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SMART CAMPUS: A REVIEW TO IDENTIFY THE FACTORS AND EMERGING TECHNOLOGIES THAT INFLUENCE THE CAMPUS FROM AN INTERDISCIPLINARY PERSPECTIVE

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Abstract

Smart campus has been a rising research domain, especially in the last decade. It is a follower of the smart city model in some respects, which is also considered its parent domain. Smart Campus has its unique literature, but it is still fragmented and lacks a holistic approach. The methodology of systematic literature review has been adopted following the PRISMA guideline to analyze the literature relating to the domain. An effort has also been made in the paper to highlight the factors affecting smart campus development, and also the relevant technologies to build a conceptual model at the end. The aim has been to identify the factors that are interdisciplinary and holistic, which is one of the main issues with the existing literature. The paper has tried to analyze the factors from multiple domains, not only from a technological perspective. The rising concerns over sustainability, carbon emissions have been used to identify those factors that are of environmental concern. The social and psychological well-being of the students has also been kept in mind in deriving the factors which is less found in the existing literature. The paper here tries to analyze this domain's relevance and conceptualize the positioning of smart campuses in relation to the smart city model. The existing literature identifies smart campuses as a part of the smart city domain. The paper contributes to the research by building a conceptual model that not only identifies a smart campus as a part of a smart city but also focuses on its unique features, which may not be found in the smart city model.

1. INTRODUCTION

1.1 Motivation and Background

Smart campus is a growing domain in research, but the literature remains fragmented. Smart city is the parent domain from which this concept has grown. Research on smart campuses should move towards holistic and interdisciplinary aspects (X. Dong et al., 2016). There are various ways to conceptualize a smart campus: technology-driven, smart city model adoption or organization, and business-driven.

The concept has been confused a lot of times with the digital campus. But it is very much different. Digital campus is more of an aggregation of technologies, but the campus is more holistic and interdisciplinary.

Digital campuses may be restricted to local area network use, but smart campuses use IoT, sensing technologies, cloud computing, RFID, and their interrelationships to develop an integrated control system. So overall, a digital campus remains isolated, but a smart campus is based on a system that shares and integrates different components.

Smart universities are small-scale cities in themselves, and better data availability to the stakeholders can help improve the user experience and follow the parent model of smart cities (Vasileva et al., 2018). Smart campus, mentioned in the paper, mainly refers to the institutions of higher education, which are pillars of the education system.

Related to the concept is the notion of an intelligent campus or i-campus. Intelligent campus promotes digital or physical Infrastructure, research, and development. Research and development encourage innovation and help adapt to changing times.

An intelligent campus can be said to be able to respond to new situations occurring in its day-to-day activities and operations (Kwok, 2015). The modern conception of the area talks about Smart Campus 4.0, which integrates Industry 4.0 with Smart Campus.

The enabling technologies like cloud computing, the Internet of Things, artificial intelligence, etc, can build a campus environment that can fulfill sustainable development goals (Mahariya et al., 2023). The main ingredients of a smart campus are teaching, management, and service. The main aim of a smart campus is to make efficient use of resources by using various kinds of intelligent services.

A smart campus is considered a mini smart city and can be used as a living lab to promote research in a smart city environment. Smart campuses are a vital component of a smart city (Min-allah & Alrashed, 2020).

But one thing must be realized: it has its unique features, which may be very different from a smart city. There is ample use of technology in a smart campus, but technologies cannot be used by themselves; they must supported by various applications to realize the real meaning of smartness.

There is a need to develop a data mining system to use the enormous amount of college-related data to aid in efficient decision-making and real-time monitoring. Both structured and unstructured data need to be handled. There is a lack of data analysis platform frameworks to help better handle data (Zhang & Jiang, 2018).

Analyzing the images in a smart campus can help monitor students in real-time. Since the number of images is large, the data can be outsourced to the cloud servers. But in this process, privacy issues need to be handled (Xia et al., 2018).

The service delivery model based on situational awareness can help in the real-time handling of smart campus data. It involves the classification of the services according to the situation types. When the user asks for any service, the service index database checks the access policy, identifies the service from the database, and pushes the list of services to the user's device (A. Yang et al., 2018).

