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Towards Smart Universities: An Integrated Framework of Artificial Intelligence, Internet of Things (IoT), and Educational Policy for Digital Transformation

Faheem Ahmed[1], **Kashia Riaz**[2], **Kamran Dahri**[3], **Dr. Iram Saddiqa**[4]
[1] Assistant Professor Department of Information Technology University of Sindh, Jamshoro
Email: faheem.abbasi@usindh.edu.pk
[2] Department of Computer Science, Allama Iqbal Open University, Islamabad, Quaid I Azam University, Islamabad
Email: kashia.riaz@aiou.edu.pk
[3] Assistant Professor, Department of Information Technology, University of Sindh, Jamshoro
Email: kamran.dahri@usindh.edu.pk
[4] Mbbs fcps (physiology), PhD fellow, BUHSCK
Email: doctoriramaamir@yahoo.com

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Corresponding author:
Faheem Ahmed
Email:
faheem.abbasi@usindh.edu.pk

ABSTRACT

The rapid advancement of digital technologies has accelerated the transformation of higher education toward Smart Universities, where Artificial meha (AI), the Internet of Things (IoT), and effective educational policies collectively enhance teaching, learning, governance, and institutional sustainability. This research constructs an integrated framework that describes AI, IoT, and Educational Policy for the sustainable digital transformation of higher education. The framework was quantitatively assessed using a cross-sectional research design. Data were collected using a structured online questionnaire to a sample of 437 people comprising students, faculty, and staff from the universities and IT professionals from public and private universities in Punjab and Sindh, Pakistan. A cross-section of universities was selected, including but not limited to, University of the Punjab, Government College University Lahore, Bahauddin Zakariya University Multan, University of Education Lahore, University of Karachi, NED University of Engineering and Technology, and University of Sindh Jamshoro. The online data collection was done using Google Forms, data were processed in Microsoft Excel, and analytic procedures were done in IBM SPSS Statistics, Version 27. Study Variable Relationships were measured and assessed using Descriptive Statistics, Correlation (Pearson), Multiple Linear Regression, t-Test, and ANOVA (One Way). The research identified the collective impact of AI, IoT, and Educational Policy in the digital transformation of Smart Universities, signifying the value of concurrent coupling of innovation (technology) and governance and/or institutional policy. The framework offers research and practice insights toward Smart and Sustainable Higher Education for university administrators, higher education policymakers, and educators.

Introduction

The continuous advancements in digital technology have compelled universities to change how they provide education, carry out research, and execute other functions. Traditional universities that principally relied on in-person teaching and manual systems are now being required to build new digitally-enabled ecosystems where education is delivered in flexible, data-rich, and learner-centered ways. Rapid advancements in technology such as Artificial Intelligence, the Internet of Things, cloud computing, big data, blockchain, and the smart campus are helping create intelligent educational environments. In these environments, academic processes can easily adapt to the preferences of learners and other stakeholders and become more efficient and personalized. Consequently, for most universities in this era, especially the ones that want to compete in the digital economy, a "Smart University" is the goal. (Zawacki-Richter et al., 2019; Bond et al., 2020)

Emerging technologies are causing students to have stricter expectations and are prompting universities around the world to adopt fundamentally different students strategies to meet the demand of evolving student needs and educational quality. Modern information technologies have blurred the distinction of educational transformation and modern educational governance and teaching practices, research and the organizational ethos of the institution. Universities are utilizing advanced technologies in the transformation of learning and teaching, the management of administrative, research, security and resource operations. The transformation helps universities create adaptive and personalized learning environments, teaches the systems to learn and predict, and improves the efficacy of communication between faculty, students, and administrators (Selwyn, 2019; Dwivedi et al., 2021).

AI enables adaptive learning, automated assessments, data-driven analytics, virtual tutoring, and more, driving major shifts in education. AI education apps analyze student data to discern learning habits, predict student performance, and determine student dropout risk, ultimately recommending individualized learning pathways. These lead to enhanced teacher and student engagement and reduced admin loads for lecturers. Universities are beginning to see that AI will support human intelligence by providing evidence-based teaching and structures for cooperative learning. Recent studies indicate that the inclusion of AI will positively impact learning and the innovative transformation of education when supported by the correct governance and ethics (Holmes et al., 2022; Chiu et al., 2023; Crompton & Burke, 2024).

Artificial Intelligence and Internet of Things as the Foundation of Smart Universities

A Smart University is a completely new model of higher education. It uses embedded digital intelligence at all levels of its operations to build interconnected and automated educational systems at all levels. It builds educational systems that can be modified in response to the new demands of the education system in a particular region. Most digital universities concentrate on online teaching systems and university information systems. Smart Universities use a number of new and emerging technologies—Artificial Intelligence (AI), the Internet of Things (IoT), cloud computing, big data, analytics, edge computing, and intelligent automation—to create learning environments that are responsive to the needs of the teaching and learning processes in a university. Smart Universities use the deep integration of these technologies to transform ordinary university classrooms into intelligent classrooms, automate most of the administrative operations of a university, increase the sustainability of the university campus, improve the university's cybersecurity, and provide real-time personalized recommendations to students. With all of the above in mind, Smart Universities are the most widely acknowledged model of the future of higher education (Antoninis, M. et al., 2023).

The function of Artificial Intelligence in Smart Universities is to mimic the operations of the human brain. AI helps machines to complete tasks that require human-like skills such as teaching, reasoning, making decisions, anticipating, processing language, and recognizing patterns. AI is employed in many areas of higher education. Such areas are teaching systems that help students learn at their own pace, grading systems that help grade students' work, systems that help detect plagiarism, and systems that evaluate the performance of students and assist teachers in their work. AI tools can help universities sift through the large amounts of interactions that students have had in class, their assessments, attendance records, and the systems the universities use to manage students' learning and generate useful recommendations. AI tools become even more useful when universities collect large amounts of student-related data. In such cases, AI tools can be used to identify gaps in student learning, anticipate student dropout, and design courses that maximize the effectiveness of learning. Researchers have shown that the use of AI by universities has a positive impact on student performance and helps the university use its resources more effectively. Additionally, it has a positive impact on strengthening the ability of the university to maintain functionality in the face of challenges (Luckin & Cukurova, 2019).

