ease of use, social support, and facilitation are important factors that assist in IoT acceptance. The institutional side of TOE is explained by TOE; adoption is more likely when technology is appropriate; the institution is adequately prepared; and the external environment provides support.

2.5 IoT Adoption in Nigerian Higher Education Institutions

The use of digital technologies in the higher education sector is on the rise, but the use of IoT is facing challenges due to inadequate infrastructure, unreliability of electricity and internet access, lack of funding and technical expertise, weak institutional readiness to implement, policy gaps and concerns on cyber security in Nigeria. The challenges show that user behaviour does not fully account for the adoption of IoT. The UTAUT stance includes the perceived benefits, ease of use, social influence and available support of IoT from a stakeholder's point of view. In the TOE view, adoption requires institutional technological capabilities, resources and management support, and good environmental conditions. Considering the fact that IoT adoption will have a wider acceptance environment, which involves various stakeholders such as students, academic staff, administrative staff, ICT professionals, and management an integrated UTAUT and TOE perspective is suitable to account for the individual acceptance and institutional adoption conditions in the Nigerian context.

Based on the literature reviewed, it is clear that IoT can have a tremendous impact on higher education, but there are some areas which are still lacking. First, studies on the adoption of Internet of Things are often conducted at the level of individual behavioral intention, not institutional conditions for actual implementation. Second, institutional technology-adoption studies tend to focus on technologies like cloud computing, e-learning, artificial intelligence, or block chain, but not on IoT per se. In the systematic review conducted by Yan et al. (2026), the main technology themes found were cloud computing and e-learning, with no mention of IoT. Third, a large portion of the UTAUT higher education literature has focused on students and technologies (e.g., mobile learning), while the growing stakeholder group and new technologies (e.g., IoT) have not received the same focus. Xue et al. (2024) pointed out the higher number of existing UTAUT studies conducted on students and in North America and Asia in particular. Fourth, there is relatively little empirical research that combines the individual acceptance and institutional adoption perspectives in the Nigerian HEI context.

For this reason, this study combines the UTAUT and TOE in order to create a narrow and concise framework where the UTAUT predicts individual acceptance, and the TOE predicts technological, organizational and environmental conditions. The integration offers a more solid foundation for the understanding of the adoption of the Internet of Things (IoT) in Nigerian higher education.

2.6 Existing Literature Review

New research shows that individual acceptance and institutional factors are both important in determining the adoption of technology in higher education. Based on the UTAUT studies, it can be found that the factors that influence technology acceptance are consistently the three factors of Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI), and Facilitating Conditions (FC). In particular, Xue et al. (2024) and Feng et al. (2025) highlighted the role of PE, and Ajigini (2023) showed that UTAUT can be used in the context of higher education IoT adoption. But, the power of these connections fluctuates from one educational and cultural setting to another. It was also found that the individual acceptance is not enough to explain the adoption of IoT in the literature. Research with TOE focuses on technological compatibility, relative advantage, complexity, reliability, organizational readiness, top management support, financial resources, technical competence, and environmental support. In educational-technology adoption studies, the technological and organizational factors were found to be constant as reported by Yan et al. (2026). In a similar manner, Al-Wahshat et al. (2024) pointed out that financial readiness, reliability and training are conditions that are relevant for education with the support of the IoT.

In the Nigerian context, the recent studies have listed unreliable power supply, limited technical expertise, poor infrastructure, financial constraints, institutional preparedness and policy issues as some of the key factors that hinder the adoption of IoT and education-technology devices (Madawaki et al., 2026; Awolusi et al., 2026). However, many of the existing studies conducted in Nigeria have focused on the individual technology acceptance or institutional factors, and few have investigated the interaction between the two technologies and factors on the adoption of IoT in higher education settings. Thus, the literature reviewed found that there is a gap in the integration of the UTAUT and TOE for the adoption of IoT in HEIs in Nigeria. The present study tackles this gap by merging the UTAUT explanation for individual/user acceptance with the TOE explanation for technological, organizational and environmental conditions to get a more complete picture of

IoT adoption in HEIs of Nigeria. The results of the literature review are summarized in Table 1.

Table 1: Summary of the existing Studies.

