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A systematic review of smart campus technologies to improve students' educational experiences

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Abstract— **The concept of a smart campus (SC) is growing, enabling institutions to improve their services, decision-making processes, and overall campus sustainability. The current epidemic has sparked and strengthened the need for a paradigm shift, with virtual schooling and remote work emerging as attractive alternatives. As an educational institution, understanding campus users' learning experiences is crucial for reviewing and ensuring outstanding university courses. This study examines the concept of smart campuses, their applications, and the potential for better learning experiences. Using the Scopus database, the researchers conducted a comprehensive literature review. At the outset, 54 items were collected. Following a screening process of 38 publications using inclusion and exclusion criteria, 18 were eventually included in the review. This study discovered that smart campuses are a valuable concept that should be developed and implemented in institutions. Aside from that, the smart campus application raises other potential options, including the use of augmented and virtual reality to enhance learning, the exploration of daily internet traffic, which enables traffic forecasting to optimize network service, and personalized services. As a result, this study adds to the understanding of the potential applications of smart campuses, particularly in the learning process on community campuses.**

Keywords— smart campus; education; learning; students

I. INTRODUCTION

The COVID-19 epidemic has accelerated universities' digital transformation by leveraging information and communications technology (ICT), digital management, and remote instruction [1]. Beyond technology, the future university aspires to meet stakeholder demands while also improving livability and quality of life, which aligns with the goal of smart campuses. The concept of the smart campus, which originated in 2000 [2], is still in its early stages, with no agreement on its definition, dimensions, or attributes. Smart campuses are conceptualized from three perspectives: technology-driven, organizational process-driven, and smart-city-driven [3].

Technology, notably the Internet of Things (IoT) and ICT, is driving smart campuses, raising the amount of information technology in higher education [1]. A wide range of technologies rapidly digitize processes, education, research, and services. The smart city combines social, economic, and environmental awareness to improve people' quality of life with cutting-edge technology such as ICT and IoT [4]. The smart campus aligns with smart city developments by leveraging technology and sustainability to transform institutions into digital and sustainable enterprises [5]. Smart campuses, with a similar structure, can be used as small-scale city models for smart city projects.

II. SMART CAMPUS

A. Definition

A standard definition of "smart campus" is lacking in literature, however authors have provided their own interpretations. [6] defines it as an effort that uses ICT to improve services, save costs, and create effective connection with campus members [7]. It can be described as a digitally augmented campus with interactive items and environments. [8] emphasized the smart campus's function in dynamically delivering services based on user needs via intelligent systems.

B. Caracterestics

The smart campus represents a new frontier in information education, with technologies such as social networks, big data, mobile technology, and the Internet of Things serving as the foundation for educational informatization. These technologies serve as carriers and support systems, providing new insights for the study of educational technology. The implementation of Internet of Things technology is fundamental to the "smart" in the smart campus.

Informationization: The intelligent campus values the use of comprehensive educational data to make educated judgments. It stresses the provision of services spanning many sectors and disciplines, with an emphasis on developing teaching assistants' information technology literacy so that they may actively contribute to the school's development.

Technology: Building virtual representations of intelligent campuses requires the use of technologies like as social networking, cloud computing, big data, the internet of things, artificial intelligence, and virtual reality. Business knowledge based on educational big data is critical in the development of smart campuses. The use of virtual reality technology is critical for successfully presenting the entire campus scene. The successful implementation of the smart campus model requires the establishment of a service framework that supports open technology and provides complete technical assistance.

Construction mode: Colleges and universities moving to smart campuses go through a development phase that includes general planning and collaboration from technical institutes. This uses a simplified and rapidly evolving model for the coordinated evolution of educational information. The complex information technology infrastructure necessitates collaborative efforts from the campus information system, social information system, and smart campus service providers. These components work together to guarantee the smart campus construction runs smoothly and is well-maintained.

III. METHODOLOGY

After outlining the major issues, we outline the technique employed in the literature review.

A. *Definition of the problem*

TABLE I. TABLE TYPE STYLES

ID	Research Question	Motivation
RQ1	What are the smart campus concepts?	Identify smart campus perceptions so that you may construct a smart campus with objective guidelines.
RQ2	What technologies assist smart campuses?	Identify the appropriate technology utilized to construct smart campus and its specific application.
RQ3	What are the issues with typical smart campuses?	Identify the smart campus application and explore difficulties related to it.
RQ4	What are smart campus features?	Identify the ameliorations of smart campus that motivates university management to develop it
RQ5	Is there the standard model for the smart campus in HEI?	Identify the generic model that could be adopted for smart campus development in the universities

B. *Method*

The purpose of this project is to conduct a thorough, transparent, and reproducible literature evaluation on smart campuses. Our technique is guided by recommendations aimed at improving the quality of the review process and honing our research findings.