AI is changing the most basic operations of university administration and how governance works. AI provides thought support systems for university managers that help them create plans to forecast trends in student enrollment, faculty workloads, and the university's physical design and future infrastructure needs, as well as help evaluate key performance indicators for the university. AI systems also help improve budgetary estimates with the aid of financial systems. Automated systems also assist managers in recruitment by providing the means to predict prospective applicants. Research management systems will benefit from AI and machine learning and help identify new and emerging areas of research, suggest and forecast collaborations between research fields, and assist in the discovery of scientific research. These things will assist in developing research management systems. AI provides tools to help university administrators conduct evidence-based management. This will make universities more responsive to the needs of their clients. The introduction of AI increases the number of problems and challenges that require ethical solutions and concerns. Algorihtmic bias, transparency, privacy, and responsible data governance are just a few of the challenges that require the development of policies that control the application of advanced technology while managing the ethical concerns it poses (Bürgin, A, 2023).

Educational Policy as the Strategic Enabler of Digital Transformation in Smart Universities

Successful digital transformation in Smart Universities relies on comprehensive educational policies that offer institutional direction, governance frameworks, ethics, funding models, and rules and regulations. Artificial Intelligence and the Internet of Things provide the technological building blocks for Smart Universities. However, coherent educational policies that construct the integration of technological disruption with institutional mission, national educational priorities, and social concerns are required in order for educational transformation to be meaningful. Educational policies act as the integrator of technology and pedagogy by constructing the means through which Smart Universities are implemented. Thus, policy formulation has emerged as one of the most important defining factors for the establishment of Smart Universities in both developed and developing countries (Badshah, A, et al., 2023).

Digital transformation policies impact nearly all aspects of university operations. This effect is clear in faculty development, curriculum development, digital infrastructure, cybersecurity governance, student data protections, research, innovation, quality assurance, and cross-sector collaboration. Governments have started to recognize the role of universities in readying tomorrow's digitally equipped workforce. As a result, technologically informed, digitally savvy, and interdisciplinary frameworks have started to appear in the higher education policies of various nations. These policy frameworks push universities to update their programs for the broadband age while also emphasizing and integrating critical thinking, ethics, creativity, and the disposition for lifelong learning into their programs. This is especially vital for Industry 4.0 and Society 5.0. Alignment of policies in this manner ensures that a nation's educational goals and technological goals are hand in hand and serve its global competitiveness (Pasi, B, et al., 2026; Saadé, R, et al., 2023).

Educational policy is crucial for resolving the challenges raised by the social and ethical impact of the deployment of Artificial Intelligence and the Internet of Things in higher education. The AI algorithms used in higher education rely on the collection of many personal and academic data and raises challenges for the protection of privacy, the provision of consent, the transparency, fairness and discrimination of algorithms, and the responsibility of institutions. The IoT infrastructures that dominate higher education are used to collect data on the location, behavior, and the environment, and may open universities to cybersecurity threats and data breaches. The effective policy therefore creates a governance mechanism for data and establishes responsibility for cybersecurity and the ethical use of AI, digital rights, and the responsibility of institutions. There is a growing call from international bodies for the adoption of a governance framework for AI that is people-centered and balances the transparency and inclusion of the AI system with its responsible use and offers a consideration for academic freedom and the privacy of individuals. These frameworks balance the alignment of AI with the advancement of educational systems and the rights of individuals (Adel, A, 2024; Quy, V, et al., 2023).

Research Objectives

- To examine the role of Artificial Intelligence (AI) and the Internet of Things (IoT) in facilitating digital transformation within smart universities.

- To investigate the influence of educational policy on the successful integration of Artificial Intelligence (AI) and Internet of Things (IoT) technologies in higher education institutions.

- To develop an integrated conceptual framework that combines Artificial Intelligence (AI), Internet of Things (IoT), and educational policy to support sustainable digital transformation in smart universities.

Research Questions

- How do Artificial Intelligence (AI) and the Internet of Things (IoT) contribute to digital transformation in smart universities?
- How does educational policy influence the successful integration of Artificial Intelligence (AI) and Internet of Things (IoT) technologies in higher education institutions?
- How can an integrated framework combining Artificial Intelligence (AI), Internet of Things (IoT), and educational policy support sustainable digital transformation in smart universities?

Problem Statement

In spite of the promising prospects offered by digital technologies for higher education, universities struggle to achieve holistic digital transformation. This is largely attributed to a piecemeal uptake of Artificial Intelligence (AI) and the Internet of Things (IoT), and supportive education policies. Many higher education institutions unilaterally deploy AI learning systems, smart campus IoT technologies, and digital governance, yet the activities remain ad-hoc and unaligned within a context of a strategic framework that integrates policy, process, and technology. This continues to deny institutions the opportunities offered by efficient, effective, and sustainable campus management and the enhancement of the quality of learning. Unipolar research has mainly addressed AI, IoT, and educational policy in isolation from one another. The lack of a unified framework makes it especially difficult to craft digital transformation strategies that are advanced, ethical, and sustainable. For this reason, there is a strong demand for the construction of an integrative framework of AI, IoT, and educational policy in order to support the situated digital transformation of universities that supports teaching, learning, and research; smart governance; and digital transformation of the whole institution.

Significance of the Study

This study is important for multiple reasons. First, it incorporates AI and IoT into higher education digital transformation literature. Second, it introduces the policy-making component of smart university development to the field of digital transformation. Third, it focuses on the interrelationships between the components to create intelligent, efficient, and sustainable educational ecosystems, considering the components of digital transformation, combined with other frameworks. To this end, the study proposes an original framework and anticipates its adoption by university administrators, policymakers, educators, and tech builders to elaborate on the frameworks and strategies for digital transformation. This framework would enable transformation of teaching and learning, institutional management, research, and efficient use of resources and transformation of sustainability on campuses. The study will also contain the ethical, secure, and caring use of technologies with focused innovations and supportive education policies. The outcome will encourage users to make informed and justified investments in higher education's digital infrastructures, research and educational personnel, and policy frameworks, and digital transformation in higher education that is aligned with strategies and frameworks of transformation in higher education at the national and international levels. This study also fills the gap in the field of higher education research by integrating technology and policy in higher education.

Literature Review

AI is a revolutionary technology for transforming higher education. It changes how universities teach, research, manage, and assist students. The idea of Smart Universities is mostly the result of the application of AI technologies. These technologies help make smart decisions, personalize learning, and design data-centric governance in education. Pham, T et al. (2020) state that Artificial Intelligence in higher education incorporates several technologies such as machine learning, natural language processing, intelligent tutoring systems, expert systems, predictive analytics, and virtual assistants, which all enhance the effectiveness of education and learning. AI, unlike traditional educational technologies, uses a great amount of academic and administrative data, which enables the university the flexibility to alter the services it provides to cater to the personal needs of its students and the needs of the university. As indicated by Lytras, M et al. (2024), AI gives universities the opportunity to move from traditional digital frameworks to intelligent ecosystems that enable, amongst others, adaptive learning, automated assessment, academic advising, and planning.

