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IMPACT OF SMART TECHNOLOGIES ON STUDENT LEARNING IN HIGHER EDUCATION: THE MEDIATING ROLE OF SMART PEDAGOGIES IN PUBLIC UNIVERSITIES OF BALOCHISTAN

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ABSTRACT

The rapid integration of Smart Technologies has changed the way learning and teaching practices in higher education are conducted. Empirical evidence on how the technologies are improving student learning is limited mostly to developing countries. This study analyses the impact of Smart Technologies on Student Learning and investigates the mediating role of Smart Pedagogies in public sector universities of Balochistan. Using a quantitative, explanatory design, data were collected from 300 university students and analysed using partial least squares structural equation modelling (PLS-SEM). Smart Technologies were modelled by constructs like mobile technology, machine learning, artificial intelligence, big data analytics and cloud computing, while Smart Pedagogies included differentiated instruction, personalised learning, collaborative learning, distance learning and generative learning. The context of the study remains underexplored in previous smart education research. The results reveal that Smart Technologies significantly influence Smart Pedagogies and Student Learning. Smart Pedagogies had a strong positive impact on Student Learning and partially mediated the relationship between Smart Technologies and Student Learning. The findings highlight that technology investments alone are insufficient; their educational value is maximised when supported by appropriate pedagogical practices. This study contributes to smart education literature by empirically validating a mediated learning framework and offers practical implications for policymakers and university administrators in resource-constrained contexts.

Keywords: *Smart Technologies, Student Learning, Collaborative Learning, Artificial Intelligence, Machine Learning, Smart Pedagogies and Higher Education*

1. INTRODUCTION

As life becomes demanding and fast, scientists and engineers always find a way to ease the burdens of humanity by introducing new technologies day by day. As technology flourishes, it influences all aspects of life in many ways. The designed system with the capability to manipulate and respond intelligently is referred to as smart technology. Any software or hardware is a smart technology if it can observe, manipulate, decide, and respond according to the scenario it has been challenged with. Smart technology focuses on using technology that uses machine learning, big data analysis, and artificial intelligence to provide cognitive awareness to objects that were considered inanimate in the past. Smart connected devices, internet of things, and smart devices are also examples of smart technology that provide the users convenience, sustainability, security, efficiency, and save money and time (Bowers, 2019). Smart technologies that are used for education include digital readers and tablets, 3D printing, gamification, artificial intelligence, mobile technology, cloud technology, and virtual reality (Fulton, 2019).

1.1 Background of the Study

Smart technologies may be based on simple or complex algorithms, but what makes them so much more penetrating is the way in which every smart technology hides its complex algorithms, commands, and information processing databases from the user (Yang, 2025). In this way, smart technologies are made more enjoyable and user-friendly for daily routine work. The utility of smart devices is increasing day by day, and the fact that they can work remotely via wireless technology gives ease of mobility to the user.

The internet has brought a new, revolutionary era of fast communication and convenient access to a vast library of diverse knowledge that has never been possible (Alimisis and Zoulias, 2013). Combining the internet with smart technology such as smart notebooks, 3D printers, digital diaries, CNC routing chips, brain-controlled gadgets, wearables, computers, smart phones, etc., makes them useful for all facets of human life. Improvements and enhancements in smart technologies are rapidly making their mark on everything that was not "smart" previously. Such a trend is also unleashing the new desires and demands that will, in the very near future, be even more clearly demarcated and well-defined (Swan, 2012).

1.2 Problem Statement

According to Williams and Pence (2011), students are more engaged in the process of learning and are better informed about the natural environment around them. Students tend to participate actively when they have their own handheld devices, such as smartphones, tablets, iPads, etc., with which to facilitate their studies. The involvement of technology in learning creates more participation of students in classes and, importantly, entices them to explore the curriculum. These days, the fastest ways of learning are easy to access. They include blog posts, videos, tutorials, etc. According to Wilson and McCarthy (2010), the utility of mobile devices has been observed to increase. 20 percent of students enrolled at Ryerson University in Toronto, Canada, were using smart devices regularly to help with their studies (Wilson and McCarthy, 2010). A much larger percentage of students stated that they desired to purchase a smart device. This is not surprising, given that the graphical user interface provided by smart technology (i.e., friendly to use) can not only steer people toward the information they seek but also permits greater ease of access to any information that may be useful in the learning process.

Plenty of certifications are available that illustrate the competency with which institutions utilize smart technology. According to Ormes (2015), students can do better research by utilizing smart technology to perform their tasks. Digging into the research, students may have an in-depth understanding of the efficacy of using smart technology to further their learning goals (Forbus and Feltovich, 2001).

The ways in which students use their smart devices are as varied as the devices themselves. Johnson, Sophia & Natarajan, and Natarajan (2017) conducted research in which there were only 10.4 percent of students who said they use their smart

devices for search engines, online encyclopedias, and libraries; the vast majority disclosed that they are more prone to using them for entertainment and communication purposes. 76 percent of students say they use apps to find academic sources. Search engines are the most used mobile apps for academic purposes (Singh et al. 2025). In this regard, this thesis intends to analyse the impact of Smart technology on learning. The aim of the paper is to assess the significance of smart technology in the learning process so that it can be adopted by the University of Balochistan effectively for the sake of improving the quality of education, and the research is underexplored previously.

1.3. Research Objectives

The main objective of this research is to analyse the impact of Smart Technologies on Student Learning and the mediating role of Smart Pedagogies in the public sector Universities of Balochistan. To achieve this overarching objective, the study seeks to:

To examine the impact of Smart Technologies on Student Learning in Higher Education.

To analyse the influence of Smart Technologies on the adoption of Smart Pedagogies in university teaching and learning.

To investigate the effect of Smart Pedagogies on Student Learning outcomes.

To determine whether Smart Pedagogies mediate the relationship between Smart Technologies and Student Learning.