The smart campus can be thought of as a multilayer system that consists of four layers. The basic layer is the sensor layer. It is the interface between the physical and the information world. The sensor layer consists of RFID, wireless sensors, and other intelligent systems. It is mainly the information collection point and provides a database to the network layer. It consists of aggregating data acquisition, and forwarding analysis through the Internet and other communication networks.

Then, the next layer is the control layer, which uses cloud computing tools to manage and store data. The upper layer is the application layer, which connects with the physical world by providing intelligent services to the specific user (Huang et al., 2016). The use of IoT in space utilization is significant for having a real-time response. Integrating user feedback data and environment variables can boost the efficiency of smart campuses (Valks et al., 2020).

1.2 Research Question and Objective

Research Question

RQ1: What are the significant technologies that boost the construction of an innovative campus?

RQ2: Is there a right conceptual model to define a smart campus?

RQ3: Does a smart campus have a holistic and interdisciplinary approach?

RQ4: How to relate different domains in the smart campus?

The main problem with conceptualizing smart campuses is that the definition has not moved from the heavy dependence on big data and digital campuses (Martins et al., 2021). The lack of an interdisciplinary approach is also a reason. There is a need to look at it from technical, social, economic, and environmental aspects.

2. METHODOLOGY

The methodology used in this paper is the systematic literature review. Around 386 articles were selected based on the keyword search. The keywords used were "smart campus" OR "smart university" OR "digital campus". The articles were screened initially based on their relevance. The use of a systematic literature review was applied to answer the research questions. The PRISMA guidelines have been used to get the relevant articles for analysis. At the end, around 64 articles were shortlisted for final analysis. The research questions mentioned in Table 1 below were kept in mind to identify the articles that best suit this research. The inclusion and exclusion are mentioned as in Table 2.

Table 1: The research questions relating to the smart campus and directions to move with these questions

Research questions	Direction
What are the significant technologies that boost the construction of a smart campus?	Identify the relevant technologies and their specific uses.
Is there a right conceptual model to define a smart campus?	Identify the conceptual framework and try to develop a model taking inspiration from the smart city model.
Does the smart campus have a holistic and interdisciplinary approach to analyzing the factors?	Try to move from the aggregation of digital technology to an approach that includes governance, sustainability, health, etc, and their interrelationships.
How to relate different domains in the smart campus?	Identify the main factors and try to develop their interrelations.

Table 2: The inclusion and exclusion criteria to shortlist the relevant papers

Inclusion criteria	Exclusion criteria
Only articles and review papers	Non-peer-reviewed papers, not relevant to the research objective
Domains selected	Abstract, short paper, or technical report
Open access in the English language Mention of different factors in a smart campus	Documents that use Smart Campus as a case study

3. RESULTS AND FINDINGS

The trend in the publications mentioned in Figure 1 speaks a lot about the rising number of research papers in this domain. There is a small peak in 2018 starting from 2016. But this again slows down. The higher peak is shown in the period between 2020 and 2024. So it can be concluded that the research in the domain of smart campus has been increasing in the last decade. But the biggest progress is seen in the last five years, from the period of 2020.