At the same time, it focuses on the wider picture of digital transformation, where technology concerns not the mere assistance of operations, but the active role of the facilitator of innovation, sustainability, and competition. As such, Smart Universities depend more on AI technologies to build flexible, learner-centered educational frameworks that are evidence based and are easily adaptable to new educational needs and challenges.

Artificial Intelligence (AI) has reshaped the teaching-learning process and improved teaching quality through personalization and adaptiveness. In standardized instructional models, teaching strategies tend to be homogenous and neglect student differences in capabilities, needs, and preferences. AI-based adaptive learning solutions address the shortcomings of traditional pedagogical models. These solutions monitor student learning, detect gaps, and offer adaptive learning content tailored to the individual. According to Mehmood, N (2023), intelligent tutoring systems offer 'one-to-one' instruction by providing personalized learning routes, feedback, and engagement, which, in turn, positively impacts the performance of learners. In addition, Ghnemat, R (2022) commented that AI-based educational applications allow individualized learning by analyzing student progress and dynamically changing educational materials to optimize learning. AI also enhances learning through learning resources when students use chatbots and virtual assistants for real-time support. Faculty also benefits from using virtual learning support systems through reduced workload, while students have improved satisfaction, increased retention, and heightened learning through improving accessibility and engagement. Interested researchers have pointed out that the use of generative AI can encourage and harmful collaborative learning by allowing the automatic generation of educational content and intelligent academic assistance by offering the potential to undermine academic integrity in higher education (Kasneci et al, 2023).

Artificial Intelligence is critical for Smart Universities' management and planning. Aside from teaching, AI impacts all aspects of planning in Smart Universities. Universities have large amounts of data due to admissions, enrollment, studies, finance, research, library data and campus operations. AI and predictive analytics assist in the planning and governance of universities. Yordanova, Z. (2024) states universities can use machine learning to predict future student enrollment and graduation rates, proactively identify students who may fail, and improve the management of teaching staff and university resources. Zeeshan, K et al. (2022) state that AI positively impacts the effectiveness of a university by enabling the use of data for the enhancement and assurance of quality and for the evaluation of the performance of a university and for the implementation of improvement initiatives. Such systems improve the quality of administration and lower costs by automating repetitive activities such as the screening of admissions , scheduling of examinations, verification of documents, and financial reporting. Automated AI literature discovery, data analysis, collaboration and research impact tools can increase a universities research capability and innovation. AI impacts educational quality, sustainability, and competitiveness in higher education.

Internet of Things (IoT) and Smart Campus Development in Higher Education

The Internet of Things (IoT) systems are among the most revolutionary technologies continuing the digital transformation of higher education systems. IoT systems are configured to support the creation of smart, interconnected, and data-centric campus systems. IoT systems are networks of devices that have been embedded with sensors, software, and communication as well as internet capabilities and that are designed to collect, send, and exchange analytic data in an uninterrupted fashion. Al-Emran et al. (2020) argue that, with the use of IoT systems, higher education institutions can connect classrooms, laboratories, libraries, transportation, security, and all the administrative services into one digital ecosystem that will improve the efficiency of institutions and the effectiveness of education. As such, the notion of a smart campus has expanded from the mere application of digital systems to intelligent systems that can perform autonomous monitoring, predictive decision-making, and optimization of resources in real-time. As contended by Alam (2022), smart campuses use IoT systems and combine them with cloud systems, artificial intelligence, and big data in an effort to enhance educational services as well as the sustainability of the campus, the operations of the campus, and the management and governance of the institution. Universities all around the world are becoming increasingly aware of the IoT systems and their services as the basic technology that can create Smart Universities that fulfill the requirements of contemporary pedagogy and the 4th Industrial Revolution.

One of the major advancements brought about by Augmented Intelligence in Higher Education is the resultant development of "smart" learning tools and environments that maximize teaching and learning potential. Conventional classrooms are often not able to meet the technological demands to analyze learning behavior, effectively manage classroom tools and resources, or offer learning assistance in real time. Smart classrooms, designed with the support of the Internet of Things (IoT), address these challenges with the use of an interconnected array of sensors, displays, wearable devices, automatic attendance systems, environment and health sensors, and intelligent communication systems. In the words of Gupta et al. (2023), with the help of the

Internet of Things (IoT), institutions of learning are able to constantly monitor classroom occupancy, temperature, lighting, air quality, and even classroom equipment. This allows the optimal adjustment of classroom environments in a manner that enhances learning and comfort of the students. Connected learning devices also allow students to jointly learn and collaborate, while interacting with the teacher and learning resources in real time, irrespective of distance. In the words of Ray et al. (2021), increased learning and teaching flexibility and improved learning and teaching interaction and engagement, are outcomes of learning environments designed with the support of the Internet of Things (IoT).

Beyond instructional improvement, IoT transforms management and workflow with smart campus management. Today's universities consist of complex systems; buildings, labs, transport systems, libraries, energy systems, healthcare, and security. All of these systems create a lot of operational data. With IoT, we can configure systems and use sensors with smart control to create a campus system that monitors and manages all of these resources. According to Min-Allah and Alrashed (2020) in a smart campus, management and control of energy consumption and management of waste, and control of heating and cooling systems, and control of water supply, are achieved through IoT systems, and as a result, environmental protection is achieved. Predictive maintenance is the same concept. IoT systems monitor maintenance of lab equipment, elevators, and the electrical and mechanical systems of all the buildings on the campus. This helps maintenance staff identify problems before break down. Martínez, I et al., (2021) notes that there is a significant reduction in the cost of running the campus and the sustainability of the campus is greatly improved. Finally, smart management of campus parking systems, smart campus transport systems, and other smart systems, all contribute to the efficient movement of people and improved safety on the campus.

Educational Policy and Digital Governance for Smart Universities

Developing a Smart University involves the integration of educational policy and digital governance, as the presence of advanced technologies alone does not guarantee the successful implementation of a digital transformation. Without the appropriate policy instruments and regulatory frameworks, technological innovations may result in digital disruption instead of a transformation. Intelligent technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), cloud computing, and big data analytics, when combined with digital governance, make the digital Smart University a reality. Educational policies define the visions, governance, ethics, and implementation frameworks for the responsible and effective use of these technologies. According to Mohamed Hashim, M et al., (2022), educational policy is instrumental in the digital transformation of higher educational institutions in an equitable, inclusive, and sustained manner, through the establishment of parameters for the use of technologies, the development of digital competence, the use of ethical artificial intelligence, and the establishment of accountability frameworks. Likewise, the Organisation for Economic Co-operation and Development (Okunlaya, R, et al., 2022) states that effective digital transformation demands an all-encompassing governance system that corresponds technological use to the goals of education, the aims of the institution, and the broader national context. As a result, Smart Universities have come to be appreciated as policy-based educational institutions, where technological innovations are complemented by governance frameworks. Digital governance is the framework policy through which universities manage diverse digital projects, compliance with regulations and sustain innovations within the institution.

