Smart Campus Vocational College with Digital Twin for Sustainable Comfort Monitoring

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Abstract: *Vocational colleges present obstacles to the development of organizations and knowledge that can meet the needs of smart campuses. At the same time, smart campuses promote environmental sustainability and stimulate the widespread use of new information and communication technologies. That is why the smart campus of the College of Vocational Education has been developed. This is a college where technology, equipment and applications create new experiences or services and facilitate them. The Vocational College's Smart Campus is conceptualized as a testing base for other smart campuses, and has been driven by the need to research smart and sustainable approaches to life, colleges, vocational education, higher education and other activities that have never been thoroughly addressed. This research proposes the Vocational College's Smart Campus concept to simulate data generation with an IOT-based network of wireless sensors in the field of environmental monitoring and mood detection to provide insight into comfort levels, in addition to exploring the university's ability to participate in sustainability projects. Preliminary results highlight the importance of workspace monitoring, as performance has been proven to be directly influenced by the environment in vocational colleges to increase energy efficiency.*

Keywords: Digital twin, IOT, Environmental monitoring, Smart campus

1. Introduction

In educational research, laboratories using IoT technology are designed, which are connected to traditional network facilities through the IoT of designed and used architecture. (Fernández-Macías et al., n.d.) It shows that the smart campuses of vocational colleges can effectively control classroom use and achieve low application latency with high throughput and good practice capabilities.

Internally, Academies are in the process of changing strategically to adapt to the challenges posed by the growing impact of digitization and the continued development of institutional and labor market expectations. This global change is contextualized in a broader story of profound social change.(Shea et al., 2020) Emerging technological trends require the creation and implementation of digital strategies in education, with clarity of vision and the ability to make timely decisions. Responding to this change, (Fernández-Macías et al., n.d.) educational institutions are focused on managing schools. For example, they are addressing the need to teach in almost all conditions, face-to-face or long distance, adopting technologies focused on digital management and learning evaluation, and promoting communication technology and collaboration. At the heart of this change to collaboration and environmental monitoring of schools is: convenient and sustainable schools.(Leal Filho et al., 2018)

Most schools approach digital transformation too (Uskov et al., 2018) cautiously, with the result that the rate of digital change in higher education is lagging behind other sectors. The development of smart schools must be able to accommodate the growing demand while promoting environmental sustainability. Recent years have seen the emergence of new information and communication technologies such as the IOT Big Data and Digital Twin. However, the use of such a number of technologies in a wide geographical area requires experimentation and testing. The goal of experimenting with the use of these ICT technologies is to support the effective management of (Vasileva et al., 2018; Villegas-Ch et al., 2019) "small" smart schools. In the context of the smart campus, it is important take into account the needs of students and staff who are on campus while improving the sustainability of the environment

This study suggests that comfort in the educational environment is an important variable for the success of learning and the evolution of society. Comfort is often associated with personal and separate factors such as temperature, brightness and water content. (Zaballos et al., 2020) The management of the device seamlessly is unobtrusive in order to get some reasonable conclusions. A lot of effort has been made to improve ICT-based solutions with the aim of a more accurate and complete system. However, these recurring solutions often fail to quantify the side effects of measuring comfort in the educational environment that continue to have a significant impact on related problems. (Ricciardi & Buratti, 2018)

In essence, current ICT-based proposals to monitor local comfort take a qualitative view of comfort while emphasizing the importance of maintaining the technological paradigm of value for money. Therefore, the existing developments are increasing in accordance with processes of thinking and technologies that remain fundamentally unchanged. (Fortes et al., 2021) Yet understanding, monitoring, predicting and increasing comfort in an educational environment requires a holistic and cross-layered perspective that can frame and quantify the relationships of the users involved. Dealing with school comfort cannot be solved directly as many dependent variables are constantly changing. This is why it is said that safety and comfort in the educational environment has remained sampling for many years, mainly due to the complexity of objective quantification and execution. (Uskov et al., 2018)