1.4 Significance of the research

This research is significant for adding to the body of knowledge regarding the application of Smart technology in higher learning. The research will help in understanding the role of smart technology in improving the E-learning of students. The significance of the smart technologies will be assessed based on the support that they provide in the learning process. It will help academicians to design their curriculum in an advanced way to incorporate more smart technologies for the sake of improving the learning process. Students will have ease in using various smart technologies for understanding different concepts and learning the most effective ways to deal with complex problems (Singh et al. 2025). Academicians and researchers can further explore the significance of smart technologies to change their policies towards providing a better future for everyone. The study is also effective in providing knowledge about the impact of Smart technology in learning, and the study was underexplored previously in Pakistan.

The smart technology used for teaching students in universities is very helpful in enhancing the learning process. The higher education commission and academicians can use the smart technologies that are being used by different universities across the globe for improving the teaching and learning process in Balochistan. It will be helpful for the students to have several new alternatives that would really make their learning process more enjoyable and exciting. The academic process can overall be improved, and everyone can focus more on collaborative learning, personalized learning, simulations, discussion forums, and concept building (Pan et al. 2023).

1.5 Scope of the research

The revolutionary smart innovations are decidedly improving the ways in which HE students learn. In this regard, the scope of this research is to analyse and determine the impact of smart technology on the lives of students. In particular, it will focus on smart technology as it pertains to learning. In this way, we might better formulate strategic policies for the effective implementation of smart technology in learning environments. The research will focus on the various smart technologies that are being used for learning and the different teaching pedagogies that can be used for enhancing the learning process. The students will engage properly in the classroom and outside by using these smart technologies. The data will be collected from students at different universities in Balochistan, and the research will focus on the impact of smart technology on learning. The study will focus on the learning of students and the effectiveness of smart technologies. The purpose of the research is to create awareness about the important role of smart technology for learning and its effectiveness. There are several benefits that

can be achieved by using smart technologies, so students must realize the significance of smart technology and the methods in which they can use them properly to improve their learning. The research is going to be very much focused on the technology that is best for students and the long-term benefits of using the technology for the learning process.

2. Literature review

According to Al-Bataineh et al. (2008), currently, the nature of higher education learning is changing compared to the traditional mode due to the rise in technological advancement and, most specifically, due to the proliferation of Smart technology. Globally, internet penetration is on an uptrend, and it can reach even the most remote sectors of the economy (Alexander, 2004). In this regard, the cost of a smartphone has considerably reduced. This has made it possible for an average student to acquire one (Naveed et al. 2023). The acquisition of smartphones has led to changes in higher education learning. For the purposes of explaining the rationale for the impact of Smart technology in learning as the main objective of the study, a comprehensive overview of both interpretive and descriptive theoretical frameworks is well laid out. There is no existing pedagogy describing the impact of Smart technology on learning. However, the researcher built a theoretical framework for the research based on the constructivist, cognitivist, and behaviourist theoretical perspectives (Singh et al. 2025).

2.1 Societal Foundation of the Study

This century is characterized by rapid changes and rapidly developing technological, economic, social, cultural, and political situations. Globally, individuals have over-relied on Smart technology to a point where it is hard to survive without one. According to Oliveira, Ana & Pombo (2017), the best strategy is to integrate conventional teaching methods with technology-based learning. This will ensure the generation raised is not only technologically informed, but it has acquired the required models and modes of learning. However, in the current technological, information-driven society, information overload has become a challenge. This is attributed to an increase in procedures, rules, concepts, and facts guiding the nature of learning and delivery (Singh et al. 2025). As a result, educators in higher education learning are faced with major information challenges. The uptake of arithmetic, writing and reading is based on information technology search for the purposes of defining which is legal and which is not.

2.2 Characteristics of Students in Universities

The savvy generation cannot survive without the use of Smart technology. In this regard, denying technology applications in learning can prove passive and discouraging to technological power generation. Consequently, higher education has incorporated technological tools that enable the young generation to process and think about information. Cunningham (2017) states that technologies are constructed to address the young generation's needs of having a customizable learning environment, maintaining interaction and communication with instructors and peers. In this regard, the demand for technology-literate instructors has also risen, capable of creating course platforms which are technologically supported, learner support models, an engaging environment of learning and personalized instruction. So much revolution is expected in higher learning to respond to the growing students' needs regarding digital learning. Moreover, the societal demands for higher skills and expertise have put individuals on the heels of more learning, which can only become possible through technological advancement (Cunningham, 2017). In this regard, the impact of technology on higher education learning is improving lives. Nevertheless, it is not adequate to rule out possible dangers and threats to learners which may not breed the required profitable results (Rehman et al. 2026).

2.3 Emerging forms of learning with Smart Technology

The educational landscape is largely impacted by the neuroscience and cognitive psychology fields. Consequently, the integration of information technology into the above fields has not only

affected the nature of practice but also impacted academia. According to Bourne, Mayadas & Campbell (2000), the use of technology-based learning has changed the nature of information delivery, which has shifted to podcasts, wikis, blogs, synchronous online seminars, and asynchronous learning networks. These tools have made it possible to change learning into collaborative learning, interaction, and communication. For example, students have discussion forums on which they can discuss the issues or challenges related to a specific course, and they can resolve these issues by collaborating with each other and seeking the guidance of the course instructor.

In this regard, technological advancement in higher education has brought about serious concerns as well as opportunities. Smart devices are used with the internet to reduce time and effort to access information resources (Moreira, Ferreira, Santos, & Durao, 2017; Yeap, Ramayah, & Soto-Acosta, 2016). Technology enhanced the means to communicate and interact. Collaboration between learners and working groups became easier both for teachers and learners. Simulators and interactive platforms, virtual tools and laboratories, visual and audio applications, and electronic games are all examples of what technology offers for learners and teachers to enhance the teaching and learning environment (Wai, Ng, Chiu, Ho, & Lo, 2018; Xiangming & Song, 2018). Practitioners start to exchange new emerging terminology that is associated with electronic interaction, like e-Government, e-Learning, e-Health, e-Commerce, and e-Banking. Further to that, terms like C2B (Customer to Business), B2B (Business to Business), C2G (Citizen to Government) and the like were born (De Witt & Gloerfeld, 2018; Navarro, Molina, & Redondo, 2016).