Smart Universities' educational policies have the task of developing plans on how new technologies can be embedded in teaching, learning, and research, as well as in administrative processes. The pace of evolution of AI, IoT, blockchain, and other technologies, including learning analytics, has transformed higher education from a traditional knowledge delivery system to advanced educational systems and intelligent ecosystems that require planning and restructuring at the institutional level. The European Commission (2022) argues that to retain global competitiveness in the knowledge economy, digital education policies focus on improving curricula, digital skills, and educators, along with research activities and technology investments. Based on Van Hoang, (2024), educational policies also support the redesign of teaching and learning models that accommodate and promote a student-focused approach, a digital and interdisciplinary way of working, and lifelong learning. As digital technologies are more widely used by universities in all academic and administrative processes, policies need to work together on consistency and sustainability for the long-term growth and development of the institution.

Digital governance makes Smart Universities more effective by encouraging management practices based on evidence. This is accomplished by instituting transparent practices and data governance. Modern universities generate a lot of data. This includes data pertaining to academia, administration, finance, research, and operations. This data requires governance. Digital governance systems allow for universities to incorporate smart technologies that support predictive analytics, create and utilize institutional dashboards, and employ AI-driven decision support systems. These technologies influence the management of finance and the

evaluation of performance, as well as the strategic planning and forecasting of enrollments and the monitoring of academic quality. Governance of data corroborates that institutional data is collected, processed, stored, and used while upholding the legal and ethical standards and maintaining quality, accuracy, and security of data. According to the World Bank (2023), universities that implement digital governance systems are more agile, transparent, effective, and accountable than universities that implement isolated digital systems. Digital governance creates standardized methods of integrating and coordinating university and government policies and practices. This means it creates standardized methods for coordinating university governance and providing inter-university governance, which improves collaboration among university governors, faculty, students, and civil and industrial partners and technology providers. These systems diversify integrated governance and modular governance systems in Smart Universities.

Research Gap

The effects of AI, IoT, and digital transformation on higher education have been the focus of numerous studies, but research on their combined effects as interlinked elements of a Smart University system is virtually non-existent. Studies have largely concentrated on the application of AI to teaching and learning, the creation of smart campus infrastructures through the IoT, and the development of education, policy, and digital governance in a fragmented manner. This has resulted in a lack of understanding of the interconnectedness of these research areas and of their implications for the sustainable digital transformation of education. Furthermore, very few frameworks have been designed to express the unified view of AI, IoT, and educational policy, which would aid in the formulation of strategies and determine directions for the development of institutions in the higher education sector. Research to date has also less frequently addressed the synchronization of technological innovations and governance structures, ethics, institutional preparedness, and sustainability. This has led to a lack of theories and practices in the area of creating a comprehensive integrated model of Smart University education that combines AI, IoT, and educational policymaking. To address this gap, this study proposes an integrated model that presents a clear view of sustainable digital transformation in higher education.

Research Hypotheses

H1: There is a significant positive correlation between Artificial Intelligence (AI), Internet of Things (IoT), Educational Policy, and Digital Transformation in Smart Universities.

H2: Artificial Intelligence (AI), Internet of Things (IoT), and Educational Policy significantly predict Digital Transformation in Smart Universities.

H3: There is a significant difference in perceptions of Digital Transformation in Smart Universities based on respondents' gender.

H4: There is a significant difference in perceptions of Digital Transformation in Smart Universities across respondents with different educational qualification levels.

Conceptual Framework

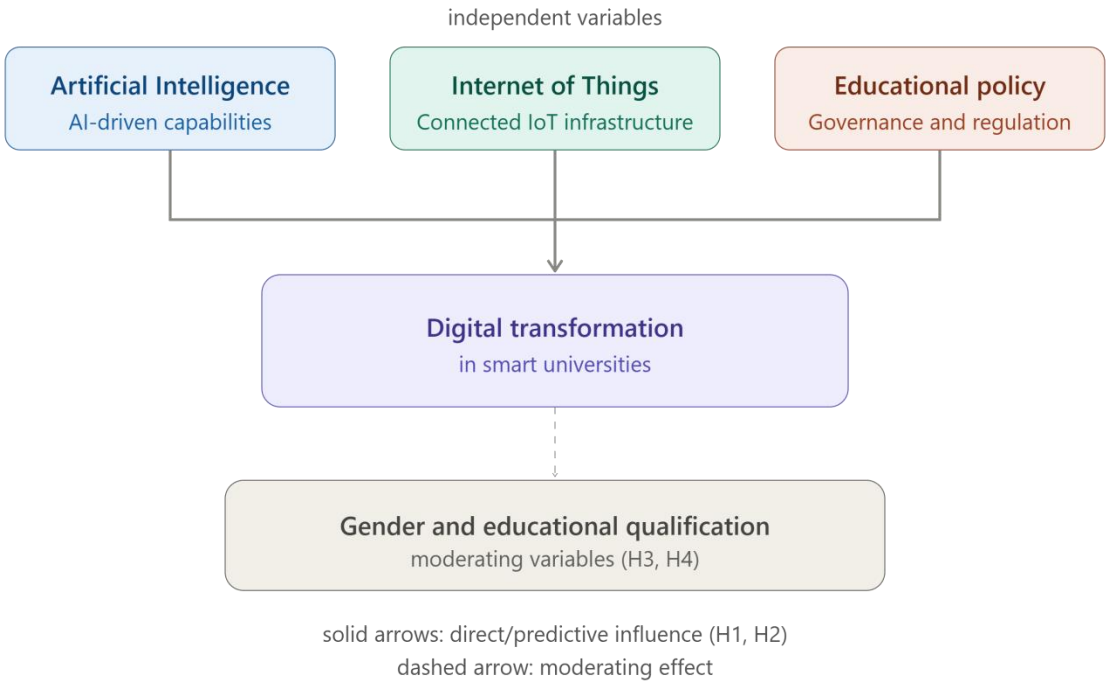

Figure 1: Conceptual Framework

Research Methodology

Research Design

A quantitative approach was deemed fitting for the study since it identifies and objectifies the relationship among research variables through the collection of numerical data that can be analyzed statistically. A cross-sectional survey design was utilized since data were only collected once from respondents. This was conducted to explore the combined role of Artificial Intelligence (AI), Internet of Things (IoT), and Educational Policy for the advancement of the digital transformation of smart universities. The use of a quantitative approach in this study was justified on the grounds that this research approach provides a framework for the objective measurement of the perceptions of respondents, as well as the determination of the relationship of research variables by means of inferential statistics. A researcher-administered questionnaire was the primary means of data collection as the use of a questionnaire enables the respondents to provide uniform responses, thus improving the consistency of data and allowing the researcher to collect data from a large number of respondents (Creswell & Creswell, 2018).