Figure 1:The review process

We employed a four-stage technique based on Planning, Search, Analysis, and Reporting to thoroughly investigate the notion of the SC.

IV. REVIEW AND RESULT

A. *Smart Campus Concept*

The concept of a smart campus, also known as an intelligent campus (icampus), has received considerable interest in academic research. To gain a thorough knowledge of the smart campus concept, researchers look at subjects such as holistic e-learning, social networking, collaborative work communication, and green and ICT sustainability. Kwok [9] provides a thorough description that spans several elements, with a special emphasis on the approach to the learning process. [3] investigates student opinions of the smart campus using an online survey platform at two colleges in Thailand and the Czech Republic. The study indicates a variety of opinions, with Thai students viewing the smart campus as an intrinsic part of their everyday lives, which may be influenced by cultural and geographic variances.

B. Smart campus technology

Cloud computing, IoT, Virtual Reality, Augmented Reality, Artificial Intelligence, and mobile devices have been recognized as enabling technologies for smart campuses in previous research. These technologies are classified into five categories: data computing and storage, IoT technologies, intelligent technologies, immersive technologies, and mobile technologies. The table below summarizes the number of papers and accompanying references that use these technologies within each domain. A key discovery is the interconnected nature of many smart campus applications, which necessitates collaborative interactions across disciplines and promotes technology fusion towards a common developmental goal. It is vital to note that the following sections introduce and expand on the notion and scope of each domain.

TABLE II. TECHNOLOGIES USED IN SMART CAMPUSE

Technology fields	*references*
Data computing	[10] – [14]
Iot	[15] – [18]
Smart technology.	[19] – [22]
Immersive technology	[23] – [26]
Mobile technology	[27] – [30]

C. Dimensions of Smart Campus

Enabling technologies are carefully woven into a multiplicity of sophisticated applications on smart campuses, resulting in an integrated system with cooperative and self-adaptive features [31]. By seeing a smart campus as a microcosm of a smart city, this analysis follows the domain identification approach created for smart cities [32], with arguments customized to the context of smart campuses. Smart applications on smart campuses are divided into four categories: smart learning, smart living, smart environment, and smart management. The table below summarizes the number of papers and their corresponding references that delve into applications within each domain. The parts that follow go into greater detail about each application domain.

TABLE III. DOMAINS OF SMART CAMPUSE

Domain	references
Smart Education	[17], [33], [34]
Smart economy	[34] – [36]
Smart living	[37] – [39]
Smart environment	[37], [40], [41]
Smart managment	[42] – [44]
Smart technology	[45] – [47]
Smart security	[46], [48], [49]

D. Smart education

Researchers have long sought to integrate technology into education, an aim that has been driven by the COVID-19 pandemic issue and the need for widespread remote education access. Smart learning entails learners using advanced technology to access materials, participate in activities, and develop knowledge and interpersonal networks. Its ultimate goal is to improve learners' innovative abilities for better educational outcomes. The literature extensively investigates applications in the smart learning domain, focusing on advances in this discipline.

Smart Pedagogy: Within technology-enhanced learning, smart pedagogy effortlessly integrates technology and pedagogy while adhering to recognized learning theories. It provides as a framework for educators to support transformative education by incorporating technology for metacognitive development, fostering knowledge building, and encouraging the development of digital capabilities. Smart pedagogical competency is essential for assuring the pedagogical efficiency of technology in a variety of learning situations. Smart pedagogy is classified into various types depending on their distinct learning properties, such as personalized learning [50], collaborative learning, immersive learning, and ubiquitous learning [51].

Smart Classroom: A new classroom model has evolved that combines IoT, cloud computing, AR, and VR for increased functionality. Intelligent tools in the smart classroom facilitate instruction, resource acquisition, and interaction while maintaining situational awareness. The goal is to build an environment that is both humanized and intelligent, combining the physical and digital realms to help learners adapt to the actual world. Notable applications include IoT-enabled smart classroom ontologies for semantic interoperability, privacy-preserving attendance monitoring using sensors[4], and AI-driven attendance prediction and optimal room allocation.