2.4 Smart Technology used as a Cognitive Tool

In 2014, Paz-Albo Prieto (2014) carried out a study at Rey Juan Carlos University, Spain. The aim was to explore the perceptions of students on the use of *Socrative* as a Student Response System (SRS) via mobile phones. *Socrative* was a means to increase interactivity in the classroom. A questionnaire-based survey was conducted to inquire into students' perceptions of their use. Data was collected from 70 randomly selected students. Results revealed that *Socrative* can much better engage students in the learning process, promoting collaboration and encouraging participation. However, some problems related to the use of SRSs were revealed, such as the off-task use of smartphones in the classroom. In 2017, Anshari et al. (2017) performed a study on whether embracing smartphones in classroom teaching enhances learning or perhaps interferes. The study was carried out through a survey and an interview/discussion with a focus group of students. Authors found that students use their smartphones to access teaching materials or supporting information, or as learning aids. These devices provide convenience, portability, comprehensive learning experiences, multiple sources, multitasking, and are environmentally friendly. Embracement of technological advancement has enabled the creation of cognitive learning tools, which have impacted positive learning in higher education (Pan et al. 2023). Traditionally, technological conceptions were applied in rote learning in the form of practice and mundane drills. In this regard, a distinction between the traditional technological learning and the current cognitive technological learning is that for the cognitive technological learning, learners have the freedom of constructing knowledge, which is opposed to the traditional technological learning that braces students as passive recipients (Amjad, Bibi, & Rehman, 2025). Medina (2017) stated that smart technologies facilitate metacognitive processing and memory organization, bridge the gap between skills used in higher-order thinking and skills used in lower-level cognitive and finally enable problem-solving through hypothesis testing and generation.

2.5 Smart Pedagogies and Learning

Smart Pedagogies are needed for the sake of ensuring that the students can easily learn difficult concepts. It is not only the smart technology that is going to play a significant role, but it should be supported by excellent instructional methods that are designed to ensure maximum learning of the

students (Huang, 2010). The teachers should be aware of the smart pedagogies and teaching methods that are needed for the sake of meeting the expectations and needs of all the students. Some students want individual attention that allows them to learn easily, some students learn by interacting in groups, some learn by practical examples, and some students learn from real-life scenarios. So smart pedagogies are critical for instructors to ensure that the needs of all the students are met within the class, and the smart technologies can then be used along with smart pedagogies to enhance the learning process (Anshari et al. 2017).

- Class-based differentiated instruction. Differentiated instruction is a process to approach teaching and learning for students with different abilities in the same class (Hall 2002).
- Group-based collaborative learning. Collaborative learning is a situation in which two or more people learn or attempt to learn something together (Dillenbourg 1999).
- Individual-based personalized learning. Personalized learning is defined as adjusting pace (individualization), adjusting approach (differentiation) and connecting to the learners' interests and experiences (Atkins et al. 2010) to meet the students' needs and provide support to foster learning ability among individual students (Bentley and Miller 2004).
- Mass-based generative learning. The fundamental concept of generative learning involves the creation and refinement of personal mental constructions of the environment.

Zhu, Yu and Riezebos (2016) have used the research model for understanding the impact of smart technologies on learning. The smarter education ideology is the independent variable that is mediated by smart learning environment and smart pedagogies to assess its impact on the smart learners.

2.6 Universities Transformed through Smart Technology

Majid, Ishfaq, and Verma (2018) state that technological Web 2.0-based learning tools create the following affordances. They provide learners with opportunities for customized resources and information, enabling learners to become more creative in presentation, allowing the creation of interactive communities for knowledge sharing and dialogue and finally, allowing students display their achievements.

These changes are attributed to the communication and knowledge –based society. Adaptability is crucial for small businesses that want to grow and scale their business activities, so students can evaluate businesses based on the opportunities and threats that are prevailing in the economy and suggest the most feasible strategies (Rehman, Amjad, Ramzan, & Ahmed, 2026). Learners are more attracted to distributive and flexible learning, which can reach them wherever they are. Bond et al. (2024). Constructivist learning is the most needed in the higher education setup. These entail the use of search engines, websites, conferencing, discussion forums and emails. Big data analytics are used for analyzing large amounts of information so that effective solutions to various business problems can be achieved. Machine learning is being used for the purpose of equipping the computers with the needed information to perform several tasks that humans do in an intelligent and smart manner. Technology has also enlarged the curriculum due to the availability of vast resources through the internet.

2.7 Conceptual framework

The main objective of this research is to analyze the impact of Smart technology on learning. To understand the conceptual framework of this research, it incorporates the application of the Technology Acceptance Model. This model is based on the fact that technology is important in enabling learning and improving performance. According to Al-Bataineh et al. (2008), the Technology Acceptance Model is the most important model applied in information system testing.

Alexander (2004) argues that the Technology Acceptance Model is important in analyzing potential users' use and acceptance of technology. The model is considered important in analyzing actual usage behaviour, attitude toward using, perceived ease of use, perceived usefulness and

system design features. The model is also important in analyzing the impact of Smart technology in learning and teaching (Davis, 1989). The model is applicable in designing the intention of use geared by culture, behaviour and perceived use. This model has been widely used and extended in educational technology research, which includes different studies that focus on smart learning environments (Liu et al. 2003).