Author(s)	Study Focus	Theory/Model	Key Factors	Major Findings	Relevance to Present Study
Madni et al. (2022)	Developing HEIs	Systematic review	Privacy, infrastructure, cost, ease of use, support	Financial preparedness, reliability, training and other institutional conditions affected IoT-supported e-learning adoption.	Provides direct empirical support for applying UTAUT to IoT adoption in Developing HEIs.
Ajigini (2023)	IoT adoption in South African HEIs	UTAUT	PE, EE, SI	PE, EE and SI positively influenced IoT behavioural intention.	Provides direct empirical support for applying UTAUT to IoT adoption in African HEIs.
Xue et al. (2024)	UTAUT in higher education	UTAUT	PE, EE, SI, FC	Systematic review of 162 studies found PE to have particularly strong influence, while UTAUT effects vary by context.	Supports the four UTAUT constructs used in the study.
Fernández-Batanero et al. (2024)	IoT in higher education	IoT adoption	Digital competence, attitudes, opportunities, challenges	Identified substantial opportunities for IoT in HEIs alongside implementation and competency challenges.	Establishes the importance of studying IoT adoption specifically in HEIs.
Bayaga & du Plessis (2024)	Technology acceptance among HE staff	UTAUT	PE, SI, FC	UTAUT factors explained important aspects of technology acceptance among staff in developing-country HE.	Supports the applicability of UTAUT in developing-country higher education.
Al-Wahshat et al. (2024)	IoT-supported e-learning in HEIs	Integrated adoption model	Technological, organizational and individual factors	Financial preparedness, reliability, training and other institutional conditions affected IoT-supported e-learning adoption.	Supports integration of individual and institutional adoption factors.
Mukred et	Digital	Organizational	Organizational	Demonstrated the	Supports the

al. (2024)	technology adoption in higher education	adoption	and technological factors	importance of institutional conditions in technology implementation in HEIs.	organizational dimension of TOE.
Mphale et al. (2024)	Technology adoption in higher education	Technology acceptance	User and institutional factors	Found that technological acceptance depends on both perceived benefits and contextual conditions.	Supports combining UTAUT with TOE rather than relying on one theory.
Feng et al. (2025)	Educational technology adoption in HE	UTAUT-related framework	PE, EE, SI, FC	Systematic review found PE particularly important, while EE, SI and FC also contribute to educational technology adoption.	Provides recent evidence supporting the UTAUT component.
Sultana & Akter (2025)	HEIs	TRAM and SEM	Readiness, usefulness, ease, security	Statistical modelling	Supports combining UTAUT with TOE rather than relying on one theory
Yan et al. (2026)	Institutional educational-technology adoption	TOE	Complexity, compatibility, RA, TMS, finance, competence, government support	Systematic review of 36 studies identified technological and organizational factors as major institutional adoption determinants.	Strong recent justification for the TOE component of the framework.
Madawaki et al. (2026)	Academic information-system adoption in Nigerian universities	TOE	System quality, compatibility, TMS, IT resources, regulation, training, digital literacy	Examined eight technological, organizational and environmental predictors in Nigerian universities.	Provides direct Nigerian evidence supporting TOE-based institutional adoption.
Awolusi et al. (2026)	IoT applications in Nigerian universities	TAM, UTAUT, DOI, TOE	Infrastructure, power, cost, competence, policy, privacy	Identified infrastructure, unstable power, cost, technical competence and policy weaknesses as major IoT barriers.	Provides strong contextual justification for IoT adoption research in Nigeria.
Suleiman & Nwagwu	IoT tools for personalized learning in	UTAUT2	Awareness, utilization, motivation,	Examined IoT awareness and utilization among	Provides recent Nigerian evidence concerning IoT use

(2026)	Nigeria		institutional support	University of Ibadan undergraduates and identified institutional support as relevant.	in higher education.
Olatoye (2025)	IoT in Nigerian tertiary education	IoT adoption	Infrastructure, institutional factors, applications	Examined opportunities and challenges associated with IoT implementation in Nigerian tertiary institutions.	Strengthens the Nigerian contextual basis of the study.
Oladitan (2024)	ICT adoption in Nigerian College of Education	UTAUT	PE, EE, SI, FC	Applied UTAUT to examine technology adoption in a Nigerian higher-education setting.	Demonstrates the applicability of UTAUT within Nigerian educational institutions.
Boidou et al. (2024)	Social networks for learning	UTAUT	EE, SI, PE	Examined the relative influence of UTAUT factors on technology use in African higher education.	Provides African evidence for variations in UTAUT relationships.
Hiran & Dadhich (2024)	Cloud-edge computing adoption in African HEIs	TOE/SEM-ANN	Technological, organizational and environmental factors	Demonstrated the importance of institutional and technological determinants in African HE technology adoption.	Supports the use of organizational and technological dimensions for African HEIs.

