

# **A THEORETICAL APPROACH TO EVALUATING SMART EDUCATIONAL ENVIRONMENTS**

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## **Abstract**

Advancements in smart, mobile, and wearable technologies are redefining how individuals interact and compute, leading to the emergence of smart learning environments (SLEs) that support personalized and inclusive educational experiences. While several evaluation frameworks exist for learning environments, few adequately address the unique characteristics of smart learning contexts. This study proposes and validates an integrated evaluation model specifically tailored for SLEs, drawing on the strengths and addressing the limitations of the Technology Acceptance Model (TAM) and the Theory of Planned Behavior (TPB).

The validation process involved focused group discussions comprising students, lecturers from the Faculty of Science, and e-learning experts at Adamawa State University, Mubi, Nigeria. Data were analyzed thematically to uncover contextual factors influencing the acceptance and use of smart learning technologies. The findings revealed three additional constructs—perceived quality, perceived support, and perceived technology resources—which enhance the explanatory power of the combined TAM-TPB framework in smart learning environments. The integrated model offers a comprehensive lens for examining both the intention and actual usage of smart learning systems. It serves as a practical tool for educational institutions, policymakers, and technology developers to guide the design, implementation, and evaluation of inclusive smart learning strategies. By contextualizing technology acceptance within the dynamics of resource availability and support systems, the model ensures relevance and applicability in real-world educational settings.

**Keywords:** Smart learning environment, Technology Acceptance Model (TAM), Theory of Planned Behavior (TPB), Educational technology adoption

## **INTRODUCTION**

The increasing developments in smart and mobile technologies such as artificial intelligence, machine learning, the Internet of Things (IoT), and wearable computing devices have continued to impact every sphere of life. It is now possible to compute anywhere using the superior power of mobile devices connected to the internet (Serba & Loan, 2020; Fakinlede et al., 2015). The educational institutions, as the center for research, innovation, and development, have continued to be more innovative due to these new technological developments.

The educational institutions are now called smart campuses, smart education, smart learning environments, smart classrooms, and smart learning processes as the results of the transformative power of smart and mobile technologies (Spector, 2016; Yot-Dominguez & Marcelo, 2019; Zhu et al., 2016). Educational institutions are

taking these opportunities and, coupled with the infrastructure deficits, are now offering a blended pedagogical framework to meet the needs of on-campus and off-campus students and those on remote learning. This promotes the increasing deployment of skill-based courses in an online learning environment to meet skills gaps in the digital workforce (Rosmansyah et al., 2022; Hoel & Mason, 2017; Zhu et al., 2016; Zhu & He, 2012).

A smart learning environment is developing using smart and wearable technologies to support personalized experiences for inclusive learning experiences (Rosmansyah et al., 2022; Serba & Loan, 2020). This intelligent learning environment can support online learning experiences for interaction and engagement. Furthermore, the learning environment can support learners' diverse learning behaviors and needs. However, there is a lack of a well-defined and comprehensive evaluation model of a smart learning environment based on its characteristics and other contextual factors to support implementation and deployment decisions.

Thus, the research questions are: What are the factors influencing the use of a smart learning environment, and how can these factors be modeled and validated to provide a novel comprehensive model for evaluating a smart learning environment? Addressing these questions will provide insights into implementing and deploying a smart learning environment for an inclusive learning experience.

## **BACKGROUND AND RELATED WORKS**

### *Smart Learning Environment*

Smart, mobile, and wearable computing advancements are transforming how people compute and interact daily. These technologies are transforming learning environments into smart learning environments capable of providing personalization for inclusive learning experiences. According to Hwang (2014), a smart learning environment is "the technology-supported learning environment that adapts and provides appropriate support (feedback, guidance, hint, or tool) in the right place and right time based on the individual needs that might be determined by analyzing the behavior and performance of the learner." A smart learning environment takes into account the characteristics of learner, makes available individualized educational materials and user-friendly interactive technologies, records and analyzes the learning process in its entirety, and offers feedback on the learner's progress (Rosmansyah et al., 2022; Hoel & Mason, 2017; Zhu et al., 2016).