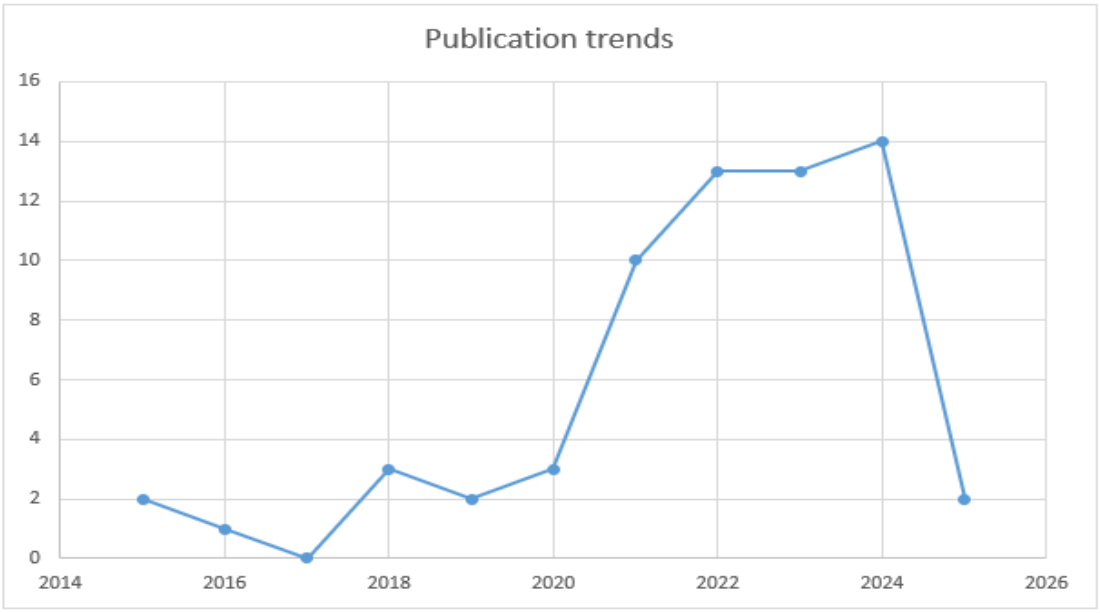

Figure 1: The trends in the publications in the smart campus domain

(Source: Author)

The smart campus has an interdisciplinary perspective, and it is necessary to understand its factors to analyze them properly. There are issues related to the environment, health, and mental well-being of the students. Factors relating to these issues need to be added along with other factors. The traditional focus on technology and infrastructure has to shift to include these factors. In order to fulfill the sustainable development goals the factors like smart waste systems, carbon emission monitoring are crucial. There is a need to look at the social and psychological well-being of the students apart from the learning environment. So the factor campus connectivity has been added, which includes physical, social as well and psychological connectivity. The mental and physical well-being should be the utmost priority of the campus. There can be counselling sessions to handle these issues. The factors are not just technology-based but also have domains like health, sustainability, etc. So, it gives a holistic view that is still to be explored. The factors have been found in the above sources, but there is still a need for a smart campus and a digital campus. To develop a a true smart campus which is way ahead of being an aggregation of technologies. Table 3 talks about the major technologies that are a part of any university, but Table 4 helps to get the overall picture by listing all the factors that consist of multiple disciplines. These factors are used by Figure 2 to develop a smart campus conceptual model.

3.1 Smart Campus Technologies

The use of emerging technologies and different educational tools is an integral part of a smart campus. The teaching pedagogy has moved on from pen and board towards the use of smart boards, which are based on sensing technologies. There is the use of RFID in the smart attendance system. The classes are held by the instructors in both online and offline modes. There is also the use of machine learning to identify the patterns in the learning of the students. This also helps to know the students who are facing issues and to deal with them. There is a use of e-governance platforms to help in decision-making as far as the management is concerned.

Table 3: The technologies and tools used in a smart campus with their sources

Technology	Sources
Smart board	(Z. Y. Dong et al., 2020b) (Ahmed et al., 2022) (Achour et al., 2021)
Sensing technologies	(Abdullah, 2023) (Omotayo et al., 2021)
Artificial Intelligence	(Sneesl et al., 2022) (Achour et al., 2021) (Xu et al., 2018)
Smart parking system	(Niu et al., 2022) (Niu et al., 2022) (Faza et al., 2020)
Smart waste management	(Shishakly et al., 2024) (Al-Dmour, 2023)
RFID	(Xu et al., 2018) (Li et al., 2023)
Enterprise resource planning	(Yip et al., 2022) (Eldeeb & Alves, n.d.)

3.2 Smart campus conceptual model

Table 4 mentions the interdisciplinary factors with the sources identified from the analysis of the literature. The factors identified are from the diverse areas of the campus. From a smart classroom with a focus on creating a learning environment to carbon emission monitoring and energy systems.

Most of the factors have technological aspects attached to them, making them smart. Like in hybrid teaching, there is a use of both online and offline modes of teaching, enhancing the use of technology in learning.

The flexible use of online and offline platforms helps the instructors to create student student-friendly environment. It also serves the need when physical access to the class is not available. Apart from that, simulation-based learning makes use of technology to make learning interesting and playful. It promotes peer learning and brings out the hidden creativity of the students.