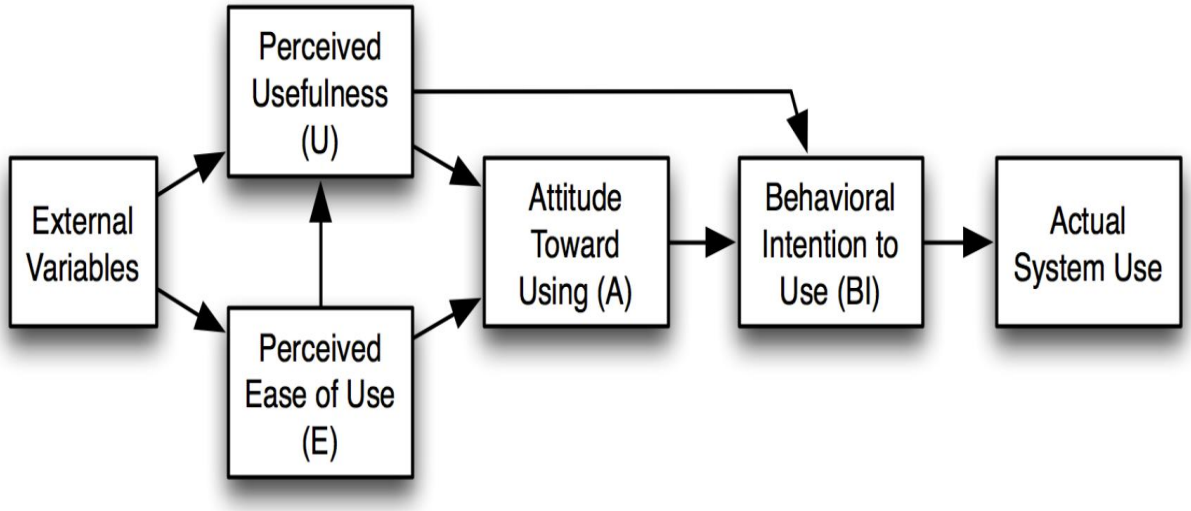

Figure 1: Technology Acceptance Model Adapted from Davis (1989); applied in Liu et al. (2003)

3. Research Methodology

The main objective of this thesis is to evaluate the impact of smartphone technology on university students' learning. This chapter contains the research design applied by the researcher, the tool of data collection, the method applied in data collection, and the method applied in the analysis of the collected data. The philosophy of the research is clearly defined along with the validity, research ethics, and reliability (Wang, 2021; Naveed et al., 2023).

3.1 Theoretical Framework

The research framework is stated along with the variables. The Smart technology is the independent variable, and its impact is being analysed on the Learning that is the dependent variable. The relationship is also mediated by the smart pedagogies to determine the best possible strategies that should be implemented by universities (Hair and Alamer, 2022; Hair et al., 2022).

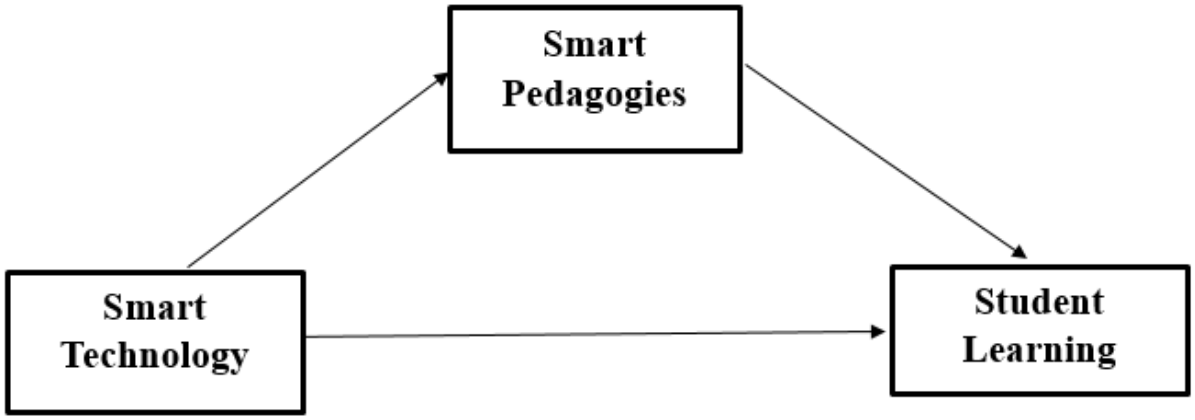

Figure 2: Theoretical Framework of the research

A further detailed model with all the constructs is going to highlight the important variables and their impact on each other. The smart technologies that include mobile technology, artificial intelligence, big data analytics, machine learning and cloud computing will be the independent variable. The Smart technologies and Smart Pedagogies are conceptualized as some high-order constructs that are composed of several first-order dimensions. Smart Pedagogies will be the mediating variable with the appropriate constructs. Learning will be the dependent variable. The impact of smart technologies on learning will be analyzed, and it will be mediated by smart pedagogies. In line with the conceptual model, Smart Technologies and Smart Pedagogies were modelled as second-order reflective constructs composed of several first-order dimensions, while Student Learning was specified as a first-order reflective construct. Smart technology-based constructs are the ones that are adopted by previous research studies (Naveed et al., 2023; Pan et al., 2023; Janson et al., 2024; Ahmad and Ullah, 2022; Mohammad and Abdullah, 2020).

Smart Technologies (ST) – second-order reflective construct comprising Mobile Technology (MT), Big Data Analytics (BD), Artificial Intelligence (AI), Machine Learning (ML) and Cloud Computing (CC). These dimensions reflect the increasing use of intelligent and cloud-based tools in higher education (Naveed et al., 2023; Ahmad and Ullah, 2022; Pan et al., 2023; Garzón and Acevedo, 2025). Items were adapted from Zhu et al. (2016), Wang (2021) and recent work on smart and online learning environments (Pan et al., 2023; Yang, 2021).