The smart learning environment and the smart devices can interact with a learner and make decisions depending on the learner's actions. The use of data analytics may serve to promote learners' success by monitoring their progress, and teachers can utilize it to deliver helpful feedback by visualizing learning data. Learners are provided with digital materials, interaction, essential learning assistance, supportive tools, and learning ideas at the appropriate time, location, and format (Egielewa *et al.*, 2021; Zhu et al., 2016).

A smart learning environment can provide a hybrid learning system that provides learners and other stakeholders with a motivational learning process while simultaneously achieving learning outcomes due to the employment of intelligent tools and techniques (Rosmansyah et al., 2022). It comprises contextual awareness, location

awareness, real-world scenarios, recommendation systems, numerous engagement channels, assistance, personalization, and adaption (Hwang, 2014). Learners are more motivated to attain their goals when these features support inclusive learning experiences (Egielewa *et al.*, 2021; Serba & Loan, 2020).

#### *Related Works*

The success or failure of technology implementation and adoption depends on user's level of acceptance (Mohammadi & Garibaldi, 2010; Hua *et al.*, 2014). Several models or frameworks have been developed to evaluate learning environments. For example, Akour *et al.* (2021) developed an extended technology acceptance model (TAM) and theory of planned behavior (TPB) to analyze university adoption of mobile learning platforms for accessing course materials, searching the web for information related to their disciplines, sharing knowledge, and submitting assignments during the COVID-19 pandemic. Although the model-integrated constructs form well-known behavioral models, they lack contextual factors that might influence the evaluation of mobile learning. Moreover, the model was not qualitatively validated to explore other intrinsic factors that might influence the adoption of mobile learning.

Hamid *et al.* (2020) explored factors influencing students' acceptance of learning management systems by extending the Technology Acceptance Model (TAM) using system design, system accessibility, technical support, and subjective norm as external variables. The study revealed that all the constructs of the TAM, including the extended ones, support the student's intention to use the learning management system. Similarly, Abubakar *et al.* (2021) used an extended unified theory of acceptance and use of technology (UTAUT) by including training, impact on the instructors' attitude, and computer self-efficacy towards the attitude to use a learning management system. The findings show that instructors' attitudes impact students' behavior toward using the learning management system. In addition, Mailizar & Maulina (2021) used extended TAM to explore factors influencing students' behavioral intention to use e-learning during COVID-19. The extension used system quality and experiences as external constructs. The findings show that all the constructs supported behavioral intention to use e-learning and thus recommended exploring e-learning qualities and support mechanisms. However, these models lack the intrinsic characteristics of the smart learning environment and thus require integration with another robust model to evaluate the smart learning environment.

Ramayana & Bali (2015) developed the *integrated Fit Model* for evaluating the success and acceptance of e-learning by integrating human-technology-organization (HOT) fit (Yusof *et al.* 2006), IS success (DeLone & McLean, 2003), & unified technology acceptance and use of technology (UTAUT) (Venkatesh *et al.* 2012). This is an excellent framework for evaluating user satisfaction in a learning environment that is segmented into three dimensions. However, the constructs within each dimension still need further investigations to have a comprehensive and specific measure to address evaluation issues. The dynamic characteristics of smart technologies called for a new approach to evaluation constructs and dimensions.