There is extensive use of technology in the form of the Internet of Things (IoT), and its integration with cloud platforms promotes the availability of real-time data to every component of the campus. But with the availability of real-time data, there are issues of handling data.

So cybersecurity becomes a critical factor here. The extensive use of IoT and sensing technologies has become an essential component of smart buildings inside a campus. But apart from these factors, which use advanced technologies, there are concerns related to the environment that need to be addressed; hence, factors relating to smart waste systems and carbon emission monitoring have been added. The biggest asset of the factors identified in Table 4 is the factor of campus connectivity.

It ensures not only the physical connectivity but also the social and psychological connectivity. Hence, the factors have been developed keeping in mind not only the technological aspects but also social, environmental, and psychological issues.

It is the need of the hour to go beyond technology in factor identification. There can be psychological issues, differences in learning behavior, and career-related anxiety. These are beyond the scope of a campus that focuses on core technologies.

The factors derived for the smart campus can be developed by the rapid use of IoT technology. By collecting sensor data like weather, temperature, CO2 levels, and CCTV videos, an index system can be developed to evaluate a smart campus. So these factors can also help in developing a smart campus evaluation index (Guo, 2025).

Table 4: The factors that are part of the smart campus conceptual model

Factor	Sources
Smart Classroom (SC)	(A. Yang et al., 2018)
Hybrid Teaching (HT)	(Villegas-Ch et al., 2020)
Simulation based learning (SBL)	(Li et al., 2023)
IoT and sensing technology (IST)	(Abdullah, 2023)
Cloud connectivity (CC)	(Omotayo et al., 2021)
Cyber Security (CS)	(Achour et al., 2021
Smart building design (SBD)	(Qian et al., 2014)
Energy systems and automation (ESA)	(Azizi et al., 2020)
Smart Waste Systems (SWS)	(C. T. Yang et al., 2020)
Carbon Emission Monitoring (CEM)	(Shishakly et al., 2024)
Smart Budgeting and Governance (SBG)	(Z. Y. Dong et al., 2020a)
Smart Parking System (SPS)	(Zheng et al., 2018)
Campus Connectivity (CC)	(Prandi et al., 2020)

After analyzing the relevant literature, it has been proposed that the smart campus should be looked at from a diverse angle. Digital campus is an outdated concept, and this should be highlighted. Smart campuses should consist of varied and holistic factors instead of the summation of the technologies involved. The idea should look at multiple angles, from Infrastructure to Governance to health and sustainability. From the analysis of the current literature, it has been found that Life and health have become vital factors in this domain. So, a model is proposed in this paper that talks about how health and Life are essential factors that are lacking in the existing literature. The model focuses on the change required in the conceptualization with the interdisciplinary factors and the enhanced role of mental and physical health. There should be a separate focus on smart living, personal counseling, and mental care. Students in a university are away from their parents' care and have high expectations, so a unique Infrastructure and assistance should be developed. A weighted score model can be used to identify the importance of each dimension in a smart campus can aid in decision making and resource allocation (Anagnostopoulos et al., 2021). Since the pandemic has changed the perspective of administration and policymakers, there should be some change in conceptualizing an innovative campus. The following factors and sub-factors were identified by analyzing the current literature.

3.2.1 Smart Classroom

The first factor is the smart classroom, which has seen much growth due to the advancements in online Learning and hybrid education. There are smart boards, which are an essential requirement of a smart classroom. The smart classroom has other vital features like a bright projector, smart attendance system, RFID, etc. (A. Yang et al., 2018). The classroom should enable Learning by doing instead of using rote-based methods. The discussions and problem-solving are part of the daily classes. There is also a requirement for personalized attention towards individual doubts, because of which personalized Learning has been taken as a key sub-factor. Nowadays, with AI, individual learning potential can be analyzed, and courses can cater to differences in individual learning capabilities.