Smart Library: The intelligent library is built on the foundations of traditional libraries but uses sophisticated technologies to improve its functionality. It includes advantages such as greater knowledge exchange, user convenience, and service efficiency, all of which are supported by the Internet of Things. An example from Reference [52] shows a sophisticated smart library that uses a wireless system, specifically radio frequency identification (RFID), to precisely locate books on shelves. RFID electronic tags contain information about shelves, books, and book carts. Another example from Reference [53] is the creation of a smartphone application that assists students in discovering open seats and automating the use of lockers to secure their possessions.

Smart Laboratory: A technology-enhanced laboratory environment seeks to simplify and automate data administration and operations, frequently cooperating with a teaching platform to provide unified resource management and real-time services. Mobile devices are used for information distribution and acquisition. In the example of [54], a smart laboratory system based on IoT and mobile applications analyzes lab activities using sensors such as energy consumption, equipment usage, and environmental conditions.

E. Smart economy

The Smart Economy concept promotes the use of personalized, secure, and intelligent economic services and systems in academic settings. Its primary goal is to improve the university's economic landscape by boosting collaborative consumption, supporting business creation, and increasing employment prospects. Academic experts and industry practitioners alike emphasize the importance of electronic transactions in creating a smart economy, even in the setting of public universities. Existing research emphasizes the necessity of universities actively encouraging entrepreneurship and creative company concepts, which contribute to economic sustainability and local employability. While the introduction of personalized and user-friendly products and services has been studied, the merging of the collaborative economy into the smart economy dimension is a fresh addition to the existing body of literature [5].

F. Smart living

A smart campus reflects concerns similar to those found in a small city, where people deal with issues including limited parking, crowded places, high pressure, and navigation difficulties on large campuses. Academic institutions are increasingly prioritizing campus informatization to deliver better smart living services and experiences. The goal is to enable both students and professors to readily utilize the benefits of big data inside the campus setting, resulting in greater engagement in campus life. Smart health, smart navigation, smart transportation, and other related advancements are notable examples of transformational applications.

G. Smart environment

To address climate threats, a smart campus must prioritize environmentally friendly behaviors, particularly those related to energy, water resources, and hygiene. This relationship is crucial for achieving the world's Sustainable Development Goals [31]. The "green campus" initiative, which is key to the smart campus concept, has attracted much attention. Researchers are continually working to develop smart environment technologies that integrate a variety of environmentally favorable ways. The emphasis on a smart environment on campus is divided into four key components: smart energy, smart waste management, smart water use, and smart air conditioning.

H. Smart management

Significant advances in educational institution information technology have created new issues in campus management. A strong approach to campus management is required to ensure the campus's smooth operation, on-demand service delivery, asset integrity, and optimal utilization. In contrast, a lack of management poses a significant obstacle to stakeholder interaction and efficient use of campus resources. In the available literature, smart campus management is primarily focused on four major aspects: smart asset management, smart security management, smart learning management, and smart time and space management.

I. Smart technology

Smart Technology is a transversal component that is essential for creating a smart campus by connecting and supporting other dimensions through technological breakthroughs. It acts as the foundation, incorporating many innovations to create a Smart Campus. Expert discussions focus on how to utilize technological breakthroughs in a variety of academic situations. This transversal component has a broad technological system design that facilitates data processing and management. It adapts to the various academic dimensions rather than focusing on certain technology.

J. Smart security

To process real-time information, campus security officers use technology such as the Internet of Things (IoT), cloud computing, and big data. The usage of mobile Internet establishes a comprehensive management platform, which contributes to increased campus safety through services such as safety inspections and disaster response. The overall goal is to proactively avoid and respond to disasters and criminal activity through efficient and accurate security monitoring. The system aims for complete, real-time security monitoring and quick response to occurrences, including the speedy identification of victims.

K. Characteristic of University Campuses

Considering a university campus as a tiny city provides an experimental environment for adopting smart campus technologies. This technique can identify shared traits between a campus and a metropolis [47]. For example:

• **Complexity:** campuses of universities face substantial challenges due to the complexity of processes inside their boundaries and immediate effect area. "Complexity science" refers to the self-organizational capabilities and adaptive features of intricate systems, such as climate, natural ecosystems, the economy, and, in this case, university campuses.

• **Diversity:** Diversity on university campuses varies depending on criteria such as geographical location, academic focus, and socioeconomic structure. varied places coexist on each campus, and as more varied agents participate, campus functions become more sophisticated and disparate. The size and functional complexity of a campus, combined with dimension variables, lead to the increased number of agents. must be considered when formulating policies.