Smart Pedagogies (SP) – second-order reflective construct comprising Class-based differentiated instruction (CDI), Group-based collaborative learning (GC), Distance Learning (DL), Individual-based personalized learning (IP), Mass-based generative learning (MG). These dimensions reflect pedagogical practices that exploit smart technologies for personalized, collaborative and generative learning (Zhu et al., 2016; Wang, 2021; Sapiah et al., 2025).

Student Learning (SL) – first-order reflective construct capturing students' perceived improvement in understanding, application of knowledge, problem-solving, critical thinking and engagement as a result of smart technology–supported learning activities (Wang, 2021; Yang, 2021; Pan et al., 2023; Guldan et al., 2025).

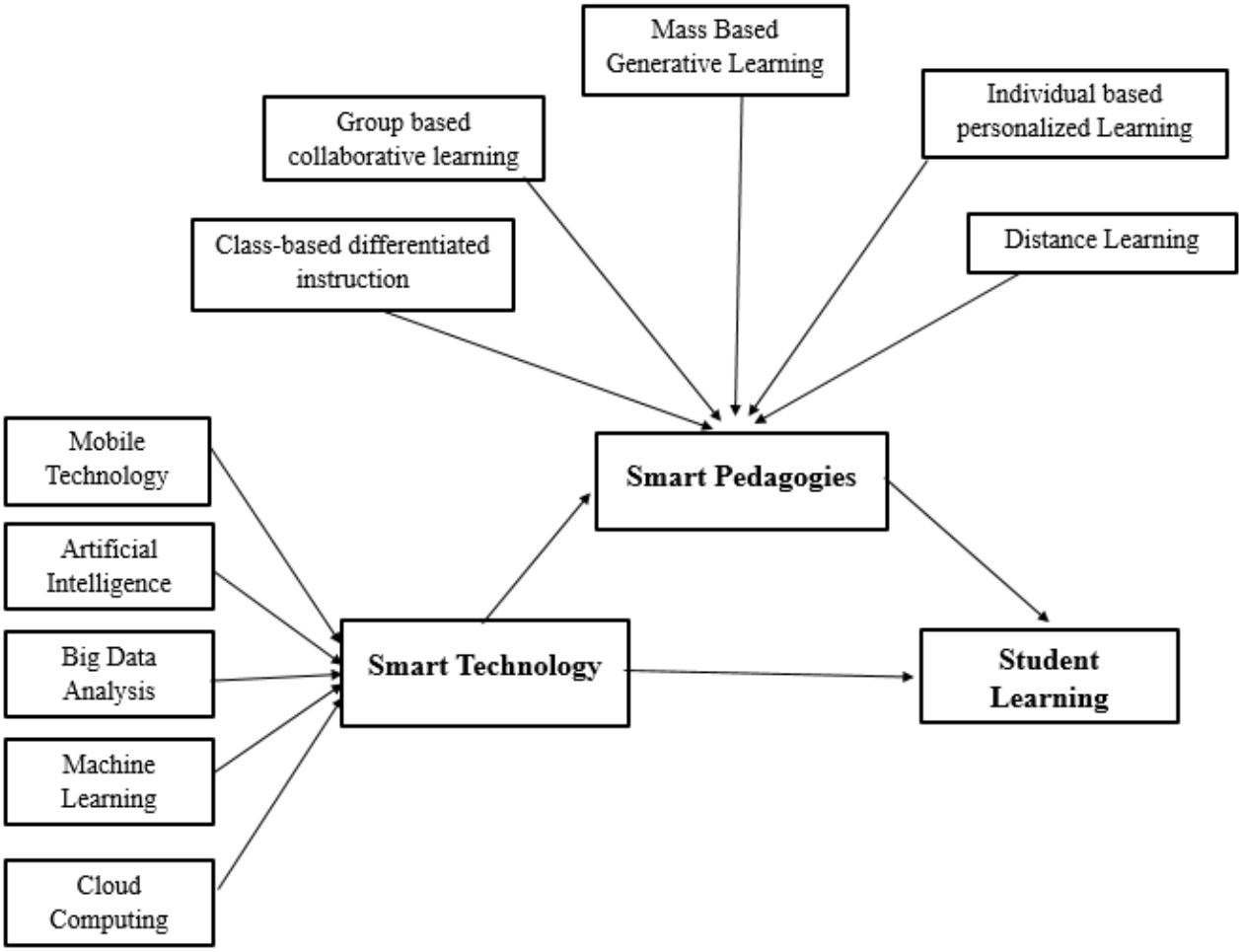

Figure 3: Framework with the constructs for the main variables of the study

3.2 Hypothesis Development

H1: Smart Technologies positively influence Smart Pedagogies.
H2: Smart Technologies positively influence Student Learning.
H3: Smart Pedagogies positively influence Student Learning.
H4: Smart Pedagogies mediate the relationship between Smart Technologies and Student Learning.

3.3 Research Design

The use of an explanatory research design is considered effective towards understanding the relationship between the research variables. De (2006) explanatory research entails the process of applying mathematical and other scientific concepts in identifying relationships in the data. The aim of the research is to find the impact of using Smart technology in student learning. Hesse-Biber & Leavy (2006) state that one can apply a deductive or inductive research approach. Hesse-Biber & Leavy (2006), a deductive research approach is the process of identifying a theory based on the population of interest and conducting research to justify the theory. This research will use a deductive research design to investigate the impact of smartphones on learning. The already existing theory is being tested, and a similar framework has been used by researchers.

3.4 Population and Sample

Podesva & Sharma (2013) state that a researcher who seeks to collect information from a target population must identify a sample to save resources required for the study to be successful.

In this regard, a sample represents a subset of the entire population a researcher is interested in. The data is going to be collected from students at the universities, around 370 students, about the impact of smart technologies mediated by smart pedagogies on learning. The sample size that was finalised was considered adequate for multivariate analysis and structural equation modelling. The sampling strategy that will be used is simple random sampling to avoid bias and ensure that the participants are selected from every university to get reliable information. In this case, the researcher's interest was to evaluate the impact of Smart technology on learning. There are 370 students who will be participating and sharing their opinions through questionnaires about the impact of smart technologies on e-learning.