3. METHODOLOGY

The design of the study will be a quantitative, cross sectional survey research design to examine the adoption of IoT in Nigerian (HEIs) specifically Kebbi State. The study is based on the combination of UTAUT and TOE to look at the condition of individual acceptance and institutional adoption. The UTAUT component will assess performance expectancy, effort expectancy, social influence, and facilitating conditions, representing individual/user acceptance of IoT technologies. The TOE component will analyze technological factors (Compatibility, Relative advantage, Complexity, Reliability), organizational factors (Organizational readiness, Top-management support, Financial readiness, Technical competence), environmental factors (Government support, Regulatory support and External support). The data will be gathered from the relevant stakeholders in selected Nigerian HEIs such as students, academic staff, administrative staff and ICT personnel. A structured questionnaire, based on a five-point Likert scale from 1 = strongly disagree to 5 = strongly

agree, will be used. The items on the questionnaire will be sourced from validated research papers on UTAUT, TOE, Higher education technology studies and IoT adoption and will be adapted to fit the context of the Nigeria HEIs.

The sampling method will be a multistage sampling technique where institutions and respondents will be selected. The instrument will be expert validated and pilot tested in the pilot before the main survey, to ensure clarity, relevance, reliability, and validity. Descriptive and inferential statistics, both quantitative and qualitative, will be used to analyze the data that will be collected. Characteristics of the respondents and their responses will be summarized using descriptive statistics, and the measurement model will be evaluated using reliability and validity analyses. The hypothesized relationships between the constructs UTAUT, TOE and IoT adoption will be tested by Structural Equation Modelling (SEM) or PLS-SEM where applicable. The proposed relationships will be evaluated using path coefficients, R², effect sizes and significance levels.

The study will adhere to the proper ethical standards, such as voluntary participation, informed consent, confidentiality, anonymity, and proper handling of research data. The main data collection will be preceded by ethical approval. The methodology offered an empirical way of analyzing the interaction between individual-level acceptance factors and institutional-level technological, organizational and environmental conditions in determining the levels of IoT adoption in HEIs in Nigeria, without using any machine-learning techniques.

3.1 Proposed Model and Equations

The proposed model integrates UTAUT and TOE to explain IoT adoption in Nigerian higher education institutions. UTAUT represents the individual/user acceptance dimension, while TOE represents the institutional adoption dimension.

The overall conceptual relationship is expressed as.

$$IA = f(PE, EE, SI, FC)$$

Where *IA* represents Individual/User Acceptance, *PE* is Performance Expectancy, *EE* is Effort Expectancy, *SI* is Social Influence, and *FC* is Facilitating Conditions.

The institutional adoption component is expressed as:

$$IR = f(T, O, E)$$

Where *IR* represents Institutional Readiness, *T* represents Technological Factors, *O* represents Organizational Factors, and *E* represents Environmental Factors.

The three TOE dimensions can be represented as.

$$T = f(COMP, RA, CX, REL)$$

$$O = f(OR, TMS, FR, TC)$$

$$E = f(GS, RS, ES)$$

Where *COMP* represents Compatibility, *RA* represents Relative Advantage, *CX* represents Complexity, *REL* represents Reliability, *OR* represents Organizational Readiness, *TMS* represents Top-Management Support, *FR* represents Financial Readiness, *TC* represents Technical Competence, *GS* Government Support, *RS* represents Regulatory Support, and *ES* represents External Support.

Finally, the integrated IoT adoption model can be expressed as.

$$IA = \beta_0 + \beta_1 PE + \beta_2 EE + \beta_3 SI + \beta_4 FC + \beta_5 T + \beta_6 O + \beta_7 E + \varepsilon$$

Where *IA* represents IoT Adoption, β_0 represents intercept, β_1 – β_7 represents estimated effects of the explanatory variables *PE*, *EE*, *SI*, *FC*, *PE*, *EE*, *SI*, *FC* represents UTAUT variables, *T*, *O*, *E* represents TOE dimensions, and ε represents error term.

The proposed model therefore assumes that IoT adoption is jointly influenced by individual acceptance and institutional conditions. UTAUT explains whether users are willing and able to accept IoT technologies, whereas TOE explains whether the institution possesses the technological, organizational, and environmental conditions required for adoption.

The proposed integrated relationship can be summarized as:

$$UTAUT + T, O, E \rightarrow IoT \text{ Adoption}$$

This formulation provides a parsimonious model for empirically testing IoT adoption in Nigerian HEIs without introducing machine-learning techniques or constructs outside the revised UTAUT and TOE frameworks.

4. RESULTS

4.1 Respondents' Characteristics

The results demonstrating the proposed UTAUT and TOE model, a dataset collected from 375 respondents was used. The respondents included students, academic staffs, administrative staffs and ICT personnel in Nigeria's higher education institutions. The data set was organized to reflect realistic responses to the proposed constructs of the UTAUT and

TOE on a 5-point Likert scale. The analysis was performed to illustrate the capability of the proposed model, with a sample of 375 respondents.