Population of the Study

The study population included the students, teaching staff, academic administrators, and IT professionals employed in public and private higher education institutions in Punjab and Sindh, Pakistan. The selected geographic areas were chosen for the study as they accommodate a majority of Pakistan's higher education institutions and are the most advanced regions, in terms of the adoption of digital technologies for the improvement of educational delivery and management of educational institutions.

#	University	City	Respondents	Percentage
1	University of the Punjab	Lahore	49	11.21%
2	Government College University Lahore	Lahore	38	8.70%
3	University of Education Lahore	Lahore	33	7.55%
4	University of Engineering and Technology Lahore	Lahore	33	7.55%

#	University	City	Respondents	Percentage
5	COMSATS University Islamabad (Lahore Campus)	Lahore	33	7.55%
6	Bahauddin Zakariya University	Multan	38	8.70%
7	The Islamia University of Bahawalpur	Bahawalpur	33	7.55%
8	University of Karachi	Karachi	49	11.21%
9	NED University of Engineering and Technology	Karachi	38	8.70%
10	University of Sindh	Jamshoro	33	7.55%
11	Shah Abdul Latif University	Khairpur	29	6.64%
12	Sindh Madressatul Islam University	Karachi	31	7.09%
Total			**437**	**100%**

Target Audience

The participants were undergraduate students, postgraduate students, and doctoral students, university lecturers, assistant professors, associate professors, professors, academic administrators, information technology officers, digital transformation coordinators, and institutional policymakers of the public and private universities in Punjab and Sindh, Pakistan. These participants were appropriate for the study as they directly concerned teaching and learning, digital governance, and the application of technologies in the higher education sector.

Sampling Technique

Non-probability convenience sampling was used to select respondents from the identified universities. The use of this sampling technique was justified because this type of sampling provided the researcher with the opportunity to access participants who were readily available and willing to complete the survey. Convenience sampling is the most common sampling method used in research related to educational technology and higher education because of its ease of use, low cost, and ability to collect responses from participants who are located in different places and might be in more difficult to access within a short time (Etikan et al., 2016).

Sample Size

The total number of respondents for this particular study was 437. This sample included students, faculty members, university administrators, and information technology professionals working at both public and private higher education institutions in the provinces of Punjab and Sindh in Pakistan. The sample size was adequate to provide sufficient statistical power and an adequate basis for making inferences about the study variables and the relationships among them.

Data Collection Procedure

Data were collected using a survey that was comprised of a structured questionnaire that was modified from a number of studies that were validated and published in research that used Artificial Intelligence, the Internet of Things, educational policy, and digital transformation. The survey was made up of five sections, with four sections containing the measurement items for the study variables, and the other containing the demographic information of the participants. Each measurement item was assessed using a five-point Likert scale in which 1 = Strongly Disagree and 5 = Strongly Agree. The remaining options were used to capture the levels of disagreements or agreements of the participants to the statements.

The measurement scale for Artificial Intelligence (AI) was developed based on Chiu et al. (2023) and Holmes et al. (2022) in terms of AI-enhanced learning, smart decision making, automated learning services, and learner personalization. The Internet of Things (IoT) scale was also developed based on Al-Emran et al. (2020), and Min-Allah and Alrashed (2020) in terms of smart campus design, connected learning technologies, instant monitoring, and smart resource management. The Educational Policy scale was derived from the works of UNESCO (2021), and OECD (2023) in terms of organizational digital governance, policy and support, ethics and regulation, faculty enhancement, and tactical digital planning. The Digital Transformation in Higher Education scale was developed based on the works of Bond et al. (2020), and Dwivedi et al. (2023) in terms of the digital readiness of an organization,

the depth of technology, and the efficiency and effectiveness of operations along with digital learning and innovation in the organization.

Google Forms was used to design the questionnaire. The link for the online survey was shared via institutional emails, university social media groups, WhatsApp groups, and networks of academics, among university staff and students in selected universities of Punjab and Sindh, Pakistan. Participation was completely voluntary. The responses provided in Google Forms were recorded and automatically downloaded into Microsoft Excel, and the data were checked for completeness, accuracy for coding and no missing values, prior to being imported into IBM SPSS Statistics Version 27 for data analysis.

Ethical Considerations

Adhering to ethical principles was a priority throughout the study. The option to participate was offered on a voluntary basis. Participants were offered insight on the study and its aims prior to the completion of the formalized questionnaire. Consent was provided at the onset of the survey. Assurances were provided that identity would be protected and that the data would reside in a confidential framework. The data would be used for formalized, academic study and no personally identifying information would be captured. Participants had the option to exit the survey without consequence at any time. Data collected would be maintained in a secure framework and would be the only information accessible to the researcher. This would be ensured to allow the study to comply with the frameworks of social science research.

Data Analysis

Questionnaires were exported from Google Forms and placed in Excel for the data to be screened, coded, verified, and cleaned. The verified data were placed in IBM SPSS Statistics Version 27 for further analysis. The demographic characteristics of the respondents and the study variables were summarized and described using means, standard deviations, and other calculations of central tendency and variability.

Pearson correlation analysis considered how the components of AI and IoT, Educational Policy, and Digital Transformation in Smart Universities interrelate. Meanwhile, the Multiple Linear Regression analysis studied how AI, IoT, and Educational Policy can affect the Digital Transformation process. Differences in perceptions of Digital Transformation from the respondents' gender were studied using an independent samples t-test. A one-way Analysis of Variance (ANOVA) was applied to check the variance in perceptions of Digital Transformation among respondents with different educational qualifications. The 0.05 level of statistical significance was adopted, and the results were interpreted and presented in relevant tables.