3.5 Research philosophy

Wong& Williams (2004) research philosophy is indicative of a brief concerning the procedures for analysing and gathering data concerning a certain phenomenon. Wong& Williams (2004) research philosophy is defined by doxology, which is a belief, and an epistemology, which is known. The main aim of research is to transform belief into knowledge. In this regard, this research seeks to analyse the impact of smart technology on learning. Wong& Williams (2004) identify two main research philosophies undertaken in research: the positivist and the interpretivist. Pring (2004) posits that research philosophy is used because it is possible to describe and observe reality based on a person's objective viewpoint. Pring (2004) posits that support for the idea of conducting repeated observation on an isolated phenomenon. In this regard, positivism involves the analysis of a single independent variable through the application of various variations in order to identify the constituent elements, the relationship between elements and the irregularities. This research is based on a positivist research design in which the researcher identified a topic of interest because quantitative data is going to be collected that will be analysed with statistical tools and techniques to ensure reliability, and the findings can be generalised. The information accumulated in this report is accurately written and supported through the analysed data.

3.6 Data Collection

Read & Graham (2002), primary data is data collected by the researcher for the purposes of carrying out research. The main advantages of primary data are that one can tailor the data collected to meet the objective of the research. Secondly, a researcher has confidence in the primary data as a way of bringing forward a new phenomenon or developing a new phenomenon. Thirdly, the researcher can find out much more information for the development of his concept in the process of collecting data from the field.

The research sought to construct a questionnaire, and it will be shared with the students. Harrell (2009) considers a questionnaire as an effective data collection tool which is commonly used in quantitative data analysis. Harrell's (2009) questionnaires are constructed with the objective of the thesis statement in mind. The research adopted a closed-ended questionnaire measured on a five-point Likert scale that was given to the students. The following questions will be focused on when the complete questionnaire is developed. It will be adopted with certain changes to ensure that the objectives of this research can be achieved successfully.

Is Smart technology improving the way in which students learn?

What is the impact of smart technology on the lives of students?

What are the most viable strategic policies for the effective implementation of smart technology in a learning environment?

What is the real use of smart technology for students?

How have smart technologies affected the learning environment of students in the past?

What is the potential of smart technology and internet technology in the classroom?

3.7 Data Analysis

Hesse-Biber & Leavy (2006), the process of data analysis entails evaluation, recapping, condensing, and illustrating the collected data through the application of logical techniques or statistical

methods. The research will be completed by analysing the information received from the questionnaires and using the statistical software for the Social Package. The Structural equation modelling that uses the partial least squares (PLS-SEM) was used through SmartPLS for analysing the structural and measurement models, as the nature of the study was predictive, non-normal data assumptions, and there were many higher-order latent constructs.

3.8 Validity and Reliability

Gregson's (2008) validity test is applied to measure the accuracy and the truthfulness of the instruments used in the research. Gregson's (2008) validity is essential in determining whether the research instrument was capable of answering the research questions and objectives. As a result, the researcher identified that the respondents understood the requirements of the study and the questionnaire questions. The answers given were considered correct and accurate in analysing the data regarding the impact of Smart technology in learning. The validity and reliability were properly measured statistically in the data analysis process. Gregson's (2008) reliability is used to determine the consistency of the research questions with the objectives of the research. Gregson (2008) reliability is achieved through conducting a test and a retest of the variables under study. It is important to apply the same methodology in conducting a reliability test to determine coherence and accuracy. It was an important stage in data collection for explaining the requirements of the study to the respondents and for establishing the reliability of the data. The data was highly reliable and was considered a success by the researcher.

3.9 Research Ethics

Pring (2004) defines research ethics as the code of conduct expected to be observed by any discipline in practice. In this regard, some of the research ethics the research will focus upon include confidentiality, accuracy, reliability, and effective communication for the sake of collecting data. The questionnaires will be distributed to students who are willing to participate in the research study, and they will give their consent. After that, they will be given the questionnaires. The participants will be informed about the purpose of the study, and all the required steps will be taken to ensure authentic data is provided without any bias.

4. Results and Findings

4.1 Sample characteristics

The total number of respondents for the study was 300, out of which 55.7% were male students and 44.3% were female students. There were around 81.3% undergraduate students, and almost 18.7% of the students were in the postgraduate program. There were 39% percent of the respondents from the University of Baluchistan, 18% students were from Sardar Bahadur Khan Women's University, 31% percent students were from BUITEMS and 12% from Lasbela University.

4.1.1 Descriptive statistics

Table 1 shows the descriptive statistics for the constructs of the study based on all the participants, who were the 300 students from Balochistan. The Likert Scale was used, and the mean values along with the standard deviation for the data are given. Further, the data does not have any skewness or kurtosis, as the values are within the range of -2 to +2, which are normal, and they are appropriate for further multivariate analysis.

Table 1: Descriptive statistics of the main study variables (n = 300)

Construct	*Mean*	*Standard Deviation*	*Skewness*	*Kurtosis*
Smart Technologies	3.78	0.71	−0.42	0.36
Smart Pedagogies	3.85	0.68	−0.47	0.41
Student Learning	3.92	0.66	−0.51	0.44

4.1.2 Correlation analysis

Before the structural analysis could be conducted, the correlation analysis was conducted, which tried to analyse the relationship between the main variables of the study, including Smart Technologies, Smart Pedagogies, and Student Learning. Table 2 shows that the variables have a positive and significant relationship, which supports the preliminary hypothesized relationships.