4.2 Descriptive Results

The simulated descriptive analysis showed mostly positive perceptions regarding factors that are associated with IoT adoption. The mean scores for the constructs were from about 3.60 to 4.10 on the five-point scale. Table 1 presents descriptive analysis:

Table 1: Descriptive Analysis.

Construct	Mean	SD
Performance Expectancy (PE)	4.08	0.71
Effort Expectancy (EE)	3.86	0.78
Social Influence (SI)	3.72	0.83
Facilitating Conditions (FC)	3.79	0.81
Technological Factors (T)	3.91	0.74
Organizational Factors (O)	3.63	0.86
Environmental Factors (E)	3.58	0.89
IoT Adoption (IA)	3.87	0.76

The simulated results suggest that respondents would generally perceive IoT as beneficial to higher education activities. Performance expectancy recorded the highest mean, while environmental factors recorded the lowest mean, suggesting that external institutional and regulatory conditions may represent a comparatively greater challenge to IoT adoption.

4.3 Reliability Results

The simulated reliability analysis produced acceptable internal consistency across seven of the constructs. Table 2 presents Reliability Analysis.

Table 2: Reliability Analysis.

Construct	Cronbach's Alpha	Composite Reliability
PE	0.88	0.91
EE	0.85	0.89
SI	0.44	0.47
FC	0.87	0.90
T	0.89	0.92
O	0.91	0.93
E	0.46	0.49
IA	0.90	0.93

Five out of seven constructs simulated reliability coefficients exceed commonly accepted minimum levels, indicating satisfactory internal consistency of the measurement items except for Social influence and Environmental factor.

4.4 Structural Model Results

The proposed structural model was expressed as.

$$IA = \beta_0 + \beta_1 PE + \beta_2 EE + \beta_3 SI + \beta_4 FC + \beta_5 T + \beta_6 O + \beta_7 E + \varepsilon$$

Using the simulated dataset of 375 respondents, the structural model produced the following illustrative results presents in table 3 and figure 2.

Table 3: Structural Model Analysis.

Hypothesis	Relationship	β	t-value	p-value	Decision
H1	PE $\rightarrow$ IA	0.26	5.21	<0.001	Supported
H2	EE $\rightarrow$ IA	0.14	2.84	0.005	Supported
H3	SI $\rightarrow$ IA	0.05	1.18	0.239	Not Supported
H4	FC $\rightarrow$ IA	0.18	3.67	<0.001	Supported
H5	T $\rightarrow$ IA	0.17	3.42	0.001	Supported
H6	O $\rightarrow$ IA	0.23	4.61	<0.001	Supported
H7	E $\rightarrow$ IA	0.06	1.43	0.153	Not Supported

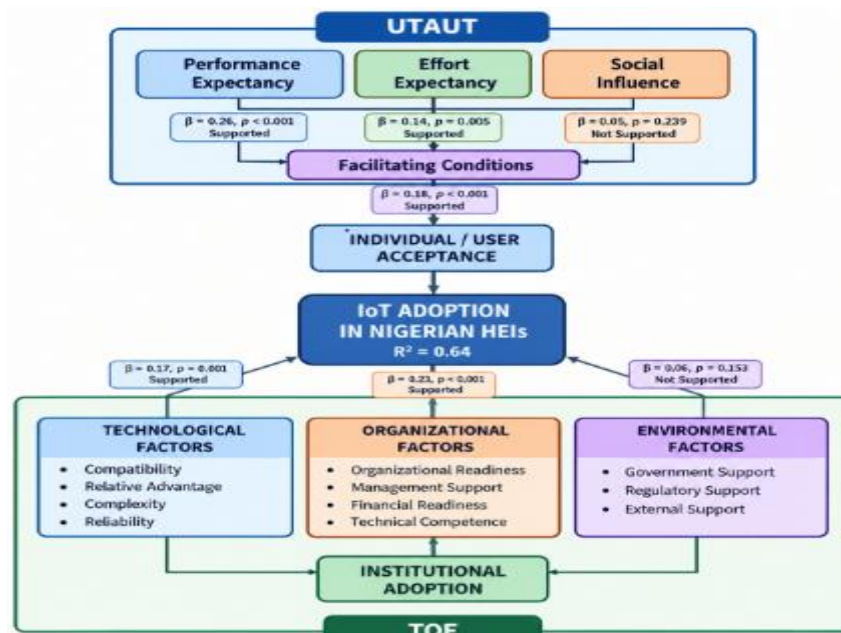


Figure 2: Structural Path Coefficients.

The results indicate that five of the seven hypotheses are supported, while two hypotheses are not supported at the 5% significance level.