Evaluating technology-enhanced learning provides insights to educational stakeholders about why learning technology fails or succeeds and how best it can be implemented for effective pedagogical delivery. Thus, technology-enhanced learning and evaluation of system implementation is an important endeavor, evident through many publications (Guerra et al., 2016; Nussbaumer et al., 2015; Mohammed & Garibaldi, 2010). A smart learning environment, as an emerging learning environment, is a hybrid learning system that provides learners and other stakeholders with a motivational learning process while achieving learning outcomes due to the employment of intelligent tools and techniques (Rosmansyah et al., 2022). It is characterized by context awareness, location awareness, real-world scenarios, recommendation systems, multiple channels of interactions, support, personalization, adaptation, etc. (Hwang, 2014). These characteristics support inclusive learning experiences and motivate learners to achieve goals (Egielewa et al., 2021; Serba & Loan, 2020). Several models or frameworks have been previously developed to evaluate learning environments. However, most of them were not validated to understand the perception and experiences of the learners in enriching the constructs of the model. Furthermore, there is a scarcity of a model that includes the characteristics of a smart learning environment to make informed decisions regarding the implementation and deployment.

#### **METHODOLOGY FOR DEVELOPMENT OF THEORETICAL MODEL**

Several integrated models have been used to evaluate the learning environment; however, most models were not validated qualitatively to understand other behavioral and contextual factors impacting the use of a learning environment. Furthermore, because of their characteristics, most models were limited in scope to evaluate smart learning environments. For example, Akour et al. (2021) developed an extended TAM and TPB to analyze university adoption of mobile learning. Although the model-integrated constructs are from well-known behavioral models, they lack contextual factors to evaluate smart learning environments. Moreover, the model was not validated to explore other contextual factors that might influence the adoption of mobile learning.

This study extended the integration of TAM and TPB to understand other behavioral and contextual factors influencing the use of a smart learning environment. TAM and TPB have been used to explain or predict individual adoption from the user's perspective (Venkatesh & Davis, 2000). TPB complements TAM constructs and adds or enhances explanatory and predictive powers (Premkumar & Roberts, 1999; Venkatesh & Davis, 2000). TAM with TPB constructs allows for predicting users' acceptance of technology for both volitional and non-volitional conditions (Thong, Yap & Raman, 2012). This research integrates TPB constructs and cannot use TPB as a sole model because it lacks strong explanatory power and cannot stand independently (Awa et al., 2015). Furthermore, each model lacks comprehensive constructs to evaluate a smart learning environment.

*Technology acceptance model (TAM)*: This model is derived from the concept that "perceived usefulness and ease of use" influence technology adoption. It hinges on a belief that perceived usefulness is the extent to which an individual believes that using a particular technology will enhance their job performance. Perceived ease of use

is the extent to which one believes using a particular technology will make their work easier (Venkatesh & Davis, 2000). This model further explains that perceived usefulness and ease of use drive users to adopt new technology. This model proved to be one of the widely accepted models. The constructs of TAM are perceived ease of use, perceived usefulness, attitude towards use, and actual usage.

*Theory of Planned Behavior (TPB)*: This model was guided by three types of thoughts: behavioral belief, normative belief, and control belief (Armitage & Conner, 2000). This theory is believed to be effective in validating users' innovation acceptance. The three (3) antecedents (attitude towards behavior, subjective norms, and perceived behavioral control) directly or indirectly predict individual behaviors and intentions for new technology.

The integration of these constructs served as the initial model for evaluating the smart learning environment, as shown in Table 1.

Table 1: The categorization of the constructs of TAM and TPB

Theory	Constructs
Technology Acceptance Model (TAM)	Perceived ease of use (PEOU), Perceived Usefulness (PU), Actual Usage (AU)
Theory of Planned Behavior (TPB)	Attitude Towards Use (ATB), Subjective Norms (SN), Perceived Behavioral Control (PBC), Behavioral Intention (BI),

However, integrating these constructs is limited to providing factors influencing the use of a smart learning environment. It lacks contextual factors and the characteristics of a smart learning environment to understand issues around implementing and deploying a smart learning environment. Hence, there is a need to validate the model among experts and potential users to understand factors influencing the use of a smart learning environment to develop a welldocumented comprehensive model for evaluating a smart learning environment.