Learning theories in this domain try to identify the actors in education and build an educational model. In this model, there is a requirement for the active involvement of students and teachers. There should be a transition from passive Learning to active participation in learning activities. Higher-order thinking needs to be developed through dialogue and interaction with immediate feedback. The teachers should design the learning activity according to the discipline. Also, try to adapt to the needs of all kinds of learners. Immediate feedback is also needed (Villegas-Ch

et al., 2020). A Zigbee wireless sensor-based network can be used to construct a smart teaching-based system. The system helps to identify the location of the students and analyzes the network structure of the smart teaching system (Shyong et al., 2022).

3.2.2 Simulation-Based Learning

To make learning more fruitful, robot systems and artificial intelligence can do wonders. Virtual assistants can make the learning process between teachers and students more informative. The telepresence allows students to attend classes when they cannot do so due to illness, etc. Guide robots move around the institution building to give information on book searching, restaurant menus, events, programs, etc. So, the robots can help reduce the workload of teachers and staff and increase students' engagement in campus activities (Nguyen et al., 2022). The proposed model of a smart campus focuses on a ubiquitous environment consisting of a social community platform for knowledge sharing and context-aware Learning to create an experiential learning loop (Atif et al., 2015). Student readiness for Industry 4.0 needs to be analyzed to promote better engagement and knowledge sharing. Smart classroom is an integral component of a smart campus, and some tools enhance the learning environment. One such tool in use is Nestor AI, which trains itself and predicts the student's attention by analyzing the learner's emotional and facial expressions. Some studies also examine the student's attentiveness and other responses apart from the facial expressions (Kwet & Prinsloo, 2020).

3.2.3 Hybrid Teaching

The model can use the concept of remote laboratories to integrate those who are using the online platforms for Learning. The use of network function virtualization and software-defined storage to enhance the autonomic capabilities in cloud services to meet the end-user demand. Judging and analyzing the student's performance is one of the key components for teaching success. Numerous algorithms have been developed in the existing literature, including the multilayer perceptron (Qu et al., 2018). Text analytics has become crucial for smart campus domains. Text analytics should focus on sentiment analysis and learner feedback, which can identify their emotions and learning engagement (Dake & Gyimah, 2023).

3.2.4 Student Behavior Recognition

The use of IoT in a smart classroom promotes the learning environment. The main components that can be part of the system are temperature sensors that maintain an adequate temperature. The photoresistor is used to capture the light intensity in the classroom. To make the Learning process a real success in a smart classroom, the Learning and teaching component can use learning behavior analytics to analyze the student behavior in the classroom. A decision tree-based classification algorithm can help predict the engagement level of students in the class (Kwok, 2015). The use of Augmented reality can enhance personalized Learning. An augmented reality-based smart campus model can be used, combining GPS, sensors, and augmented reality to promote multidisciplinary Learning. It also helps the learners learn quickly (Shyong et al., 2022). Prediction of the performance of students using a recurrent neural network to reduce college dropouts and those who are at risk of failure. The different factors like academic background, work experience, and interest in the course can be used to predict the students' performance (Liu et al., 2021).

3.2.5 Smart building design

The next factor that has been found in the current literature is Smart building design. Smart building includes both physical and digital Infrastructure. The current literature mentions the importance of smart building, digital security, and waste management as key parts of

Infrastructure. However, the theoretical construct has not discussed the linkages between all the components. So, the connectivity between the components becomes vital. Connectivity is a link that is required between all the elements of the digital and physical Infrastructure. This is an addition to the existing models, which do not discuss the connection between the infrastructure components.

3.2.6 Energy systems and automation

Energy and environmental monitoring systems can be developed to construct smart buildings. The system is based on the distributed form of sensor nodes, which can analyze data related to temperature, humidity, air quality, carbon dioxide concentration, etc (Qian et al., 2014). The IoT occupancy systems that are used in smart campuses can have autonomous wireless devices. Space utilization is one of the applications where digital Infrastructure can be developed. However, there are empirical studies on models to improve space use efficiency through the use of data by IoT tools. It is one of the crucial innovations that can develop the digital Infrastructure of the smart campus model. It can enhance the capacity of the smart buildings sub-component of the model (Azizi et al., 2020).The model calls for smart waste management to form smart waste bins with hybrid sensors or image classification algorithms to differentiate the different waste materials (Longo et al., 2021)