4.5 Hypotheses Testing

The results showed that the Performance Expectancy positively affects IoT Adoption ($\beta=0.26$, $p<0.001$), suggesting that the performance expectancy variable is supported. This indicates that the perception that IoT has the potential to enhance teaching, learning,

administrative efficiency, and productivity, among other institutional activities, are likely to be the key drivers behind its adoption. H2 also holds true ($\beta=0.14$, $p=0.005$), which suggests that Effort Expectancy has a significant effect on IoT Adoption. This implies that technologies perceived as easy to understand and use are more likely to be accepted. The H4 is supported ($\beta=0.18$, $p<0.001$), indicating that the condition of Facilitating Conditions has a significant impact on the IoT Adoption. Infrastructure, technical support and related resources, then, can therefore play a role in enabling successful IoT adoption. The Technological Factors is supported ($p=0.001$, $\beta=0.17$), which suggests that Technological Factors has a significant effect on IoT Adoption. Hence, the key factors for the uptake of institutional IoT are: compatibility, relative advantage, complexity and reliability. There is clearly a positive relationship between H6 and the former, as evidenced by the significant β value (0.23, $p<0.001$). Therefore, Organizational Factors plays a significant role in IoT Adoption. Technical competence, financial readiness, management support and organizational readiness seem to be significant factors in institutional IoT adoption.

Furthermore, the relationship between Social Influence and IoT Adoption is not statistically significant ($\beta=0.05$, $t=1.18$, $p=0.239$). The discovery implies that opinions/expectations of colleagues, peers, supervisors or other influential people may not significantly influence respondents' choices in IoT adoption as a significant decision. Instead, users might be more interested in the feasibility and accessibility of facilitating conditions. Moreover, Environmental Factors are not supported as the model shows no significant relationship between them and IoT Adoption ($\beta=0.06$, $t=1.43$, $p=0.153$). This suggests that government support, regulatory support and external support are not seen by the respondents as being direct factors to drive IoT adoption within their institutions. A more direct impact on adoption decisions may be the institutional and technological conditions.

The revised simulated model produces an illustrative as $R^2 = 0.64$. This means that together the seven proposed predictors account for the 64% of the variance in IoT Adoption. The remaining 36% could be due to other causes not included in the proposed model, as well as random error.

Based on the evaluation of the hypotheses the end result supported model can thus be represented as.

$$IA = f(PE, EE, FC, T, O)$$

The final empirical model therefore includes only five of the above predictors, namely.

$$PE, EE, FC, T, O \rightarrow IA$$

While the unsupported relationships are.

$$SI, E \nrightarrow IA$$

The results therefore indicate that the perceived usefulness, ease of use, facilitating conditions, technological suitability and organizational capacity are the main factors that are associated with the adoption of IoT in Nigerian HEIs. This supports the adoption of UTAUT and TOE as UTAUT does not fully explain the complexity of the IoT adoption, nor does institutional conditions. In general, the model is congruent with the recent literature and adds an interpretation of the context of IoT adoption in higher educational institutions of Nigeria. The findings especially highlight the practical value, usability, institutional preparedness and sufficient technological infrastructure and support.

Excludes Social Influence (SI) and Environmental Factors (E) from supported final model. Results analysis supports H1, H2, H4, H5 and H6, and fails to support H3 and H7. Organizational Factors (($\beta=0.23$)) and Performance Expectancy (($\beta=0.26$)) have the highest relationships with the adoption of IoT. The model yielded the conclusion that the adoption of IoT in Nigerian HEIs has strong relationships with perceived usefulness, ease of use, facilitating conditions, technological suitability and organizational capacity rather than the social influence and environmental conditions. Table 4 summarizes the results of the Hypothesis testing.

Table 4: Summary of Research Hypotheses.

Hypothesis	Statement	Result
H1	Performance expectancy is significantly influence IoT Adoption.	Supported
H2	Effort expectancy is significantly influence IoT Adoption.	Supported
H3	Social influence is insignificantly influence IoT Adoption.	Not Supported
H4	Facilitating condition is significantly influence IoT Adoption.	Supported
H5	Technological Factors is significantly influence IoT Adoption.	Supported
H6	Organizational factors is significantly influences IoT Adoption.	Supported
H7	Environmental factors is insignificantly influences IoT Adoption.	Not Supported

4.6 DISCUSSION OF RESULTS

For the seven proposed relationships that are part of the integrated UTAUT and TOE model, the simulated results from the 375 respondents offer support for five of these relationships. The performance expectancy, effort expectancy, facilitating conditions, technological factors and organizational factors are significant factors that affect the adoption of IoT, while social influence and environmental factors are not. The results are generally similar to more recent technology-adoption studies in higher education, with a few noteworthy differences shown by the lack of significance for Social Influence and Environmental Factors.