Table 2: Correlation matrix of the main constructs

Construct	*Smart Technologies*	*Smart Pedagogies*	*Student Learning*
Smart Technologies	1.00		
Smart Pedagogies	0.63**	1.00	
Student Learning	0.57**	0.70**	1.00

4.2 Measurement model

4.2.1 Indicator reliability

All of the reflective indicators had the standardized outer loadings of around 0.70, with the majority exceeding 0.75. Two items that had loadings between 0.64 and 0.69 were removed after assessing them based on their content contribution. The final indicator loadings for all the different constructs ranged from 0.71 to around 0.9, which indicated satisfactory indicator reliability (Hair et al., 2022).

4.2.2 Internal consistency and convergent validity

Table 3 Presents the AVE and reliability statistics for the higher order constructs and the overall student learning.

Table 3: Reliability and convergent validity

Construct	*Cronbach's α*	*Composite reliability (CR)*	*AVE*
Smart Technologies (ST)	0.92	0.94	0.70
Smart Pedagogies (SP)	0.93	0.95	0.72
Student Learning (SL)	0.90	0.93	0.68

All the constructs had recommended values above the threshold of 0.70. for the Cronbach's alpha. and the composite reliability is 0.50. for the AVE. This confirmed convergent validity and also the internal consistency (Hair and Alamer, 2022; Magno and Cassia, 2024).

4.2.3 Discriminant validity

The discriminant validity was assessed using the Fornell–Larcker criterion and HTMT ratios. Table 4 shows the square root of the AVE for each construct (diagonal) that is greater than the overall inter-construct correlations (off-diagonal).

Table 4: Fornell–Larcker criterion

Construct	*ST*	*SP*	*SL*
ST	**0.84**		
SP	0.63	**0.85**	
SL	0.57	0.70	**0.82**

HTMT values that were below 0.85 for all the construct pairs (HTMT_ST–SP = 0.74; HTMT_ST–SL = 0.67; HTMT_SP–SL = 0.80), indicated satisfactory level of discriminant validity.

4.3 Structural model

4.3.1 Collinearity and model fit

4.3.2 Explained variance and predictive relevance

Smart technologies were able to explain 42% of the variance that was present in the smart pedagogies (R^2_SP = 0.42). Was around 64% of the variance in student learning that was explained together by the smart pedagogies and smart technologies (R^2_SL = 0.64), This is considered extremely substantial in behavioral research (Hair et al., 2022).

The variance inflation factor (VIF) values were below the value 3.0 for the predictor constructs. This clearly shows that there is no multicollinearity concerns. The Standardized Root Mean Square Residual (SRMR) was 0.054, below the 0.08 cut-off. This suggests that this is an appropriate model fit.

Blindfolding procedures yielded Q^2 Values that were greater than zero for both of the endogenous constructs (Q^2_SP = 0.28; Q^2_SL = 0.44), highlighting good predictive relevance.

4.3.3 Path coefficients and effect sizes

Bootstrapping with the 5,000 subsamples was used to properly assess the significance of the different structural paths. Table 3 summarizes the overall standardized path coefficients, also the *t*-values, along with p-values and the effect sizes (f^2).

Table 5: Structural path coefficients and effect sizes

Hypothesis	*Path*	*β*	*t-value*	*p-value*	f^2	*Interpretation*
H1	ST → SP	0.65	14.02	<0.001	0.72	Large, significant
H2	ST → SL	0.21	2.88	0.004	0.07	Small–medium, significant
H3	SP → SL	0.55	8.73	<0.001	0.42	Medium–large, significant

All the different paths are statistically significant and positive at P <0.01, that is supporting H1, H2 and H3. The Smart technologies have a strong and very significant impact on the Smart Pedagogies and a smaller direct effect on the student learning, while smart pedagogies have a stronger positive impact on the Student Learning.

4.4 Mediation analysis

The mediating role of the Smart Pedagogies between the relationship among Smart Technologies and Student Learning was properly examined by assessing the indirect effects and then comparing the direct effects before and after actually including the mediator (Hair et al. 2022). If we focus on the indirect effect of Smart Technologies on the Student Learning through the Smart Pedagogies, it was:

β_indirect = ST → SP × SP → SL = 0.65 × 0.55 ≈ 0.36

Bootstrapped β_indirect = 0.36, t = 6.02, p < 0.001

In comparison the direct effect of independent variable Smart Technologies on the dependent variable Student learning was significant (β_direct = 0.21, p = 0.004) as the Smart Pedagogies were added to the model the magnitude was reduced as compared to the total effect. The overall total effect was:

β_total = β_direct + β_indirect = 0.21 + 0.36 = 0.57

These results highlight that there is **partial mediation**, supporting H4: Smart Pedagogies strengthen and also partially mediate the significant and positive relationship that exists between Smart Technologies and Student Learning.

4.5 Summary of hypotheses testing

Table 6: Summary of hypotheses

Hypothesis	*Statement*	*Result*
H1	Smart Technologies have a positive effect on Smart Pedagogies.	Supported
H2	Smart Technologies have a positive effect on Student Learning.	Supported
H3	Smart Pedagogies have a positive effect on Student Learning.	Supported
H4	Smart Pedagogies mediate the relationship between Smart Technologies and Student Learning.	Supported

4.6 Structural model diagram

The final PLS-SEM based model can be depicted as follows:

Smart Technologies (ST) → Smart Pedagogies (SP): β = 0.65 (R^2_SP = 0.42)

ST → Student Learning (SL): β = 0.21

SP → SL: β = 0.55 (R^2_SL = 0.64)

The higher-order constructs were represented by the arrows from their dimensions (MT, AI, BD, ML, CC for ST; CDI, GC, IP, DL, MG for SP), as all their outer loadings were exceeding 0.70.

5. Discussion

The findings of the paper highlight that smart technologies and smart pedagogies combined do shape student learning in the public sector universities of Balochistan. This substantial path from the smart technologies to smart pedagogies (β = 0.65) shows that as different universities provide proper access to cloud-based platforms, mobile devices, big data analytics, AI-enhanced tools, and machine learning applications, the teachers are more likely to properly implement the different Smart Pedagogies approaches. These results are also aligned with the recent studies that were conducted related to mobile learning tools and intelligence-based devices used for encouraging personalized, interactive, and collaborative teaching practices (Wang, 2021; Pan et al., 2023; Yang, 2021).