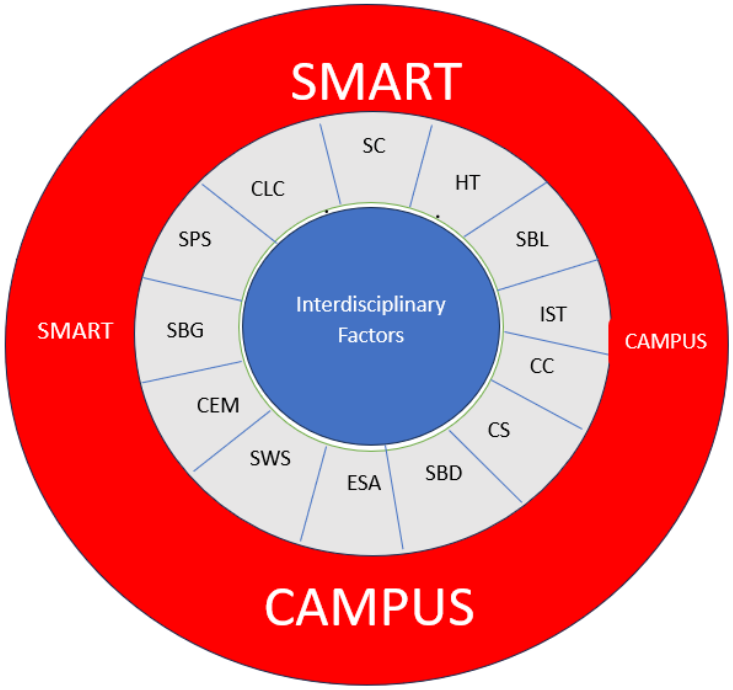

Figure 2: The smart campus conceptual model showing its interdisciplinary factors

(Source: Author)

3.2.7 Smart Budgeting and Governance

The other factor found in the literature is smart budgeting and governance. But here in the given model, the Governance is not just about the machinery and hierarchy, but about the idea of Governance as a developing and evolving system with the rising technology. So, the traditional notion of Governance is not the aim of the model; it is a flexible system involving all the stakeholders, not just those in the hierarchy. The current literature does not talk about the involvement of student committees in the administrative decision-making and their suggestion.

The model provides an idea of Governance that is integrated with academia and the students. The existing model does mention the role of faculties, but enhancements have been made in the model to involve student bodies in decision-making. Developing digital systems like a mobile platform is the need of the hour. The formation of the platform should focus on three aspects formation of social groups based on interest mining, educational guidance based on the information present on the mobile platform, and the development of a secondary trading platform based on optimization of the allocation of resources (X. Dong et al., 2016).

3.2.8 Cyber Security

Privacy and security are among the concerns of the various cloud storage platforms being used on the smart campus. The case study on smart campus data using the cloud has shown that most users believe that their data is at risk, and blockchain is one of the solutions (Azizi et al., 2020). Since the rise of AI and machine learning, data-driven decision-making has been the talk of the business world. This also holds true for a smart campus. The efficient use and analysis of data on different factors on campus can help optimize and efficiently utilize resources. So, the role of machine learning becomes vital in the decision-making process. E-governance is also a feature of a smart university. However, the model's proposed idea is moving away from administration, which is just the aggregation of technology use. Still, it should work on artificial intelligence and human intelligence complementation to enhance efficiency.

3.2.9 Campus Connectivity

The most significant innovation of the model is the inclusion of campus connectivity in the factor identification. This factor is rarely mentioned in the existing literature. Since the pandemic, the issue of health has become the biggest concern. This should also be integrated into an innovative campus model. The campus connectivity here refers to not only physical connectivity but also social and psychological connectivity. This means hygiene and health should be a part of the learning environment.

There is less mention of how health and hygiene can be integrated into the learning process. So this is the real essence of Life, the health factor here. The engagement includes involvement in sports, physical exercise, and mindful activities. A separate mindfulness center in a smart campus is the need of the hour. The other angle of this factor is the maintenance of mental health with the involvement of the university to conduct personal counseling for mental health and also for future careers. The model proposes using a wifi hotspot-based mobile platform that analyzes student interactions without affecting user privacy (Zheng et al., 2018). The model proposes the importance of community members in constructing an intelligent environment. A prosperous web-based interface can be developed to help students interact with the hyperlocal data (Prandi et al., 2020).