Our research proposes a process change using IoT technology to monitor and optimize comfort in the vocational college learning environment. It provides a framework for comprehensive analysis and modeling of internal and external comforts that represents the social and environmental interactions of three strategic stakeholders: (Vasileva et al., 2018) Teachers & Learners, Facilities Management Officer, and Energy Service Provider. If these dimensions have an impact on comfort, then that impact is defined, quantified and validated with innovative scientific methods. This will drive the concept of new technologies that can transform comfort analysis in modern times in physical and virtual educational environments. This success will provide them with unconventional functionality to improve sustainability, while also helping to understand, observe, design, and recognize a comfortable learning environment. (Zaballos et al., 2020)

This research defines two objectives: convenience and energy savings. IoT devices are responsible for detecting comfort and energy efficiency levels in vocational science, and then carrying out corrective actions. Therefore, IoT systems involve a group of smart devices that can be used to achieve these goals. (Liu et al., 2021a) For example, agents are responsible for improving energy efficiency and comfort in a given classroom and recognizing and stimulating physical environments such as classrooms through IoT sensors and applications. In educational institutions (schools, vocational colleges, universities, etc.) (Uskov et al., 2018) the majority of these facilities were built a long time ago to meet the educational needs of the rapidly increasing local population due to social changes such as universal education. Academies require a huge infrastructure to accommodate students, faculty, and staff. However, the overall comfort of these environments receives little or no attention. This is a measure that balances the well-being of all users, efficiency of related processes, and the environmental impact of facilities. (Fialho et al., 2022)

This research proposes a smart campus concept for the Vocational College in order to examine the integration of building data modeling tools with wireless sensor networks on the IOT in the field of environmental monitoring, and thereby produce insights into the level of convenience. Digital Twin (Elayan et al., 2021) is selected for this project because its performance has been proven to be directly influenced by the parameters of the environment. The infrastructure for monitoring comfort can also be recycled to monitor physical parameters from schools to increase energy efficiency.(Zaballos et al., 2020)

2. Literature Review

2.1 Smart campus

Ajriya City urges the widespread use of new information and communication technology. However, experimenting with these technologies over vast geographical areas is not possible. That is why smart campuses, universities (Fialho et al., 2022) where technological equipment and applications create new experiences or services and facilitate operations experiment on a smaller scale, are so useful. The concept of smart campuses as testing bases for smart cities is gaining momentum for research. Meanwhile universities acknowledge the academic role of an intelligent and sustainable approach to vocational education. (Fortes et al., 2021)

Smart cities must be large cities that can accommodate the growing needs of citizens while promoting environmental sustainability. With the emergence of new information and communication technologies such as the IOT and Big Data, smart cities are getting closer to realization.(Vasileva et al., 2018; Villegas-Ch et al., 2019) However, the use of such a number of technologies over a wide geographical area requires trials and tests. That is why our research proposes to build smart campuses. To experiment with the use of these ICT technologies. The goal is to support the effective management of a "small" smart campus, which takes into account the needs of students and staff on campus while improving environmental sustainability. (Alvarez-Campana et al., 2017)

The term smart campus is used to refer to digital online platforms that manipulate university content and provide a set of techniques aimed at increasing the intelligence of university students and the ease of knowledge transfer.(Chiandone et al., 2019) University campuses typically consist of large buildings with high energy needs. The challenges associated with high energy costs and environmental impacts are clear incentives to achieve efficiency and sustainability goals. University buildings are also important as demonstration sites for new technologies and systems. (Omotayo et al., 2021) Smart campuses are receiving increased attention, primarily because they are an ideal environment for developing, evaluating, and monitoring smart city and smart building solutions before applying them on a larger scale.

Based on the growing number of articles published on smart campuses, there is evidently a lot of work that offers the implementation of smart and sustainable options on university campuses from an energy and ICT perspective. Some studies focus on implementing energy saving options. (Yang et al., 2018)

For example, (Fortes et al., 2019) a general framework of layers of smart campuses, including the core technological infrastructure associated with applications, was applied at the University of Malaga in Spain. Analysis and design service discovery and perceived data integration algorithms were applied to situational awareness on the smart campus, (Villegas-Ch et al., 2019)showing how multidimensional scenario-based data fusion methods can be used to perform intelligent controls for energy savings on campus. focuses on cloud architecture and big data to support university campuses. (Hannan et al., 2018) A review of different types of internet systems of energy- based indoor energy management systems (such as power routers storage and materials systems, as well as renewable energy sources) shows what an IoT platform looks like. It can be used at the college level to promote energy-saving behaviors supported by the data collected by such platforms. (Liu et al., 2021b)