Smart Technologies highlighted a positive and direct effect on student learning (β = 0.21), which indicated that the students were intensively using different smart technologies for their academic tasks and were able to perceive things in a better manner and comprehensively, which highlighted more engagement and improved problem-solving.se findings are aligned with the recent systematic reviews that show that AI and mobile-based learning can support flexibility, improve outcomes, and enhance learner autonomy as they are integrated into the courses (Naveed et al., 2023; Asadullah et al., 2023; Bond et al., 2024; Garzón and Acevedo, 2025).

The strongest effect in the model has been highlighted between smart pedagogies and student learning (β = 0.55), which indicates that the technology alone cannot be sufficient for achieving positive outcomes. It confirms that there is a need for differentiated instruction, personalized tasks, collaborative learning structures, distance-enabled activities, and generative learning opportunities that are able to properly use the technological potential for improved learning. The findings are aligned with the previous strategies conducted on Smart Learning Environment, which used to focus on the central role of the learning design and pedagogy (Zhu et al., 2016; Wang, 2021; Sapiah et al., 2025; Yang, 2021).

The results from the mediation analysis show that Smart Pedagogies are partially mediating the relation between Smart Technologies and Student learning. Smart Technologies have a direct and indirect effect, in which the indirect effect through Smart pedagogies (β_indirect = 0.36) exceeds the direct effect. The primary mechanism is pedagogical, which enhances student learning by using Smart Technologies. Teachers are able to design personalized, engaging, and generative learning activities. That faster is deeper learning, similarly, the immediate role of teaching methods has been reported in different studies that are conducted in different higher education institutions using AI along with smart learning environments (Long et al., 2025; Yang, 2021).

The high R^2 value that was found for Student Learning (0.64) highlights that the combination of

smart pedagogies and smart technologies provides a very powerful kind of explanatory framework. This is something that is noteworthy, particularly in the context of Balochistan, where there are infrastructural constraints and also a digital divide that have historically limited the overall technology-based enhanced learning. The findings are consistent with the previous results of the research studies that indicate integration of smart technologies with smart pedagogies can enhance advanced student learning substantially. The findings support the point of view that even in resource-constrained settings, if there is a properly designed integration of smart pedagogies and Smart Technologies that can enhance student learning substantially (Yang, 2021).

6. Conclusion

This study focused on the impact of smart technologies on student learning in the public sector universities of Balochistan, and focused on the role of smart pedagogies in mediating this relationship. Using PLS-SEM along with the data of the 300 students of the different public sector universities of Balochistan. The analysis highlighted that smart technologies are having a strong and significant impact on smart pedagogies. Further, it was highlighted that smart technologies and smart pedagogies had a very significant positive impact on student learning. Finally, it was determined that smart pedagogies partially mediated the relationship that was present between student learning and smart technologies, with the mediated effect stronger than the direct effect. The results clearly highlight the significant role that Smart Technologies play in enhancing student learning. But their overall effectiveness can be further enhanced by using smart pedagogies that help in leveraging the technology for differentiated, personalized, collaborative, and generative learning. For the different universities of Balochistan, the findings show that the digital transformation should be properly integrated in their pedagogical processes and integrated technology rather than only in investing in the software and hardware.

Limitations and recommendations

There are a few limitations of the study. Firstly, the study has adopted a cross-sectional survey design that limits its overall capability of drawing strong causal inferences; instead, longitudinal or other experimental studies could have captured the changes in technological infrastructure and the different pedagogical practices and how they affected student learning over time. The data is based on the public sector universities in Balochistan, which shows a single regional context. Although the context is very important and significant, and also under research, the findings cannot be generalized to the overall private sector universities. Since the data has been collected from the student, there might have been some common method biases, and there should have been some triangulation that should have been adopted, which is something that future studies can focus on. Also, the research model did not include certain variables like digital literacy, Institutional support, technostress, or the digital divide that have shown a lot of influence on technological adoption and learning outcomes (Krokhina et al., 2024; Janson et al., 2024).

There are some recommendations for practice in which it is crucial to align technology investments with the different pedagogical capacity building. University leaders and the higher education commission should focus on smart infrastructure that includes cloud platforms, AI-enabled tools, and Wi-fi devices. This would allow them to use a systematic capacity-building process for the academic staff, for the purpose of smart pedagogies. There should be more emphasis on professional development programs that are trying to enhance the differentiated tasks, a personalized feedback technology, supported collaborative learning, and distance learning components. It is also recommended that there should be institutional guidelines for properly using smart teaching and learning by focusing on institutions to formulate clear policies or guidelines that would integrate the smart technologies and different smart pedagogies into their courses and programs. These can include ethical guidelines and the way AI tools should be used in teaching and assessment. They should place emphasis on digital literacy throughout the universities of Balochistan.

The uniThe university should focus on the big data tools and learning analytics for monitoring student engagement and also identifying any type of learners at risk so that personalized, timely interventions can be developed. Practices are aligning with the global trends in the AI-enabled education and supporting the evidence-informed decision making (Bond et al., 2024; Yang, 2025).
It is recommended for future researchers to focus on a model that is extended by incorporating moderators such as digital readiness, institutional support, techno stress, and student motivation. Different comparative studies can be conducted across provinces or even countries to properly explore the infrastructural or socioeconomic differences that are shaping the relationship between smart pedagogies, smart technologies, and student learning. The various specific components of smart technologies, like AI-based intelligence learning assistants, along with the cloud e-learning platforms, and the distinct contributions they make to the different dimensions of student learning, such as self-regulation, creativity, and collaboration (Singh et al., 2025; Janson et al., 2024).

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Research Ethics

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