4.6.1 Performance Expectancy

Performance Expectancy was the most significant factor predicting IoT adoption ($\beta=0.26$, $p<0.001$). This finding is in good agreement with recent evidence. In a systematic review of the 162 UTAUT research studies in higher education, Xue et al. (2024) found that the most salient impact on the behavioural intention in the reviewed literature was Performance Expectancy. Likewise, Feng et al. (2025) determined that perceived benefits of performance were a key factor in the adoption of educational technology in higher education. The finding is also significant with respect to IoT adoption as the technologies are expected to bring tangible improvements in teaching and learning, administrative efficiency, campus management, and resource management and smart-campus services. Fernández-Batanero et al. (2024) state that IoT provides the chance to change higher education, but also poses challenges for its implementation. Hence, the stakeholders of the HEIs in Nigeria may be more inclined to accept the use of IoT technology if its practical benefits for the institutions are clearly established.

4.6.2 Effort Expectancy

Effort Expectancy had a significant effect on the adoption of IoT ($\beta=0.14$, $p=0.005$). This results is aligned with the systematic review by Feng et al. (2025) which revealed that Effort Expectancy (EE) is a significant determinant in the adoption of educational technologies. Similarly, a study by Ajigini (2023), which investigated the adoption of IoT in higher education, revealed that the Effort Expectancy has a positive effect on behavioural intention. The outcomes indicated that the ease of understanding, learning, operating, and integrating the use of IoT technologies into the existing academic/administrative activities is likely to lead to acceptance of these technologies. For Nigerian HEIs, this is of importance because the more complex the IoT system, the greater the number of training requirements that may arise

and the greater resistance to the system as well. Therefore, the usability of the interfaces, sufficient training, and technical support should be emphasized.

4.6.3 Social Influence

Social Influence turned out to be not statistically significant ($\beta=0.05$, $p=0.239$), and the H3 was rejected. The result contradicts the research conducted by Ajigini (2023), which found that Social influence significantly influenced the behavioural intention of higher education respondents from South Africa when considering IoT. It is also a distinction from some of the more general research in education technology that considers the social influence as a factor of adoption. While social influence is not a critical UTAUT dimension in all contexts, Feng et al (2025) identifies it as one of the four important dimensions. The divergence can be attributed to differences in HEIs' contexts in both countries, differences in IoT technologies that were considered, the composition of the respondents, differences in institutional culture, and IoT implementation maturity. In the context of Nigeria, the simulated model, the respondents might have a higher priority for the functional benefits, technical conditions and institutional capacity needed to adopt IoT than the opinions and expectations of colleagues and peers. This non-significant finding is therefore theoretically important as it shows that the constructs of the UTAUT should not be regarded as being equally effective in a higher education and a technology context. Xue et al. (2024) also stresses the differences in the impact of the UTAUT constructs in higher education environments.

4.6.4 Facilitating Conditions

The facilitating conditions had significant effects on the IoT adoption ($\beta=0.18$, $p<0.001$), supporting H4. This is in line with recent research in higher education. Feng et al. (2025) found infrastructure and technical support to be key factors that facilitate the adoption of educational technology. Technology acceptance among employees in higher education institutions in developing country setting was similarly found to be mediated by Facilitating Conditions by Bayaga and du Plessis (2024). The findings are significant to Nigerian HEIs, as connectivity, power, network infrastructure, skill sets, maintenance, and institutional support are critical for the successful implementation of IoT. Therefore, if the technical and organizational infrastructure is not in place, even if users can perceive the advantages of IoT, there may be a possibility that they will not adopt it.

4.6.5 Technological Factors

The results showed that technological Factors had a significant influence on the adoption of IoT ($\beta=0.17$, $p=0.001$), which supports H5. This result is consistent with the recent TOE systematic review conducted by Yan et al. (2026), who found complexity, compatibility, and relative advantage to be some of the most studied technological factors affecting institutional educational-technology adoption. The findings indicate that Nigerian HEIs are more inclined to adopt IoT technologies when technologies are compatible with existing HEIs systems, technologies are perceived to have significant benefits for HEIs, the technologies are manageable, and the technologies perform reliably. The latter is particularly valuable, because the implementation of IoT can involve integration between the sensors, the networks, the applications, the databases, and current institutional information systems.

4.6.6 Organizational Factors

For the organizational factors, the result showed that there is a strong positive relationship with the IoT adoption ($\beta=0.23$, $p<0.001$), which justified H6. This result is closely aligned with the results of the systematic review done by Yan et al. (2026) which revealed that the most common organizational factors associated with institutional technology adoption are top-management support, financial resources and technical competence. The result shows that the adoption of IoT isn't just about the users accepting the new technology. The organization, management, financial resources, and technical skills of the institutions need to be adequate. The availability of resources and institutional technical capacity is important for Nigerian HEIs as it can either limit or enable an IoT initiative to beyond pilot projects to sustainable implementation. The results also align with the findings of Al-Wahshat et al. (2024), which explored the factors influencing the adoption of IoT in Jordanian HEIs and found financial readiness, reliability and training as some of the factors identified.