The present research has taken an integrated perspective that includes energy options to achieve sustainable energy goals but also the use of IoT platforms to ensure the necessary conditions for using smart energy services. (Moura et al., 2021) The platform not only provides information about energy needs and production at the building level and vocational campuses, but it also ensures monitoring and control of bright core loads to reduce energy consumption and associated costs. (Wu et al., 2020)

2.2 Digital twin

Digital Twins are digital replicas of products. Especially in industry, 4.0 (Radanliev et al., 2022) digital twins are lifestyle technologies that drive business outcomes. The idea is to simulate real physical elements, digitally to synchronize with it completely. This capability increases the possibility of digital pair analysis in order to understand behavior in different situations and provide valuable information that leads to improvements and corrective actions.(Gallastegui & Forradellas, 2021)

In education, Digital Twins is a new tool that helps to learn simulated environments better and faster. Instead of studying the real thing, technologies such as virtual reality have new tools that expand the use of Digital Twins.(Picone et al., 2021) The work will be able to combine fragments of fragmented information into a more complete and accurate representation of "identity." A more precise image of such a digital mirror will be achieved. (Sanglub et al., 2019)

Academies can model their students based on Digital Twins, modify and balance knowledge education and exchange interactions and experiences based on the evolution of these digital presentations and the analysis conducted by intelligent models using artificial intelligence. (Gallastegui & Forradellas, 2021)

2.2 Internet of Things (IOT)

IOT technology comprises an interconnected network that uses data detection devices such as radio frequency identification devices, infrared sensors, laser and GPS scanning, and real-time data collection that requires monitoring connections, interactions, and more.(Elayan et al., 2021) The main function of the IOT is to realize the whole process of acquisition, data transmission, storage processing, and the application of real-time interactive data perceptions between "human-human", "human-object", and "object-object": the IOT can connect the real and virtual worlds. In the real world it supports human-computer interaction.(Wu et al., 2020) The IOT can be divided into three layers: perception layers, network layers, and application layers. The IOT detection and infrastructure layer is responsible for collecting all kinds of data from classroom environment devices and consists of sensors and sensor gateways; it is the source of IOT data. (Liu et al., 2021b)

Improving the intelligence of the teaching environment and developing multimedia teaching equipment has become a major concern for colleges and universities.(Kuandee et al., 2019) As a result, the design of IOT technology attendance management is increasingly important in educational research. Classrooms are the main structure of education. Smart classroom architectures using IoT technology are designed to connect to traditional network facilities through IoT gateways. (Moura et al., 2021)

As stated earlier, the main principle of communication within the IoT system indicates that each node must "speak" the same language in the IOT. This is a big problem due to the large number of devices. (Moura et al., 2021) Each machine has its own language that does not meet the common standard. However, this issue is solved through middleware. In related research, IoT middleware solutions are sometimes called IoT platforms, or IoT middleware platforms, as middleware is generally a platform. As proved in this project there are other middleware tools such as building data modeling or computational simulation software which can act as middleware. In general, it can be divided into four categories. (Zaballos et al., 2020)

(1) Publicly traded IoT cloud platform
(2) Open Source IoT Cloud Platform
(3) Developer-friendly IoT cloud platform
(4) End-to-end IoT cloud platforms connection

IoT design systems and platforms ensure increased energy sustainability in colleges, (Villegas-Ch et al., 2020; Wu et al., 2020) at the same time upgrading the intelligence of existing buildings through innovations for older equipment in a cost-effective and reliable way. Overall, it allows for the evaluation of innovative technologies and services. The IoT platform is designed for genius campuses but can also be used in any large public or commercial building. (Wu et al., 2020)

Based on a detailed study of the design of the genius campus, it was found that genius campuses are based on the development of open or cloud computing data platforms, service architectures, and IoT platforms.(Zaballos et al., 2020)