Table 1: **Demographic Characteristics of Respondents (N = 437)**

Demographic Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	236	54.0
	Female	201	46.0
	Total	**437**	**100.0**
Age (Years)	18–25	164	37.5
	26–35	153	35.0
	36–45	82	18.8
	Above 45	38	8.7
	Total	**437**	**100.0**
Educational Qualification	Bachelor's	118	27.0
	Master's	164	37.5
	MPhil	81	18.5
	PhD	74	16.9
	Total	**437**	**100.0**

Demographic Variable	Category	Frequency (n)	Percentage (%)
Respondent Category	Student	216	49.4
	Faculty Member	121	27.7
	University Administrator	56	12.8
	IT Professional	44	10.1
	Total	**437**	**100.0**
Type of University	Public University	256	58.6
	Private University	181	41.4
	Total	**437**	**100.0**
Province	Punjab	279	63.8
	Sindh	158	36.2
	Total	**437**	**100.0**
Teaching/Professional Experience	Less than 5 Years	146	33.4
	5–10 Years	128	29.3
	11–15 Years	88	20.1
	More than 15 Years	75	17.2
	Total	**437**	**100.0**

The demographics reveal a well-balanced sample (N = 437) from both public and private universities in Punjab and Sindh, Pakistan. The balanced gender ratios meant that both genders' viewpoints were included. Most respondents were aged 18 – 35 years, the age group that is most likely to embrace and be active users of the digital technologies available to the higher education sector. Most respondents had at least a Master's Degree, making it highly likely that respondents had the academic background and knowledge to answer questions on AI, IoT, digital transformation/disruption, and educational policy. The respondents' mix of students, university staff, faculty, and administrators, and IT personnel, provided a range of viewpoints on digital disruption/transformation. The higher concentration of respondents from public universities in Punjab reflects the higher number of universities in that province, but it also shows adequate representation of Sindh. The respondents had varied professional backgrounds, which meant diverse and valuably experienced viewpoints and engagement in the topics of smart universities and sustainable digital transformation.

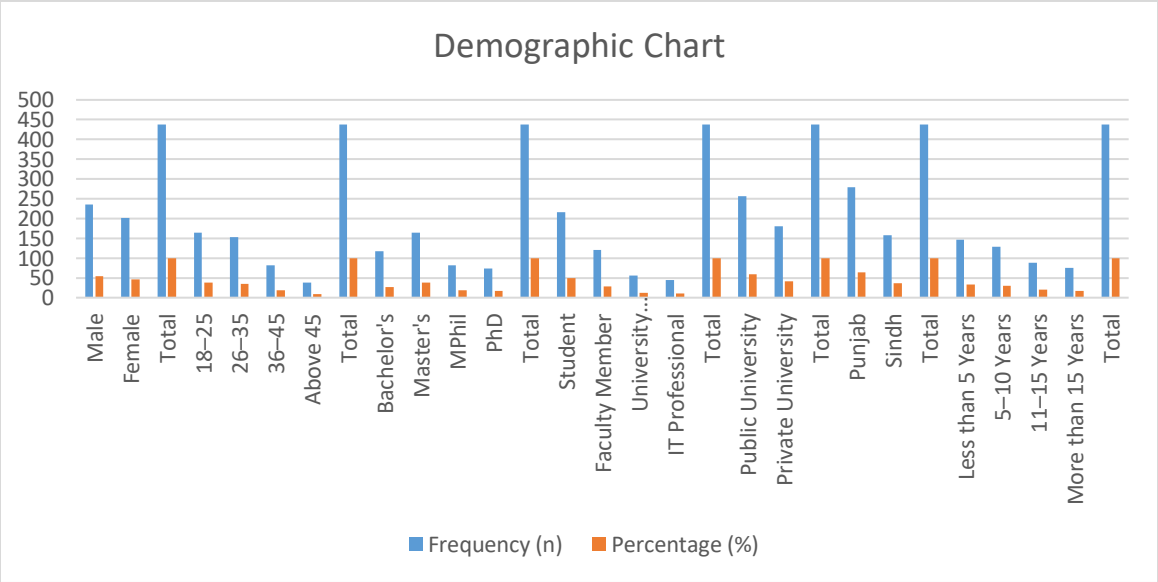

Figure 2 Demographic Chart

Table 2: **Pearson Correlation Analysis among Artificial Intelligence (AI), Internet of Things (IoT), Educational Policy, and Digital Transformation (N = 437)**

Variables	E	2	3	4
1. Artificial Intelligence (AI)	1			
2. Internet of Things (IoT)	.681**	1		
3. Educational Policy	.654**	.627**	1	
4. Digital Transformation	.748**	.712**	.689**	1

To explore the interrelationships of AI, IoT, Educational Policy, and Digital Transformation of Smart Universities, Pearson correlation analysis was used. The data provided evidence for positive and statistically significant relationships of all variables in this study. As all constructs experienced positive correlations, progress in any one variable will simultaneously progress the remaining variables. A strong positive correlation of AI was found with Digital Transformation ($r = .748$, $p < .01$). This suggests that the addition AI in the university system will be parallel with the level of Digital Transformation the university will undertake. The positive correlation of Digital Transformation with IoT ($r = .712$, $p < .01$) has a similar meaning. Educational Policy has a positive correlation with Digital Transformation ($r = .689$, $p < .01$) also. Positive correlations were also found between all the other independent variables Artificial Intelligence and the Internet of Things ($r = .681$, $p < .01$), Artificial Intelligence and Educational Policy ($r = .654$, $p < .01$), and the Internet of Things and Educational Policy ($r = .627$, $p < .01$). The evidence has shown that the greater the Digital Transformation in Smart Universities, the greater the IoT, AI, and necessary Educational Policies will be. The analysis of the data has shown that the variables in the study have statistically significant positive relationships.

Table 3: **Multiple Linear Regression Analysis Predicting Digital Transformation in Smart Universities (N = 437)**

Predictor Variables	B	SE	β	t	p
(Constant)	0.542	0.173	—	3.133	.002
Artificial Intelligence (AI)	0.421	0.049	.438	8.592	< .001
Internet of Things (IoT)	0.296	0.046	.317	6.435	< .001
Educational Policy	0.214	0.043	.246	4.977	< .001

Model Summary

R	R^2	Adjusted R^2	Std. Error of the Estimate
.821	.674	.672	0.381

ANOVA

Source	Sum of Squares	df	Mean Square	F	p
Regression	126.874	3	42.291	290.874	< .001
Residual	62.967	433	0.145		
Total	189.841	436			

A multiple linear regression was performed to analyze how Artificial Intelligence (AI), Internet of Things (IoT), and Educational Policy affect Digital Transformation within Smart Universities. Regression Analysis indicated that the combination of the predictor variables significantly explained Digital Transformation ($F(3, 433) = 290.874$, $p < .001$). The model shows a strong regression ($R = .821$, $R^2 = .674$, Adjusted $R^2 = .672$). Among the predictors, AI was the strongest predictor, followed by IoT and Educational Policy. The model shows that each of the variables was responsible for the positive transformation of Digital Smart Universities. Therefore, the strong positive standardized beta coefficient shows that adoption of AI, Implementation of IoT, and formulation of supportive Educational Policy would lead to the transformation of Digital Smart Universities. The framework developed from the three

variables demonstrates a clear critical policy formulation focus to foster Digital Smart Universities. The focus of the third policy is to foster the support of Digital transformation for Smart Universities. Educational Policy would be critical in supporting this transformation. To determine the influence of gender on the perceptions of Digital Transformation, an independent samples t-test was performed.