3.2.10 Carbon Emission Monitoring

Sustainability is one of the key factors found in modern universities because the notion of development is not just about economic development and GDP numbers, but carrying capacity to meet future generations' needs. The same applies to the idea of a sustainable campus, which is often discussed in the context of an ideal campus. The innovation of the model is the holistic viewpoint of the sustainability domain, which is lacking in the existing literature. The smart campus could be constructed as living labs to move towards a sustainable environment. The air quality monitoring is one of the crucial components, where it has been found that a decrease in air quality is related to traffic emissions. It has also been found that sustainability education can boost the construction of smart campuses as living labs (Mazutti et al., 2020).

3.2.11 IoT and sensing technology

This component also relates to the concept of a green campus using technologies like IoT. The use of IoT reduces the idle time of the computer systems, saving on electricity costs. The temperature of the computers is sent to the cloud servers. The wireless sensor network will be combined with the cloud servers to get real-time data. The system can be accessed anywhere, anytime using mobile devices (Wang, 2014). The proposed model involves real-time energy monitoring. The platform collects electricity usage in campus buildings. The processing is through data processing techniques. A Hadoop system can be used to improve the data storage and processing capacity. The abnormal electrical situations can be analyzed using a map reduction algorithm (C. T. Yang et al., 2020). One novel idea is to construct a smart tree area where students can learn and relax in an environment with sensors to measure all the critical factors like temperature, humidity, etc. It also has the presence of energy-efficient buildings and climate change management systems (Fortes et al., 2021).

3.2.12 Cloud Connectivity

The integration of all the components of the smart campus requires a platform that can store and transfer the real-time data generated. This can be done by the use of cloud platforms. This can help to interconnect the different systems and enhance data transfer and transparency. For the framework to work, technology-integrated education is needed for sustainable development. Technology must be integrated into the system to promote education and sustainable development. The factors that are vital for the development of the framework are the green campus, smart education, course design and evaluation, and technology integration into sustainable practices (Shishakly et al., 2024). The idea of a sustainable campus is the one that is not just about environmental conservation, as seen in the traditional conception. Still, the model also includes social and economic sustainability.

3.2.13 Smart parking system

For the proper transportation and planning, this factor plays a vital role. The IoT-based smart parking system is one of the innovations that can be utilized by a smart campus. The free movement of traffic requires an algorithm that can track the nearest parking. The availability of a mobile platform with real-time data serves the purpose. Other than the use of the platform to get easy parking, there is also a need to cut the fuel costs. This is not only bad economically but also leads rapid increase in carbon emissions. So, an environment-friendly parking system that reduces the existing carbon emissions from vehicles is the need of the hour.

3.3 Emerging technologies

The role of emerging technologies in the domain of smart campus is visible, especially those emerging from Industry 4.0. The table mentioning the smart technologies clearly shows the extensive use of technologies in the existing literature. It highlights the fact that technologies like IoT, RFID, machine learning, AI, smart board, smart lighting, etc, are integral components of the smart university environment. The presence of these technologies defines the smart campus. But merely the presence of these technologies is not the criterion for defining the smart campus. Instead, it signifies the concept of digital campus, which is the aggregation of these technologies. The purpose of building a smart campus lies in integrating the technologies and looking at the domain from multiple aspects, like technology, infrastructure, health, environment, climate change, etc. This brings to the very fact that it requires a holistic and interdisciplinary perspective to move towards a true conception of a smart campus instead of a digital campus, which focuses completely on the use of digital technology.

3.4 Smart campus and smart city

The smart city domain is the parent domain of the smart campus and has served as a guide for the smart campus domain. However, the difference lies in the fact that smart city literature has grown to a higher level. The existing literature on the smart campus is still fragmented. So, there is a need to see this from a broader perspective. The interrelationship between the two concepts should be developed, keeping in mind that a smart university is not only a part of a smart city but also has its own unique features.

