Digital Transformation in Education, Research and Community Service for Smart Campus

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Abstract. Technological developments, particularly in the field of Information and Community Technology (ICT), have made it possible for Higher Education Institutions (HEIs) to adopt digital technologies that enhance education, research, and community service. These three components are interrelated in higher education and are referred to as the three pillars of Tridharma. A tangible example of DT in HEIs is the Smart Campus concept. The 61 selected articles from 2014 to 2024 that comprise this paper's systematic literature review explore and clarify the ways in which DT contributes to the development of Smart Campus environments. In addition to outlining research directions that advance campus smartness, the study explains the idea of DT. The study puts the TridharmaX model, a conceptual framework that combines technical breakthroughs with the traditional ideals of education, research, and community service. The goal of this approach is to address the challenges and opportunities involved in becoming a Smart Campus. The research highlights the necessity of using particular standards and evaluation instruments to gauge the success of the Smart Campus initiative. The results show that DT can greatly increase HEI efficacy in education, research, and community service. Clear measuring frameworks are used to establish the advantages of integrated ICT techniques in Smart Campuses.

Keywords: Campus smartness, Digital transformation, Higher education, Smart Campus.

1   Introduction

Strategic DT is becoming more and more necessary for HEIs to adapt to societal and technical changes as hubs for innovations and knowledge production. The Smart Campus is one of the new ideas in this area [1],[2]. According to Imbar et al., a Smart Campus is a campus that utilizes technological resources to solve challenges by offering Smart Services to improve the quality of life. The Smart Services use available technologies to run Smart System processes automatically with minimum human intervention [3].

The Smart Campus approach enables HEIs to align more effectively with the demands of the digital economy and the evolving needs of students, employers, and society [4].

HEIs, as centers of knowledge, research, and community services, are required to achieve the best targets because a Smart Campus is not just a physical campus. By implementing the Smart Campus concept, educational institutions can set and measure relevant Key Performance Indicators (KPIs), such as student satisfaction levels, academic outcomes, and teaching effectiveness, all of which contribute to improving the overall quality of education. In addition, KPIs for HEIs include graduate employability, external student engagement, lecturers outside the HEIs, lecturer qualifications, implementation of faculty research, study program partnerships, classroom learning, and international [5][6]. However, structured guidelines for Information and Communication Technology (ICT) application in HEI settings are limited, posing challenges for institutions attempting to develop a Smart Campus [2].

Driven by competition, HEIs seek to improve their education, research, and community service processes to remain relevant. Emergency remote teaching during COVID-19 further highlighted the importance of technology in reshaping learning activities and assessments [7]. Digitalization in HEIs is an issue that concerns many educational stakeholders. ICT skills are becoming increasingly relevant in every context. One of the prime objectives for HEIs is to prepare future professionals to deal with problems and search for solutions, including digital competence as a vital skill set [8]. This challenge requires HEIs to improve the quality of learning to meet the demands of the times and optimize the use of technology to create a better academic environment.

In order to meet these demands, DT has emerged as a crucial facilitator for HEIs, enabling the creation of successful learning models that are amenable to ongoing improvement [9]. DT refers to new commercial ventures and methods of operation. Digital technology involves integrating digital technology into ever aspect of business, which will fundamentally change how companies function and provide value to their clients [10]. The education, research, and community service processes are the three interconnected parts of HEIs. These components are called the three pillars of Tridharma. Based on the Law of the Republic of Indonesia Number 12 of 2012 on higher education, Tridharma is the obligation of HEIs to conduct education processes, research, and community service [11]. This integrated approach ensures that educational institutions focus on academic excellence and contribute to community development through research and community engagement. The Director General of Higher Education, Ministry of Education and Culture, has also provided guidelines for higher education implementation and evaluation of lecturer workloads in carrying out the Tridharma of higher education [12].

Guided by the current need to equip young minds with 21st-century skills, the integration of ICT in education has changed the teaching and learning take place in educational institutions [13]. This study presents a systematic literature review to explore the intersection of DT and Tridharma through the lens of Smart Campus development.

2   Review Results

A systematic literature review is a method for evaluating and interpreting all relevant research relevant to a specific research question, topic area, or phenomenon of interest.

This study provides an unbiased evaluation of the research topic using a reliable, rigorous, and auditable methodology [14]. Table 1 shows inclusion and exclusion criteria as selection criteria for articles. A total of 61 selected articles from 2014 and 2024 were included after screening and quality assessment.

Table 1. Table captions should be placed above the tables.

Inclusion	Exclusion
Papers published between 2014 and 2024	Papers published before 2014
Journal Articles	Articles not relevant to the RQs
Conference Papers	News, reviews, non-academic articles, and opinions.
Publications in English	Publications in other languages
Studies related to Digital Transformation, Higher Education, Smart Campus, Smart Campus Framework and Smart Campus Model	Studies that are not relevant to the research topic

This section provides a detailed discussion based on the selected articles that answer the RQs.

2.1 RQ1: What Are the Key Areas where Smart Tridharma Applied in Developing Smart Campus?

The three primary pillars of HEIs (education, research, and community service) are connected to Smart Campus initiatives through the Smart Tridharma. The findings often demonstrate students' interest in attending a particular university [3], [15].

The Smart Tridharma identifies three critical areas that are essential to the creation of a smart campus. These domains provide a foundation for integrating Smart Systems to enable comprehensive operations. Several conceptual models have been proposed to support Smart Campus development. For instance, the Garuda Smart Campus Model, developed by SCCIC, provides a contextualized framework for measuring smartness in Indonesian HEIs [16]. A Smart Campus measurement model can be developed to measure the current level based on anthropocentric, systemic, and technological perspectives [2], [3], [17]. HEIs development also includes administrative modernization, curriculum reshaping, and instructional redesign, as shown in studies like Nguyen's [9] These modifications are a component of a larger Smart Campus Model that supports flexible learning spaces by including Smart Classroom settings [18], [19], [20], [21].