2.3 Environmental monitoring

The use of technology for environmental monitoring has become an important tool for public health management and plant monitoring.(Chiandone et al., 2019) The tool also allows the study to focus on climate and small climate analysis and weather forecasting. These studies can provide the knowledge needed for better resource management and planning in specific regions. Areas that may benefit from such knowledge include agriculture, livestock, fish farming, beekeeping, and more.(Dan Moiş et al., 2018)

The monitoring and controlling of energy needs and building production has been discussed at various events (Fantozzi et al., 2019) presenting the adaptation of the physical power supply systems on university sites. Chalmers University of Technology (Sweden) integrated communications and control settings that provide technical requirements for smart grid collaboration. Jadavpur University Saltlake Campus (India) (Leal Filho et al., 2018) utilized wireless sensor nodes and load monitoring. An effective web-based energy management system was introduced at the University of Crete which manages buildings campuses and spaces for effective public use, monitors energy consumption, and carries out energy operations. Analysis of each building and of the campus as a whole via technologies such as IoT blockchain or edge and fog computing is an enabler for smart campuses such as these. (Zaballos et al., 2020)

The research focuses on location-modeling case studies of co-build rooms in the medium-sized center of the laboratory. By combining these bundles of data, you can use the Bundle, which enables the overall vision of the system to be achieved as follows: on one side an IoT agent measures environmental monitoring, (Filho et al., 2021) while information about the mood of residents is used by Middleware intelligence for repeated impartial monitoring of perceived comfort. In addition, the Middleware layer is responsible for storing data in a database and communicating with visualization platforms to perform predictive analysis of the comfort of the monitored area by displaying information in a virtual classroom format and taking into account energy monitoring. (Malche et al., 2019)

IoT architecture in intelligent environments and comparisons between technologies are used for environmental monitoring. Technologies and sensors such as sensors and wireless transmitters are offered. The study conducted by the authors on intelligent monitoring using IoT facilitates the development of future work. (Filho et al., 2021)

Other articles have proposed using energy-saving alternatives in conjunction with renewable energy integration. In one study, the cost-effectiveness of turning the University of Dayton (Shea et al., 2020) into a fully renewable and renewable-based campus was evaluated. In another, microgrids were evaluated for the University of California, San Diego that combines renewable production with maximum load replacement. (Bracco et al., 2018)

Research studies have offered potential ICT platforms, but there is no confidence in taking any action. For example, a connection between the sensor network and the energy management system integrated into the CAMPUS IT infrastructure was designed for (John et al., 2018) Covenant University. A smart campus model has been introduced on the IoT for Rajshahi University (Bangladesh), but only intelligent environmental monitoring and EV charging have been introduced. Other work has developed an ICT platform but has not focused on energy management. (Du et al., 2016) Shandong Normal University (China) (Alvarez-Campana et al., 2017) has adopted a platform for authentication and data analysis to evaluate daily behaviors and habits. An IoT platform that operates throughout the Universidad Politécnica de Madrid engineering school monitors the flow of people and environmental parameters. Other studies have highlighted the uses of these platforms but focus on the distribution of energy between buildings.(Dan Moiş et al., 2018)

Based on the above research, the researchers synthesized the design data of smart campus Vocational College. The relevant technologies are studied as shown in Table 1.

Table 1. Synthesis Smart Campus with Digital Twin and IOT

Process/Phase	Authors	Description
.1digital twins - Physical Twin - Virtual Twin - Connections between the two products	(Radanliev et al., 2022) (Zaballos et al., 2020) (Picone et al., 2021) (Fialho et al., 2022) (Sanglub et al., 2019)	Creating virtual impressions that work as real-time digital pairs of objects or physical processes. From interactive approaches to table prediction, Digital Twins incorporate artificial intelligence. IoT and virtual reality data analysis
2. Internet of Things (IOT) - Things of Device	(Moura et al., 2021) (Kuandee et al., 2019)	Internet technology used to connect IoT physical devices and objects