Table 4: **Independent Samples *t*-Test for Digital Transformation by Gender (N = 437)**

Group Statistics

Gender	N	Mean	Standard Deviation	Standard Error Mean
Male	236	4.08	0.56	0.036
Female	201	3.91	0.59	0.042

Independent Samples* t-*Test

Variable	Levene's Test (F)	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% CI Lower	95% CI Upper
Digital Transformation	1.284	.258	3.102	435	.002	0.170	0.055	0.062	0.278

Male respondents (M = 4.08, SD = 0.56) held higher perceptions of Digital Transformation than female respondents (M = 3.91, SD = 0.59). Levene's Test showed equal variances (F = 1.284, p = .258). A t-test showed a mean difference of 0.170 among the 436 respondents (t(435) = 3.102, p = .002) with a 95 % confidence interval of 0.062 to 0.278. It was likely that the mean difference among respondents was not caused by sampling error. Levene's Test showed that the Gender Variable was likely to affect the perceptions of respondents of Digital Transformation in Smart Universities, in that male respondents showed a more favorable disposition than female respondents.

Table 5: **One-Way ANOVA for Digital Transformation by Educational Qualification (N = 437)**

Descriptive Statistics

Educational Qualification	N	Mean	Standard Deviation
Bachelor's	118	3.82	0.61
Master's	164	3.98	0.57
MPhil	81	4.15	0.53
PhD	74	4.28	0.49
Total	**437**	**4.03**	**0.57**

ANOVA

Source of Variation	Sum of Squares	df	Mean Square	F	Sig. (p)
Between Groups	8.654	3	2.885	9.482	< .001
Within Groups	131.742	433	0.304		
Total	**140.396**	**436**			

Post Hoc Multiple Comparisons (Tukey HSD)

Comparison	Mean Difference	Sig. (p)
Bachelor's vs Master's	-0.16	.047
Bachelor's vs MPhil	-0.33	< .001
Bachelor's vs PhD	-0.46	< .001
Master's vs MPhil	-0.17	.041
Master's vs PhD	-0.30	.003
MPhil vs PhD	-0.13	.284

A one-way ANOVA was performed for analyzing if Digital Transformation perspectives differ by respondents' educational qualifications. From the descriptive statistics, it was established that the highest mean score of Digital Transformation was reported by respondents holding a PhD (M = 4.28, SD = 0.49), followed by MPhil respondents (M = 4.15, SD = 0.53), respondents with a Master's degree (M = 3.98, SD = 0.57), and by respondents with a Bachelor's degree (M = 3.82, SD = 0.61). The results of the ANOVA analysis indicated that the educational qualification groups differed significantly ($F(3, 433) = 9.482$, $p < .001$). In terms of perceptions of Digital Transformation, respondents with differing educational qualifications differed significantly. The Tukey HSD post hoc analysis, in the set of educational qualification respondents, also revealed significant differences among respondents who hold Bachelor's and Master's degrees, Bachelor's and MPhil degrees, Bachelor's and PhD degrees, and Master's and PhD degrees. The difference in respondents who hold MPhil and PhD degrees was not significant. Based on the findings of this study, it may be concluded that respondents with higher educational qualifications reported higher perceptions of digital transformation in smart universities, which may indicate that higher educational qualifications are positively related to higher perceptions and acceptance of emerging digital technologies in the higher education sector.

Discussion

This research highlights the value of AI, IoT, and Educational Policy integration in the digital transformation of Smart Universities. The Fourth Industrial Revolution and Society 5.0 demand more from higher education. Integrating smart technologies with adaptive governance increasingly augments teaching and learning, research, and the management and sustainability of the campus. This research articulated an integrated model for AI, IoT, and Educational Policy to capture the digital transformation in higher education. The empirical data revealed meaningful connections for the various elements of the research, and argued that the governance of educational systems in the systems' Smart Universities offers the conditions for the advanced integration of technologies. The results corroborate the new research, which postulates that the digital transformation thought the governance of educational systems in the Systems' Smart Universities supports the conditions for the advanced integration of technologies (Truong, T et al., 2023).

Statistically significant positive correlations among Artificial Intelligence, Internet of Things, Educational Policy, and Digital Transformation emerged from a Pearson correlation analysis. These results imply that greater digital transformations of universities are likely to occur with the advanced implementation of AI, IoT, and supportive educational policies. The strongest correlation was found between Artificial Intelligence and Digital Transformation. This correlation indicates that Artificial Intelligence is likely one of the most predominant technologies facilitating the development of smart higher education. This statement is supported by a systematic review of the literature by Mohamed Hashim et al. (2022), where the primary focus of the review was the numerous ways in which Artificial Intelligence enhances adaptive learning, academic decision-making and intelligent tutoring systems and the overall management of a higher education institution. Likewise, Zabalawi et al. (2024) stated that with the use of Artificial Intelligence, universities are able to offer personalized learning and undertake academic planning and assessments based on predictive analytics, which are likely to result in the acceleration of digital transformation of the institution. The positive correlation between IoT and Digital Transformation is further supported by Izourane et al. (2024) and George et al. (2023), who stated that IoT makes smart management of the university campus and smart classrooms and energy efficiency and real-time monitoring of the university possible. Moreover, the correlation between Educational Policy and Digital Transformation signifies the role of strategic governance in the planning and management of technology. Rosak-Szyrocka et al. (2025) argue that the ethical use of technology and digitalization policy, including the digital capacity of the institution and the faculty, are

preconditions of successful digital transformation. From the correlation results, it may be concluded that both technology and governance smart structures are needed for sustainable digital transformation of Smart Universities.