• **Uncertainty:** Planners working with university campuses must deal with the ongoing uncertainty of their future. Projections entail predicting the campus's development over the next 10 or twenty years, and the limitations of current forecasting technologies become more apparent, particularly in dynamic and ever-changing contexts.

• **Sustainability**: A university campus significantly impacts the environment, requiring control through institutional policies due to infrastructure and energy consumption. New technologies offer tools to balance environmental considerations and natural resource consumption [31]. Smart campuses must integrate sustainable development into their design, meeting stakeholder needs without compromising future generations or natural resources.

L. Problems on traditional campuses

The development of a smart campus is an ongoing endeavor, with certain institutions taking the lead while others encounter challenges in establishing efficient information development processes. Creating a unified platform for shared resources and data is crucial for universities, but many information platforms fail to meet the crucial requirement of unified shared data, posing obstacles for various service departments. The interface is at the heart of the Internet of Things, but connecting different service sectors through a single interface proves challenging in many cases.

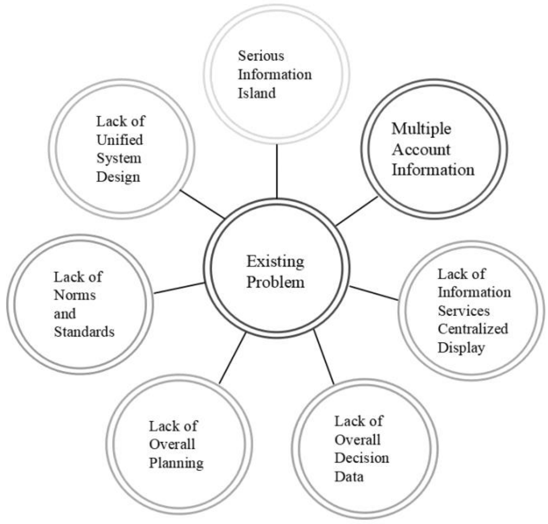

Figure 2: Problems existing in traditional campus

The core principle of smart campus construction [55] is to establish a high-quality campus network using IoT technology for the normalization and standardization of each platform. This ensures that the information derived from these data not only caters to overall service needs but also facilitates the creation of personalized information platforms. However, many colleges and universities face challenges, including a lack of comprehensive understanding of the overall campus environment, a shortage of skilled information personnel, a significant absence of value-added services reflecting campus characteristics, and difficulties in implementing smart campus plans effectively. The challenges of traditional campus systems are visually represented in Figure 2.

M. Recent Smart Campus Frameworks in Higher Education Institutions

A smart campus relies on real-time perception of physical elements, transmitting diverse data types through an information platform. The platform organizes and optimizes data, employing information mining for

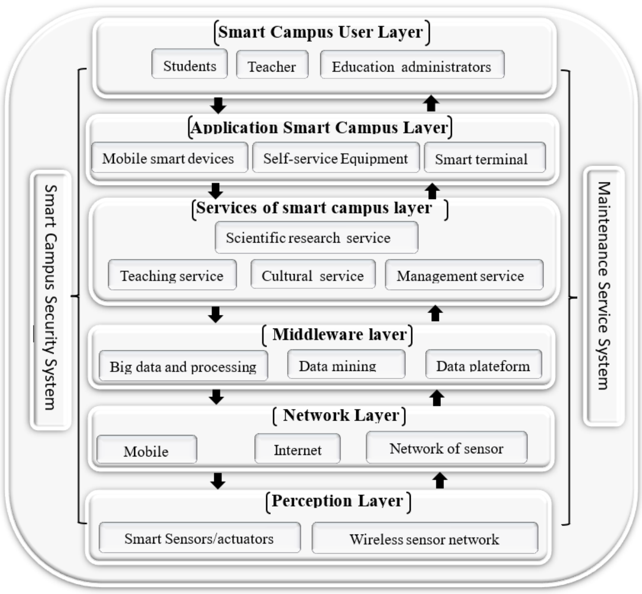

Figure 3:Smart Campus Frameworks in HEI

intelligent decision-making and control. At its core, big data technology and sensors enable environmental perception, while network technology connects various entities. Intelligent algorithms facilitate personalized services for diverse users [31].