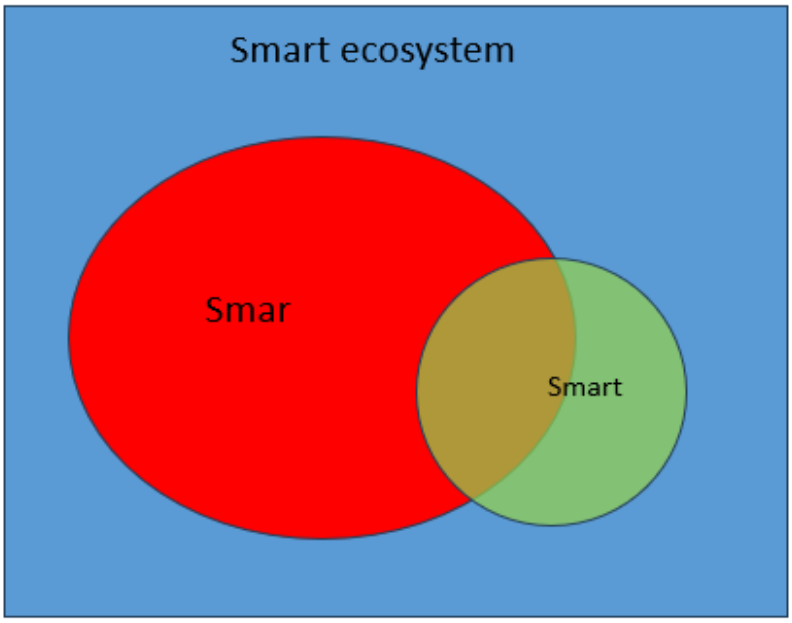

Figure 3: The smart city-campus model highlights the interrelation between smart city and innovative campus models

(Source: Author)

Figure 3 highlights the traditional model that a smart city is an integral part of a smart city. So, many smart campus domains can be taken from the smart city model. However, the innovation in the model is that the smart campus is unique, and some portions of the figure of the smart campus are outside the smart city diagram. This is to highlight the fact that problems and challenges may not be the same. The focus of an innovative campus is more on enhancing the learning environment. On the other hand, Learning is a part of a smart city, not the core of it. The use of the Internet of Things, sensing devices, smart waste management, etc. The monitoring of weather conditions is also standard. The environmental conditions help build a sustainable system, which is the prerequisite for both domains. Integration of physical and digital connectivity is part of both domains. The focus on sustainable development with carbon emission monitoring is a major goal of both areas. But the model also emphasizes that smart city development requires a huge emphasis on the construction of roads, flyovers, etc.

This means it requires infrastructure development on a very large scale. But the smart campus requires equal infrastructure, but on a smaller scale. So both areas require different planning, and a smart campus cannot be built through the methodology of a smart city. Apart from infrastructure smart campus requires a huge emphasis on learning and teaching, with a lot of use of smart technologies mentioned in Table 3. The mental and psychological well-being of the students is also a major concern. These features make the smart campus unique and advocate for the conceptualization, which can focus on both common and unique features.

CONCLUSION

The literature of smart campus, being a follower of the smart city concept, has to take its course. The analysis of the existing literature reveals the growing interest among researchers. It is easy to list down the technologies that are used in a smart campus. But in order to make it holistic, the interdisciplinary factors analyzed here will help in bringing it to its path. The search for factors which are from diverse disciplines is an innovation in itself that helps the literature to grow. The need for the campus to move towards a green campus. Sustainability has become arguably the most essential component. Carbon emissions and climate change are major concerns in the area. After the pandemic era, there is an increased concern over the health and well-being of the students. This is important from both physical and psychological perspectives. The analysis of the literature also reveals that the uniqueness of the smart campus in the smart city model has not been realized. So there is a need to realize the unique features of a smart campus, which may help its literature to move in the right direction. Hence, the smart campus concept can realize its true potential if it moves from the traditional notion of an aggregation of emerging technologies and gives it a unique place in relation to the smart city model.

The limitations of this study are that the literature review process has mainly focused on the factors that are essential for the development and working of a smart campus. The technologies that are mentioned are taken in the context of a developing country. More technical tools may be added for a developed nation. This study can be further used to identify interdisciplinary factors with the technologies used in other contexts as well. This study can also be used in decision-making analysis and in

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