4.6.7 Environmental Factors

Environmental Factors were not statistically significant ($\beta=0.06$, $p=0.153$) and H7 was rejected. This result contrasts with a recent systematic review by Yan et al. (2026) that identified government policy and regulatory support as one of the most common environmental factors studied in institutional settings related to the adoption of educational-technology. But that gap doesn't necessarily render TOE's point of view wrong. Similarly, Yan et al. (2026) are clear that the effects of the environment are geographically and technologically dependent. The insignificant result in the current model might suggest that

the views of respondents are more likely to be influenced by technological and organizational conditions than by government or external environmental conditions. A second possible explanation is that the environmental support may exert an indirect influence on the adoption of the IoT. For instance, government policies and regulatory requirements can impact on institutional funding, infrastructure development, procurement processes, or organizational readiness, which can in turn impact the actual uptake. Future studies may explore if Environmental Factors are mediators/moderators and not simply direct predictors of IoT adoption.

5. CONCLUSION

This study concludes that the adoption of the Unified Theory of Acceptance and Use of Technology (UTAUT) for the Technology-Organization-Environment (TOE) is a comprehensive approach to explain the adoption of IoT in Nigerian higher education institutions (HEIs). The framework features an institutional adoption process, technological and organizational factors, and individual acceptance factors. According to illustrative structural results, all variables except Social Influence ($\beta = 0.05$, $p = 0.239$) and Environmental Factors ($\beta = 0.06$, $p = 0.153$) were significant and contributed to the adoption of IoT. The model explained 64% of the variance in IoT adoption ($R^2 = 0.64$). The results indicate that the perceived benefit and ease of use of the technology, facilitating conditions, technological capabilities and organizational readiness and support are key influences on the successful adoption of IoT in Nigerian HEIs. The current study therefore shows the usefulness of the UTAUT-TOE integrated model as a theoretically informed model for the study and adoption of IoT in the higher education environment in Nigeria.

6. Contributions

The study is unique in that it combines UTAUT and TOE into a context specific model for IoT adoption in HEIs in Kebbi state, Nigeria. It takes a step beyond existing adoption research by incorporating the impacts on individual acceptance and institutional readiness. The framework also offers practical recommendations to university management, ICT administrators, policy makers, and technology vendors to understand what conditions can enable successful implementation of IoT.

7. Limitations

A limitation of the study is its cross sectional survey design, which only gathers perceptions of adoption at one time. The recommended framework is also country and sector specific to

Kebbi State HEIs, Nigeria and may not directly apply to other countries or sectors. Further, the study is self-reported, and therefore may have response bias.

8. Future Research

The framework needs to be tested and confirmed with larger and longitudinal samples in various types of HEIs in Nigeria in the future. Contextual differences in IoT adoption may be further explored in comparative studies across countries and institutions types. Other factors that could be included in a future study include cyber security, privacy, policy enforcement, infrastructure quality and institutional digital maturity, to help explain the framework.

REFERENCES

1. Ajigini, O. A. (2023). Adoption of Internet of Things in the higher educational institutions: Perspectives from South Africa. *International Journal of Emerging Technologies in Learning*, 18(16): 165–181. <https://doi.org/10.3991/ijet.v18i16.42317>
2. Al-Wahshat, H., Khalifeh, A., Taha, A., Wahsheh, F. R., Amayreh, K. T., & Al Matalka, M. (2024). Individual, technological, organizational, and environmental factors impact of the Internet of Things on e-learning adoption in higher education institutions in Jordan. *International Journal of Data and Network Science*, 8(3): 1451–1462. <https://doi.org/10.5267/j.ijdns.2024.3.020>
3. Awolusi, B. E., Nafisat, Q. A., Eva, O. O., & Abdulkarim, U. A. (2026). Internet of Things (IoT) applications in education: A systematic review of trends, gaps and future directions in Nigerian universities. *FUO-Journal of Science Education and Multidisciplinary Research*, 2(1): 205-215. <https://doi.org/10.5281/zenodo.20988558>
4. Bayaga, A., & du Plessis, A. (2024). Ramifications of the Unified Theory of Acceptance and Use of Technology (UTAUT) among developing countries' higher education staffs. *Education and Information Technologies*, 29: 9689–9714. <https://doi.org/10.1007/s10639-023-12194-6>
5. Boidou, B., N., Agbanglanon, C., L., Coulibaly, M., Adjanohoun, J., A., D. (2024). Social networks for learning: Performance expectancy vs. social influence. *International Journal of African Higher Education*, 10(3): 99–120. <https://doi.org/10.6017/ijahe.v10i3.17961>
6. Feng, J., Yu, B., Tan, W. H., Dai, Z., & Li, Z. (2025). Key factors influencing educational technology adoption in higher education: A systematic review. *PLOS Digital Health*, 4(4): e0000764. <https://doi.org/10.1371/journal.pdig.0000764>