Within the smart campus construction framework, the smart platform is supported by the information security system and the information operation and maintenance service system [56]. The architecture is made up of four layers: intelligent sensing, data communication, intelligent processing (which makes use of Cloud Computing and Big Data), and an intelligent recommendation terminal. Figure 3 displays a graphic representation of the smart campus architectural paradigm.

Perception layer: Using technologies like ZigBee, IP CAM, and other intelligent sensors, users at all levels can access network data. Physical sensors are used to collect data about the campus environment, resources, education, and research activities. This methodology achieves a deep understanding of user data and diverse environmental conditions across multiple tiers of the smart campus, providing critical data support for the smart campus's overall planning functionality.

Network layer: Using the campus network, mobile 5G, and other communication networks, the sensing layer's data is quickly delivered and stored. This allows for more effective communication among user terminals on the smart campus, ensuring fast and efficient data connection services.

Middleware layer: This layer combines a wide range of user activities, services, interactions, and other data to provide full data support for smart campuses. This process entails combining raw data management, intelligent algorithms, data mining engines, and other technologies to provide efficient and scientifically driven data cloud computing solutions. These services provide scientific storage and computing assistance for smart campuses.

Services of the Smart Campus layer: are entities that can be used by individuals, programs, or other services. These services can include calculators, storage devices, and communication pipelines with other users, as well as hardware devices, software filters, and a variety of other features.

Application of the Smart Campus Layer: Using big data technologies, cognitive processing, and other breakthroughs, the smart campus smoothly integrates a variety of terminals such as PCs, smart devices, and mobile devices. It uses various network connection technologies to provide users with comprehensive, intelligent, and individualized human-computer interaction modes for teaching, research, services, and management decision-making.

Smart Campus Security System: The smart campus is built on situational awareness, which uses modern sensing technologies such as usage data from campus cards, wireless networks, cameras, and other sensors to understand the campus environment. The security of the perceptual layer is critical, necessitating a review of sensing data security to assure the sensors' rationality, security, and dependability.

Maintenance Service System: The information operation and maintenance service system is critical to ensuring the reliability and scientifically sound application of data for both the intelligent processing layer and the intelligent recommendation layer within the smart campus, leveraging big data technology. Together, these two major security technologies provide solid assurance for the overall functionality and security of smart campuses.

V. Discussion And Recomendations

Following a systematic assessment and study of human experiences with smart campus technology and applications, the following recommendations can be extrapolated for future research and development.

As technology evolves, IoT and intelligent technologies continue to have a huge impact on the future of smart campuses. Simultaneously, sustained innovation establishes data computing and storage technologies as fundamental infrastructure. Nonetheless, a critical difficulty occurs in these sectors, owing to the extensive sensing environment and the collecting of sensitive human-related data, both of which present significant privacy concerns. To overcome this issue, privacy-conscious technologies, cybersecurity improvements, and consistent policies are required. The lower weight in the mobile technology sector shows there is opportunity for progress, indicating a need for increasing stakeholder involvement and innovation. Convincing stakeholders of the practical importance of sophisticated technology integration on campuses is critical. Despite its relatively little weight in systematic assessments, the immersive technology sector is quickly expanding and driving future smart campus applications. The increasing usage of AR/VR in schools, with 90% of educators supporting immersive learning for personalised student experiences, has transformative potential. However, modifying policies is difficult, especially given the large private and location information that AR/VR devices may require, underlining the importance of strong data and environmental security standards.

In the field of smart applications, smart learning takes primacy, with continued progress in overcoming technical obstacles and the advent of smart learning systems capable of providing improved individualized experiences. However, educators may face difficulty adapting to these new learning formats and pedagogies. Addressing this demands coordinated efforts in teacher training to improve their capacities and enable speedy adaption to the smart environment, hence limiting negative societal repercussions such as unemployment. Smart living and smart management domains in primary and secondary schools are less advanced than those in universities, demonstrating that smart technologies are in their early stages in these institutions. Future advances should center on adapting smart campus facilities to the individual demands of primary and secondary schoolsFurthermore, climate change has had a long-term impact on the global economy and people's lives.

VI. Conclusion

As the pinnacle of educational institutions, the concept of a smart campus has received a lot of study interest in recent years. This study provides a thorough examination of smart campus technology and applications, acknowledging the inadequacies and outdated analyses in previous studies on smart campus efforts, as well as the necessity for modern research to adopt human-centric viewpoints. It then conducts a case study focusing on human experiences to assess how well current research trends connect with the requirements and interests of stakeholders.