The analysis of multiple linear regression indicated that collectively, Artificial Intelligence, the Internet of Things, and Educational Policy explained a large amount of variance in Digital Transformation, and that, of the three, Artificial Intelligence, was the most dominant predictor. This analysis has also demonstrated the importance of the role AI plays in this transformation for higher education institutes for the development of Intelligent Learning Environments that are able to support the innovation of research; automation of administration; adaptive instructional delivery; and the predictive abilities of instructional and administrative decision-making. The dominant predictive role of AI also supports the findings of Pedro, F et al (2019) that noted the advancement of educational quality through artificial intelligence based learning systems, virtual learning assistants, automated feedback, and learning analytics, and of Toprak, M. (2024). The Internet of Things was the other main dominant predictive role for Digital Transformation. Its predictive role denotes that Smart Universities will contain intelligent campus infrastructures. These intelligent infrastructures will be able to manage, monitor, and care for the campus in learning environments that are connected and teach in a predictive manner. This is in line with the research of Yadav, D (2024) who noted that the Internet of Things enabled the creation of smart campuses which enhanced sustainability and operational effectiveness and accessibility of education. Educational Policy was another significant predictor of Digital Transformation and indicated that changes in education do not occur through the making of a technological investment alone, adequate frameworks for governance and planning are also needed. This is in line with the research of Alhazmi, A et al. (2022) regarding the necessity of coordinated policies. The proposed integrated framework is confirmed by regression in that, within the context of educational governance, the outcome of digital transformation is a result of the convergence of technological innovations and successful educational governance.

An independent samples t-test indicated significant perceptions of Digital Transformation and gender differences. Men were more inclined to perceive Digital Transformation than women respondents. Hence, perceptions of emerging educational technologies have a gender dimension. Although the difference is small, it is plausible that universities in the implementation of Digital Transformation and in the adoption of technologies, consider gender-sensitive approaches. Results of a review of literature on technology acceptance reveal inconsistent results on gender difference. Venkatesh et al (2003) stated that during the initial phases of technology implementation; gender difference can be in the perceptions of usefulness and ease of using a technology, as well as the intention to use the technology. Recent studies on educational technologies, such as that of De la Vega Hernández et al (2024), indicate that the differences in digital engagement stem from different levels of experiences with technology, and support from the institution, as well as digital literacy, and are not a reflection of gender differences. Hence, the gaps in the adoption and use of technology and participation in activities within the educational ecosystem can be addressed by ensuring that all stakeholders have equal access to digital technologies and institutional support.

A one-way Analysis of Variance (ANOVA) found that educational qualifications statistically impacted how respondents perceived Digital Transformation. Respondents with Master of Philosophy (MPhil) and Doctor of Philosophy (PhD) degrees had improved perceptions of Digital Transformation in comparison to respondents with Bachelor's degrees. This may imply that advanced degree holders are more comfortable with emergent technologies, digital research, and innovations within the sector and the institutions. This and other studies, including that of Holmes et al. (2022), have found that higher educational attainment is positively associated with digital skills, awareness of Artificial Intelligence (AI) and educational innovations, and acceptance of the innovations in education. UNESCO (2023) substantiated that digital skills, research, and training and professional development greatly affect a person's readiness for the adoption of smart educational technologies. This unites the findings of this study and those of other studies in suggesting the need for educational institutions to strengthen digital competency training for undergraduate students and early career academics. This will strengthen the preparedness of all institutional stakeholders for smart university environments.

Conclusion

The present work studied the intertwined role of Artificial Intelligence (AI), the Internet of Things (IoT), and Educational Policy in designing the sustainable digital transformation of Smart Universities. The results explained that the three complementary systems positively affect the restructuring of higher education systems in relation to teaching and learning, governance, research, and the operations of the campus. The correlation analysis identified significant positive correlations of AI, IoT, Educational Policy, and Digital Transformation. The multiple regression analysis indicated that the combined set of variables defined a significant portion of the prediction of digital transformation, in which Artificial Intelligence, in particular, was the most prominent predictor. The

independent samples t-test and one-way ANOVA revealed that the respondents' perceptions of the digital transformation were not the same, and were (in particular) gendered and education-based. The results illustrate that the respondents' perceptions of the digital transformation were differentiated by demographic factors, and that the advanced educational technologies and the transformation of educational systems were dependent upon the governance of the technologies and the administrative policies of the universities. The results also present a sustainable digital transformation of Smart Universities.

The study concludes that sustainable digital transformation in higher education requires an integrated approach located within a unified governance structure that combines advanced technologies with Artificial Intelligence and the Internet of Things, along with educational policies. Focused investment in smart digital infrastructure, combined with the building of faculty capacity, investment in digital security and ethical technology governance, and supportive policies has the potential to radically change higher education. The integrated framework developed in this study will assist university administrators, policy-makers, educators and technology developers who seek to innovate and reform higher education. The study also addresses the gaps in the current literature, especially in the area of Smart University, by providing a comprehensive analysis. In the interest of moving the sustainable digital transformation agenda in higher education further, subsequent studies may include their own variations of this framework to include additional, applicable, technological, organizational and behavioral dimensions within different educational systems and different countries.

Recommendations

1. Universities should integrate Artificial Intelligence (AI) into teaching, learning, research, and administrative processes to enhance educational quality and operational efficiency.

2. Higher education institutions should invest in Internet of Things (IoT)-enabled smart campus infrastructure to improve resource management, campus security, and sustainability.

3. Policymakers should develop comprehensive educational policies that support ethical AI adoption, digital governance, cybersecurity, and data privacy in universities.

4. Universities should provide continuous professional development and digital skills training for faculty members, administrators, and students to strengthen digital competencies.

5. Institutional leaders should establish integrated digital transformation strategies that align AI, IoT, and educational policy with long-term organizational goals.

6. Universities should strengthen digital infrastructure and promote collaboration with industry and technology partners to accelerate innovation and Smart University development.

7. Future researchers should extend the proposed integrated framework by examining additional technological, organizational, and behavioral factors across different higher education contexts to enhance the generalizability of the findings.

Future Implications

This research lays a comprehensive groundwork for the development of Smart Universities with the integrated use of Artificial Intelligence (AI), the Internet of Things (IoT), and educational policy. These developments combined with the rapid evolution of other technologies (i.e., generative AI, digital twins, blockchain, edge computing, learning analytics) present higher educational organizations with the potential to construct intelligent, adaptive, and sustainable learning ecosystems. The integrated framework focuses university administrators and policymakers on the construction of real-world organizations which incorporate innovation, a rational approach to the use of data, ethics, and the personalization of learning. Additionally, the study includes the need to focus digital infrastructure and digital competencies of faculty and policy frameworks and cybersecurity if digital transformation initiatives are to succeed. Future research could elaborate on this framework encompassing more behavioral and technological variables, cross-national and long-range studies and focus on the effects of new technologies on the quality of education and the

sustainable development of institutions. This research would strengthen the digital transformation of higher education and the establishment of Smart Universities that are adaptive, inclusive, and competitive on a global scale.

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