### Validating the Integrated Model

Given the scarcity of theoretical models for evaluating a smart-based learning environment that considered its' characteristics and other personal factors, this study was considered exploratory, and therefore, a case study approach was considered appropriate (Yin, 2003; Marshall & Rossman, 1989). A case study is useful for exploring areas where existing knowledge is limited (Eisenhardt, 1989) and is also valuable in understanding a particular situation (Yin, 2003). A single qualitative case study strategy was adopted to understand experts' and potential users' perceptions of factors influencing the use of smart learning environments.

This study adopted an exploratory qualitative case study to explore factors influencing user behavior to use a smart learning environment in the Faculty of Science, Adamawa State University Mubi-Nigeria. The study was

conducted using nine focus group discussions, with each group having six participants. Lecturers, students, and experts from the eLearning team of the university. The qualitative sample size of six groups was sufficient to validate the population, and this is based on the literature, which states that the average sample size for qualitative research can vary from 5 to 50 for a large population and from 2 to 30 for a small population. In this case, the six-sample size was sufficient to validate the population (Fugard & Potts, 2015; Guest et al., 2017). The research participants were chosen on purpose to obtain the information needed.

Data was collected using face-to-face focused group discussions, a technique well suited to exploratory research because it allows expansive discussions to illuminate factors of importance (Yin, 2003). The focused group discussions lasted between 20 and 35 minutes. The open-ended questions allowed respondents to express their experiences and views and the socially complex contexts underpinning learning technology adoption (Oppenheim, 2000; Yin, 2003).

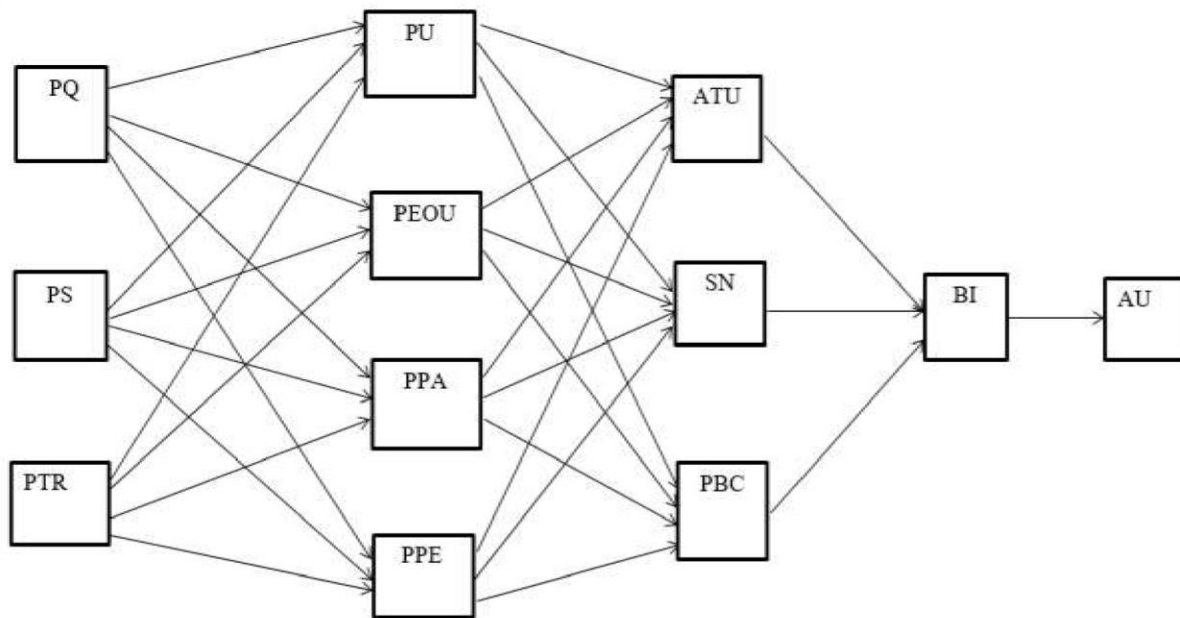
The data collected were analyzed using thematic approaches, i.e., familiarization with datasets, generation of initial codes, theme search, theme examination, and refining themes (Braun & Clarke, 2006). The results of the themes analyzed were provided to the respondents to eliminate the study's bias and offset the effects of different realities (Kaplan & Duchon, 1988). All the collected data were recorded with each participant's consent and transcribed, proofread, and annotated by the researcher and then coded using NVivo. Also, venting was used, whereby results and interpretations were discussed with professional colleagues and the interviewees to avoid the problem of multiple realities (Kaplan & Duchon, 1988).