The recognized enabling technologies on a smart campus are divided into five categories: data computing and technologies, intelligent technologies, IoT technologies, mobile technologies, and immersive technologies. Similarly, smart campus applications are divided into four categories: smart learning, smart living, smart environment, and smart management. Despite the comprehensive analysis and human-centered case study revealing consistent research patterns across most disciplines, there is a distinct shift in research priority, particularly in mobile technologies and smart environment applications.

These inequalities indicate, first and foremost, that current mobile technology apps sufficiently address the needs of teachers and students. Second, there is a conspicuous absence of research vigor in the literature, which corresponds to stakeholder environmental awareness.

References

[1] A. Rof, A. Bikfalvi, and P. Marques, “Pandemic-accelerated digital transformation of a born digital higher education institution,” Educ. Technol. Soc., vol. 25, no. 1, pp. 124–141, 2022.

[2] R.Zemsky,G.R.Wegner,andW F. Massy, Remaking the American university:Market-smart and mission-centered. Rutgers University iPress,2005.

[3] O. Přibyl, S. Opasanon, and T. Horák, “Student perception of smart campus: A case study of Czech Republic and Thailand,” in 2018 Smart City Symposium Prague (SCSP), 2018, pp. 1–7.

[4] G. Marques and R. Pitarma, “An internet of things-based environmental quality management system to supervise the indoor laboratory conditions,” Appl. Sci., vol. 9, no. 3, p. 438, 2019.

[5] A. Zaballos, A. Briones, A. Massa, P. Centelles, and V. Caballero, “A smart campus’ digital twin for sustainable comfort monitoring,” Sustainability, vol. 12, no. 21, p. 9196, 2020.

[6] W.Muhamad,N.B.Kurniawan, and S. Yazid, “Smart campus features, technologies, and applications: A systematic literature review,” in 2017 International conference on information technology systems and innovation (ICITSI), 2017, pp. 384–391.

[7] Y. Atif, S. S. Mathew, and A. Lakas, “Building a smart campus to support ubiquitous learning,” J. Ambient Intell. Humaniz. Comput., vol. 6, pp. 223–238, 2015.

[8] Z. Y. Dong, Y. Zhang, C. Yip, S. Swift, and K. Beswick, “Smart campus: definition, framework, technologies, and services,” IET Smart Cities, vol. 2, no. 1, pp. 43–54, 2020.

[9] L. Kwok, “A vision for the development of i-campus,” Smart Learn. Environ., vol. 2, pp. 1–12, 2015.

[10] X. Jiang, D. Liu, and T. Zhou, “Cloud-assisted two-factor protection mechanism for public data in smart campus,” n 2019 Internat onal Conference on Computing, Networking and Communications (ICNC), 2019, pp. 719–723.

[11] M. Wang and J. W. P. Ng, “Intelligent mobile cloud education: smart anytime-anywhere learning for the next generation campus environment,” in 2012 Eighth International Conference on Intelligent Environments, 2012, pp. 149–156.

[12] F. C. Silva, M. A. Ahmed, J. M. Martínez, and Y.-C. Kim, “Design and implementation of a blockchain-based energy trading platform for electric vehicles in smart campus parking lots,” Energies, vol. 12, no. 24, p. 4814, 2019.

[13] Lihong, “Research on the construction of smart campus social platform based on Hadoop,” in 2020 International Conference on Computer Engineering and Application (ICCEA), 2020, pp. 214–217.

[14] C.-T. Yang, S.-T. Chen, J.-C. Liu, R.-H. Liu, and C.-L. Chang, “On construction of an energy monitoring service using big data technology for the smart campus,” Cluster Comput., vol. 23, pp. 265–288, 2020.

[15] Z. Ali, M. A. Shah, A. Almogren, I. Ud Din, C. Maple, and H. A. Khattak, “Named data networking for efficient iot-based disaster