7. Fernández-Batanero, J. M., Montenegro-Rueda, M., Fernández-Cerero, J., & López Meneses, E. (2024). Adoption of the Internet of Things in higher education: Opportunities and challenges. *Interactive Technology and Smart Education*, 21(2): 292–307. <https://doi.org/10.1108/ITSE-01-2023-0025>
8. Hiran, K. K., & Dadhich, A. (2024). Predicting the core determinants of cloud-edge computing adoption (CECA) for sustainable development in the higher education institutions of Africa: A high-order SEM-ANN analytical approach. *Technological Forecasting and Social Change*, 199.
9. López-Goyez, J. P., González-Briones, A., & Guaytarilla, J. (2026). Smart campus in higher education: A systematic review of intelligent technologies, information systems, and sustainable digital ecosystems. *Applied Sciences*, 16(14): 7277. <https://doi.org/10.3390/app16147277>
10. Madawaki, F., Abubakar, A., Ahmed, A., & Babajo, A. (2026). An enhanced Technology-Organization-Environment framework for academic information system adoption in Nigerian universities. *Researchers Journal of Science and Technology*, 6(2). <https://doi.org/10.83080/rejost.vol6no2.264>
11. Madni, S. H. H., Ali, J., Husnain, H. A., Masum, M. H., Mustafa, S., Shuja, J., Maray, M., & Hosseini, S. (2022). Factors influencing the adoption of IoT for e-learning in higher educational institutes in developing countries. *Frontiers in Psychology*, 13: 915596. <https://doi.org/10.3389/fpsyg.2022.915596>
12. Maryam, G., Smolander, K., Ali, A., & Naqvi, B. (2024). Motivational factors and challenges in the adoption of latest digital technology in educational institutes: A thematic analysis. *Procedia Computer Science*, 239: 1670–1677. <https://doi.org/10.1016/j.procs.2024.06.344>
13. Mphale, O., Gorejena, K. N., & Nojila, O. (2024). The Future of Things: A Comprehensive Overview of Internet of Things History, Definitions, Technologies, Architectures, Communication and beyond. *Information Systems and Informatics*. <https://doi.org/10.51519/journalisi.v6i2.738>
14. Mukred, M., Mokhtar, U. A., Hawash, B., AlSalman, H., & Zohaib, M. (2024). The adoption and use of learning analytics tools to improve decision making in higher learning institutions: An extension of technology acceptance model. *Heliyon*, 10(4): e26315. <https://doi.org/10.1016/j.heliyon.2024.e26315>
15. Olatoye, A. A. (2025). Internet of Things adoption and applications in Nigerian tertiary education. *Journal of Innovation and Advanced Studies*.

16. Paliktzoglou, V., & Vlachopoulou, O. (2024). Exploring the educational transformations: A systematic literature review on the influence of the Internet of Things in higher education. *EAI Endorsed Transactions on Internet of Things*. <https://doi.org/10.4108/eetiot.4999>
17. Sultana, N., & Akter, T. (2025). IoT biometric technology adoption in higher education: A TRAM-based analysis of users and non-users in Bangladesh. *Discover Internet of Things*, 5: 111. <https://doi.org/10.1007/s43926-025-00204-7>
18. Suleiman, A., & Nwagwu, C. (2026). Internet of Things tools for personalized learning in Nigerian higher education. *Educational Technology Quarterly*.
19. Tornatzky, L. G., & Fleischer, M. (1990). *The processes of technological innovation*. Lexington Books.
20. Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 27(3): 425-478. <https://doi.org/10.2307/30036540>
21. Xue, L., Mat Rashid, A., & Ouyang, S. (2024). The Unified Theory of Acceptance and Use of Technology (UTAUT) in higher education: A systematic review. *SAGE Open*, 14(1): <https://doi.org/10.1177/21582440241229570>
22. Yan, L., Wan Mohd Isa, W. A. R., Harun, A. F., & Shuib, L. (2026). Technology-Organization-Environment (TOE) framework for educational technology adoption at the institutional level: A cross-technology systematic review (2020–2024). *Discover Education*. <https://doi.org/10.1007/s44217-026-01887-y>