#### Findings and Discussions

The factors from the study were grouped into themes guided by the initial factors of the integrated model in Table 1. Thus, based on the theme analysis, five contextual factors—perceived quality, perceived support, perceived technology resources, perceived personalized adaptation, and perceived experiences—were the new constructs identified from the study. The perceived quality, perceived support, and perceived technology resources are the external variables that impact the behavioral factors to influence the intention and actual usage of a smart learning environment. Thus, the external factors are perceived quality, perceived support, and perceived technology resources. The behavioral factor is perceived ease of use, usefulness, attitude towards use, attitude towards behavior, subjective norms, perceived personalized adaptation, perceived behavioral control, perceived personal experiences, intention, and actual usage, as shown in Figure 1.

Thus, integrating these factors informs the novel model for evaluating a smart learning environment. This model can be used to evaluate both the intention and actual usage of a smart learning environment and can support decisions and policy-making on implementing and deploying a smart learning environment in a contextual setting.





**Figure 1: Model for Evaluating Smart Learning Environment**

Thus, the constructs of the model are discussed as follows:

**Perceived Quality (PQ):** This is the extent of the benefits that can be delivered to the user regarding processing time, availability, and support. The responsiveness and efficiency of the smart learning environment are the qualities that are important to users. The previous studies show the quality of service has a favorable association with user intention to use learning technology (Awang *et al.*, 2019; Bembenuatty *et al.*, 2016; Mohammadi, 2015).

**Perceived Support (PS):** Several studies on implementing information systems have examined the role and value of learning support. Given how important information systems are and how they serve as a resource for an organization, support from management, teachers, and other stakeholders is key to getting people to use the technology. Learning support from teachers and top management is the degree to which the teacher or top management understands the importance of the information system functions and is involved in information system activities (Mailizar & Maulina, 2021).

**Perceived technology resources (PTR):** These are computer hardware, software, and internet connectivity that can support users. The constructs include help desks, hotlines, online support services, machine-readable support knowledge bases, faxes, automated telephone voice response systems, remote control software, and other facilities (Zogheib *et al.*, 2015). The perceived availability of technology resources affects how useful and easy to use technology is. Without technical resources and help, smart learning environments can't work effectively and efficiently (Abbad *et al.*, 2009).

**Perceived ease of use (PEOU):** Perceived Ease of Use (PEU) in the context of smart learning environments is the degree to which users think that using a smart learning environment will be easy (Lin et al., 2010). Previous research has shown that how easy something is to use has a big effect on how useful it is thought to be (Binyamin et al., 2019; Joo et al., 2018). Also, studies have shown that how easy learning environments are thought to be to use is a strong predictor of how people feel about using them (Uyouko & Wong, 2015; Zogheib et al., 2015).

**Perceived Usefulness (PU):** Perceived usefulness (PU) is how users think a smart learning environment can help them reach their teaching and learning goals. Studies in the past showed that PU had the most impact on attitude (Martinho et al., 2018; Uyouko & Wong, 2015; Zogheib et al., 2015). PU also greatly affected how people planned to act toward a smart learning environment (Al-Sayyed & Abdalhag, 2016; Uyouko & Wong, 2015).