management in a smart campus," Sustainability, vol. 12, no. 8, p. 3088, 2020.
[16] Y. Weng, N. Zhang, and C. Xia, "Multi-agent-based unsupervised detection of energy consumption anomalies on smart campus," IEEE Access, vol. 7, pp. 2169–2178, 2018.
[17] X. Xu et al., "Research on key technologies of smart campus teaching platform based on 5G network," IEEE Access, vol. 7, pp. 20664–20675, 2019.
[18] M. M. K. Al-Nadwi, N. Refat, N. Zaman, M. A. Rahman, M. Z. A. Bhuiyan, and R. Bin Razali, "Cloud enabled e-glossary system: a smart campus perspective,"in Security, Privacy, and Anonymity in Computation, Communication, and Storage: 11th International Conference and Satellite Workshops, SpaCCS 2018, Melbourne, NSW, Australia, December 11-13, 2018, Proceedings 11, 2018, pp. 251–260.
[19] S. Banerjee, T. S. Ashwin, and R. M. R. Guddeti, "Automated parking system in smart campus using computer vision technique," in TENCON 2019-2019 IEEE Region 10 Conference (TENCON), 2019, pp. 931–935.
[20] R.-H. Liu, C.-F. Kuo, C.-T. Yang, S.-T. Chen, and J.-C. Liu, "On construction of an energy monitoring service using big data technology for smart campus," in 2016 7th International Conference on Cloud Computing and Big Data (CCBD), 2016, pp. 81–86.
[21] L.-W. Chen, T.-P. Chen, D.-E. Chen, J.-X. Liu, and M.-F. Tsai, "Smart campus care and guiding with dedicated video footprinting through Internet of Things technologies," IEEE Access, vol. 6, pp. 43956–43966, 2018.
[22] S. Gaglio, G. Lo Re, M. Morana, and C. Ruocco, "Smart assistance for students and people living in a campus," in 2019 IEEE International Conference on Smart Computing (SMARTCOMP), 2019, pp. 132–137.
[23] Y. Huang et al., "Research on Smart campus based on the internet of things and virtual reality," Int. J. Smart Home, vol. 10, no. 12, pp. 213–220, 2016.
[24] J. Torres-Sospedra et al., "Enhancing integrated indoor/outdoor mobility in a smart campus," Int. J. Geogr. Inf. Sci., vol. 29, no. 11, pp. 1955–1968, 2015.
[25] F. Ramos and P. Yagol, "Augmented reality for a better navigation in a smart campus," in EDULEARN18 Proceedings, 2018, p. 7513.
[26] U. Özcan, A. Arslan, M. İlkyaz, and E. Karaarslan, "An augmented reality application for smart campus urbanization: MSKU campus prototype," in 2017 5th Internai onal Istanbul Smart Grid and Cities Congress and Fair (ICSG), 2017, pp. 100–104.
[27] B. Tabuenca, V. García-Alcántara, C. Gilarranz-Casado, and S. Barrado-Aguirre, "Fostering environmental awareness with smart IoT planters in campuses," Sensors, vol. 20, no. 8, p. 2227, 2020.
[28] G. Sun and J. Shen, "Collaborative learning through TaaS: a mobile system for courses over the cloud," in 2014 IEEE 14th International Conference on Advanced Learning Technologies, 2014, pp. 278–280.
[29] G. Delzanno, G. Guerrini, M. Leotta, and M. Ribaudo, "Physical Web for Smart Campus Management.," in WEBIST, 2018, pp.i277–284.
[30] W. Zheng, Z. Yang, L. Feng, P. Fu, and J. Shi, "APP Design of Energy Monitoring in Smart Campus Based on Android System.," Int. J. Online Biomed. Eng., vol. 15, no. 5, 2019.
[31] Y. Zhang, C. Yip, E. Lu, and Z. Y. Dong, "A Systematic Review on Technologies and Applications in Smart Campus: A Human-Centered Case Study," IEEE Access, vol. 10, pp. 16134–16149, 2022.
[32] N. Chagnon-Lessard et al., "Smart campuses: extensive review of the last decade of research and current challenges," IEEE Access, vol. 9, pp. 124200–124234, 2021.
[33] S. Fortes et al., "The campus as a smart city: University of Málaga environmental, learning, and research approaches," Sensors, vol. 19, no. 6, p. 1349, 2019.
[34] N. Min-Allah and S. Alrashed, "Smart campus—A sketch," Sustain. cities Soc., vol. 59, p. 102231, 2020.
[35] P. Fraga-Lamas, S. I. Lopes, and T. M. Fernández-Caramés, "Gr een IoT and edge AI as key technological enablers for a sustaina ble digital transition towards a smart circular economy: An in-dustry 5.0 use case," Sensors, vol. 21, no. 17, p. 5745, 2021.