2.2   RQ2: What Are the Opportunities and Challenges in Implementing Smart Tridharma within Higher Education?

Some of the most noteworthy benefits are as follows: Smart technologies facilitate more successful and tailored educational experiences by enabling innovation in research, data-driven training, and adaptive learning systems [22], [23]. Increasing competitiveness and attractiveness: Smart campus implementations attract more students and improve university rankings [24], [25]. Efficiency and data-driven decision-making: Improved governance and resource allocation are made possible by real-time data analytics [22].

Despite these benefits, there are still many obstacles to overcome, such as: Technological and Infrastructure Restraints: Access to dependable digital infrastructure is a problem for many HEIs [26]. Institutional Readiness and Faculty Resistance: Institutional inertia and skills deficits frequently impede the adoption of new technology. Due to a lack of desire, training, or a clear institutional vision, faculty and staff may oppose digital projects [27]. Digital Skills and Readiness: Disparities in staff and student digital literacy may make it more difficult for Smart technology to be adopted and used fairly. HEIs must address these issues with all-encompassing initiatives that include inclusive digital policies, professional capacity building, and infrastructure development if they are to fully grasp the potential of Smart Tridharma [28].

2.3   RQ3: How Should Smart Tridharma Be Used To Accelerate The Achievement Of Campus Smartness?

Implementing Answer RQ3 to enhance campus smartness selecting articles present valuable insights into Smart Campus concepts integration and operationalization, emphasizing technological enhancement, effective user engagement, and adaptive support systems. (1) Technological Infrastructure and Smart Campus Models [2], [9], [10]. (2) Digital Transformation in Education and Personalized Learning [29], [25], [24], [30]. (3) Student-Centric Services and Support Systems [31], [23], [32], [33]. (4Evaluation and Measurement for Continuous Improvement [2], [10], [34], [35].

Moreover, the adoption of Education 4.0, driven by the Fourth Industrial Revolution, underscores the necessity of aligning ICT infrastructure, pedagogical design, and institutional policies. The integration of competencies, technologies, and innovation ecosystems is vital to creating learning environments that are agile, inclusive, and future-ready [17], [36].

3   Research Opportunities

The Smart Tridharma method offers a basis for integration as HEIs work to develop more responsive learning environments. AI and big data provide personalized learning, which fosters lifelong learning and allows for customized educational experiences. A ranking that takes into account the responsibilities of both technology and people is

necessary for a smart system to achieve requirements. The more technology is used, the more intelligent the system gets.

The TridharmaX places a high value on interconnection, flexibility, and inclusivity while designing Smart Campuses. It promotes the thoughtful synchronization of policy, infrastructure, instruction, and engagement in the community. It establishes the foundation for future research that will evaluate, enhance, and broaden the use of Smart Campuses in different learning settings.

The Smart System cycle consists of the following processes: Sensing involves gathering data, understanding involves preprocessing and analyzing data, decision-making involves making decisions based on analysis, action involves choosing the optimal course of action, and learning involves learning from the decisions made.
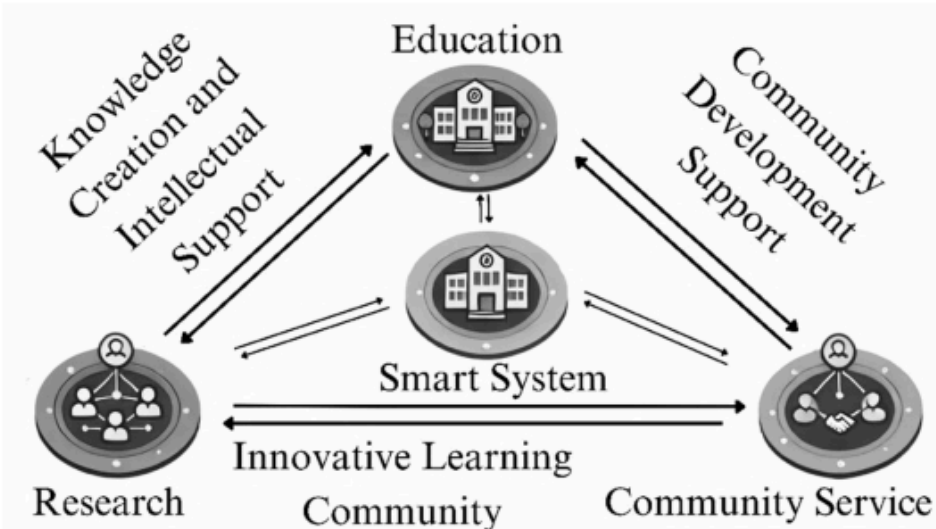

Fig. 1. TridharmaX Model

4   Conclusion

This systematic literature review has identified key areas where Smart Tridharma can be applied, indicating that its integration into education, research, and community service can significantly enhance campus smartness. The findings suggest that technology applications can improve the quality of learning, drive research innovation, and increase community engagement in community service. Furthermore, the review has highlighted the opportunities and challenges of implementing Smart Tridharma. The ability to integrate DT is critical in response to the needs of a Smart Campus. This study emphasizes the need for clear guidelines and measurement instruments to evaluate the effectiveness of Smart Campus initiatives. The study proposes the TridharmaX model as a foundational framework for future research and implementation. This model encapsulates the dynamic interplay between traditional academic missions and emerging technologies, offering a pathway toward more agile, inclusive, and sustainable higher education systems. Future research is recommended

to develop concrete guidelines, metrics, and case studies that demonstrate the model's adaptability across varied institutional contexts.

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PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8