**Perceived personalized adaption (PPA):** Advanced technology-based smart learning environments enable personalized learning. It offers an efficient learning option. Students can choose content based on their current situation at any time and wherever on campus. Personalized adaptive learning is unimpeded. Individual learners choose learning resources and services (Hwang, 2014). Personal learning environments are created by learners using varied materials and resources. Smart learning environments can manage text, audio, and video as learning resources. Since learners have diverse needs, knowledge levels, backgrounds, and interests, this lets them choose the best learning path (Zhu et al., 2016).

**Perceived Experience (PE):** Both Agarwal & Karahanna (2000) and Saadé & Bahli (2005) noted that experience is a psychological concept that can be thought of as a natural drive that includes fun and satisfaction. Previous research shows that when perceived experience is combined with TAM, its research revealed that people with a lot of experience value using technology, focusing on on-time experience, which can strongly predict how useful and easy to use something will be seen to be. So, a user may think that technology is easy to use because they think that if it's easy to use, they can use it without much thought or work. This situation can happen when people who are good with technology use it often, making the environment feel comfortable and friendly.

**Subjective Norms (SN):** Subjective norm is a social impact variable that relates to an individual's opinion that influential people around them think that the conduct in issue should or should not be done (Fishbein & Ajzen, 1977). According to studies, SN can directly or indirectly alter an individual's intention to utilize the system (Ataran & Nami, 2011; Venkatesh & Davis, 2000). Park *et al.* (2014) and Sabah (2016) found that SN affects PU system use intention.

**Perceived Behavioral Control (PBC):** This depends on how easy or hard a person thinks it is to do the behavior of interest. Situations and actions affect how behavioral control is seen, so a person's view of behavioral control can change depending on the situation. People's perceptions of how easy or hard it is to do the behavior of interest are what PBC measures (Ajzen, 1991). Previous studies have shown that PBC greatly affects whether people plan to use learning technology platforms (Al-Emran *et al.* 2020; Cheon *et al.* 2012).



**Behavioral Intention (BI):** The Theory of Planned Behavior says that a person's behavior can be explained by their behavioral intention, which is the decision to act in a certain way in the future (Al-Sayyed & Abdalhag, 2016). This model aligns with the adoption theory; behavior intention and use will greatly affect how people use smart learning environments. BI is the most important aspect that plays a role in determining whether or not a system is successful (Al-Sayyed & Abdalhag, 2016; Chang *et al.*, 2017).

**Actual Usage (AU):** Actual system use is how people act when using a system. Davis (1989) opined that actual system usage is a type of external psychomotor response that can be measured by someone who uses the system. Lo *et al.* (2015) said that usage is measured by the time spent using the technology or how often it is used. This also means using a system more than once can change how users accept it (Andy *et al.*, 2021).

### **CONCLUSION AND FURTHER WORKS**

The advancement in smart, mobile, and wearable computing is transforming how people compute and interact every day. These technologies are transforming the learning environment into a smart learning environment capable of providing personalization for inclusive learning experiences. Several evaluation frameworks were proposed to evaluate the learning environment. However, a well-explored model that considers the characteristics of a smart learning environment and personal factors is lacking.

This study explored the literature and developed an integrated model for evaluating a smart learning environment. The study further validated the model based on the strengths and limitations of the technology acceptance model (TAM) and theory of planned behavior (TPB). This study contributed to harnessing different evaluation studies in both learning technologies and IS literature to provide a comprehensive understanding of the issues and the need for a smart learning environment evaluation study that advanced the existing knowledge in user technology evaluation. Furthermore, this model unified different constructs into defined and measurable dimensions from learning technology models and evaluation.

The study identified five new factors: perceived quality, perceived support, perceived technology resources, perceived personalized adaption, and perceived experiences that can influence a smart learning environment. Although the proposed model focuses on educational settings, its evaluation study will be useful for stakeholders measuring the adoption and deployment of learning technology or other IS applications in educational and related organizations. As part of further research, this model will be used to evaluate a smart learning environment to understand if the new constructs can influence user satisfaction in using a smart learning environment.

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