[36] A. Anirudh, V. K. Pandey, J. S. Sodhi, and T. Bagga, "Next generation Indian campuses going SMART," Int. J. Appl. Bus. Econ. Res., vol. 15, no. 21, pp. 385–398, 2017.
[37] Y. Lin et al., "Improving person re-identification by attribute and identity learning," Pattern Recognit., vol. 95, pp. 151–161, 2019.
[38] N.-C. Chiu et al., "Impact of wearing masks, hand hygiene, and social distancing on influenza, enterovirus, and all-cause pneumonia during the coronavirus pandemic: retrospective national epidemiological surveillance study," J. Med. Internet Res., vol. 22, no. 8, p. e21257, 2020.
[39] D. Compare et al., "Lactobacillus casei DG and its postbiotic reduce the inflammatory mucosal response: an ex-vivo organ culture model of post-infectious irritable bowel syndrome," BMC Gastroenterol., vol. 17, pp. 1–8, 2017.
[40] A. R. Janssen and M. I. Prasetiyowati, "Gamifying student routines to improve campus experience through mobile application in Indonesia," Int. J. Eng. Technol, vol. 7, no. 4.40, pp. 85–89, 2018.
[41] J. Torres-Sospedra, R. Montoliu, S. Trilles, Ó. Belmonte, and J. Huerta, "Comprehensive analysis of distance and similarity measures for Wi-i fingerprinting indoor positioning systems," Expert Syst. Appl., vol. 42, no. 23, pp. 9263–9278, 2015.
[42] W. Villegas-Ch, M. Román-Cañizares, and X. Palacios-Pacheco, "Improvement of an online education model with the integration of machine learning and data analysis in an LMS," Appl. Sci., vol. 10, no. 15, p. 5371, 2020.
[43] T. M. Fernández-Caramés and P. Fraga-Lamas, "A Review on the Use of Blockchain for the Internet of Things," Ieee Access, vol. 6, pp. 32979–33001, 2018.
[44] M. Ablikim et al., "Future physics programme of BESIII," Chinese Phys. C, vol. 44, no. 4, p. 40001, 2020.
[45]A.iAdamkó,i"Buildingismartiuniversityiusingiinnovativeitechnologyi andiarchitecture,"iSmartiUniv.iConcepts,iSyst.iTechnol.i4,ipp.i161–188,i2018.
[46] D. Rico-Bautista, Y. Medina-Cárdenas, and C. D. Guerrero, "Smart university: a review from the educational and technological view of internet of things," Inf. Technol. Syst. Proc. ICITS 2019, pp. 427–440, 2019.
[47] A.-M. Yang, S.-S. Li, C.-H. Ren, H.-X. Liu, Y. Han, and L. Liu, "Situational awareness system in the smart campus," Ieee Access, vol. 6, pp. 63976–63986, 2018.
[48] H.Pinggui and C. Xiuqing, "Design and implementation of campus security system based on Internet of Things," in 2017 International Conference on Robots & Intelligent System (ICRIS), 2017, pp. 86–89.
[49] V. Sukanya and E. V. Priya Reddy, "Implementation effects of e-ID device in smart campus using IoT," in Advances in Decision Sciences, Image Processing, Security and Computer Vision: International Conference on Emerging Trends in Engineering (ICETE), Vol. 1, 2020, pp. 268–276.
[50] L. A. Cárdenas-Robledo and A. Peña-Ayala, "Ubiquitous learning: A systematic review," Telemat. Informatics, vol. 35, no. 5, pp. 1097–1132, 2018.
[51] F. Costa, S. Genovesi, M. Borgese, A. Michel, F. A. Dicandia, and G. Manara, "A review of RFID sensors, the new frontier of internet of things," Sensors, vol. 21, no. 9, p. 3138, 2021.
[52] M. Ertz, S. Sun, E. Boily, P. Kubiat, and G. G. Y. Quenum, "How transitioning to Industry 4.0 promotes circular product lifetimes," Ind. Mark. Manag., vol. 101, pp. 125–140, 2022.
[53] A. S. Pollock, "Accessing Energy from Artificial Intelligence Knowledge Banks Utilizing Smart Univer-'Cities': A Qualitative Study." Colorado Technical University, 2022.
[54] H. Kumar, M. K. Singh, M. P. Gupta, and J. Madaan, "Moving towards smart cities: Solutions that lead to the Smart City Transformation Framework," Technol. Forecast. Soc. Change, vol. 153, p. 119281, 2020.
[55] P.I.S.daNÓBREGA,"Smartcampus:indicators for the smartization processat universities.,"2021.
[56] M. A. Ahad, S. Paiva, G. Tripathi, and N. Feroz, "Enabling technologies and sustainable smart cities," Sustain. cities Soc., vol. 61, p. 102301, 2020.