Process/Phase	Authors	Description
- Networks communications - Data Ingestion - Data Transmission - Data Processing - Data Visualization - Data Analysis and Prediction - Security - User Interface - Could Computing	(Villegas-Ch et al., 2020) (Liu et al., 2021b) (Fialho et al., 2022) (Wu et al., 2020)	requires new analytical methods related to new tools and algorithms. Interconnected networks that use different data detection devices IoT solutions can optimize service Create an environment with proven safety and maintenance.
3. Environmental Monitoring - Facility Management - Time Reduction Management - Control Management - Efficiency Management - Temperature - Humidity - Light - indoors and outdoors	(Zaballos et al., 2020) (Alvarez-Campana et al., 2017) (Fortes et al., 2019) (Gallastegui & Forradellas, 2021) (Malche et al., 2019)	Combining data obtained from objects in an environment with the data contained in digital models of buildings. Environmental monitoring, which enables analysis of many environmental parameters such as temperature, humidity, and environmental conditions. Light, volume or air composition both indoors and outdoors, etc.
4. Smart Campus - Building Construction - Inclusive smart technology - infrastructure facilities - Equipment Management - IT networks and applications	(Omotayo et al., 2021) (Du et al., 2016) (Uskov et al., 2018) (Yang et al., 2018) (Zaballos et al., 2020)	Smart campuses are wealthy. and the division of space should be consistent with the community Sustainability of the university's infrastructure, administration and duplication. Integrating teaching, science and management to create a digital campus IoT adapting existing campus buildings is what makes buildings smart. Energy use and sustainability management approach smart gauge and data control connections with smart campus forward data application

Smart campus synthesis with digital twin and IoT has 4 elements. 1) Digital Twin is the creation of virtual reality shows that work in pairs with real-time (Fialho et al., 2022) digital objects or physical processes. (Radanliev et al., 2022) It can also combine data from past uses with (Zaballos et al., 2020) digital factors, make virtual entities exist at the same time as physical entities, make virtual software copy objects and physical systems, and it represents strategic technologies that facilitate the support of devices and systems. (Picone et al., 2021) IOT with cloud work in facility management adopts an interactive approach.(Sanglub et al., 2019) 2) IOT deploying platforms and infrastructure monitor and stimulate elements of internet technology (Moura et al., 2021) used to connect physical devices and objects. (Kuandee et al., 2019) IoT requires a new analytical method involving novel tools and algorithms.(Villegas-Ch et al., 2020) Through connected networks that use different data detection devices, (Liu et al., 2021b) IoT solutions can increase service efficiency, (Fialho et al., 2022) create environments and performance and improve safety and maintenance. (Wu et al., 2020) 3) Environmental Audit Combining data is obtained from objects in an environment (Zaballos et al., 2020) with the data contained in digital models of buildings.(Zaballos et al., 2020) Environmental monitoring allows the analysis of many environmental (Fortes et al., 2019) parameters such as humidity in temperature, etc., (Gallastegui & Forradellas, 2021) as well as light content or air elements both indoors and outdoors. (Malche et al., 2019) 4) Smart Campus Development, Campus Expansion for Community Infrastructure, and Sustainability Management involve integrating and reusing the teaching, science and technology infrastructure to build a genius campus, (Uskov et al., 2018) whether by constructing or retrofitting existing campus buildings with IoT. (Omotayo et al., 2021) What makes buildings smart is energy consumption and management practices. (Du et al., 2016) Sustainability IoTs intelligently measure water management and connectivity to control data and applications to present smart campuses.(Zaballos et al., 2020)

According to a study of published articles related to Smart Campus with Digital Twin in 2018-2022 in the Scopus database, there are articles published in each country as follows: China 47, United Kingdom 38, India and United States 28, Germany and Spain 27, Australia 19, Italy 18, Hong Kong and Portugal 14, Brazil and Canada 9, France, Malaysia and Sweden 8, Finland, Greece, Singapore and South Korea 7, Indonesia and Nigeria 6, Austria, South Africa, Switzerland, Turkey and United Arab Emirates 5, New Zealand, Pakistan and Saudi Arabia 4, Belgium, Hungary, Israel, Russian Federation, Thailand, Ukraine and Viet Nam 3, Czech Republic, Estonia, Ireland, Japan, Macao, Mexico, Netherlands and Taiwan 2, Bangladesh, Croatia, Denmark, Ecuador, Egypt, Iraq, Kazakhstan, Nepal, Norway, Peru, Poland, Qatar, Slovenia, Tunisia 1 As shown in figure 1.

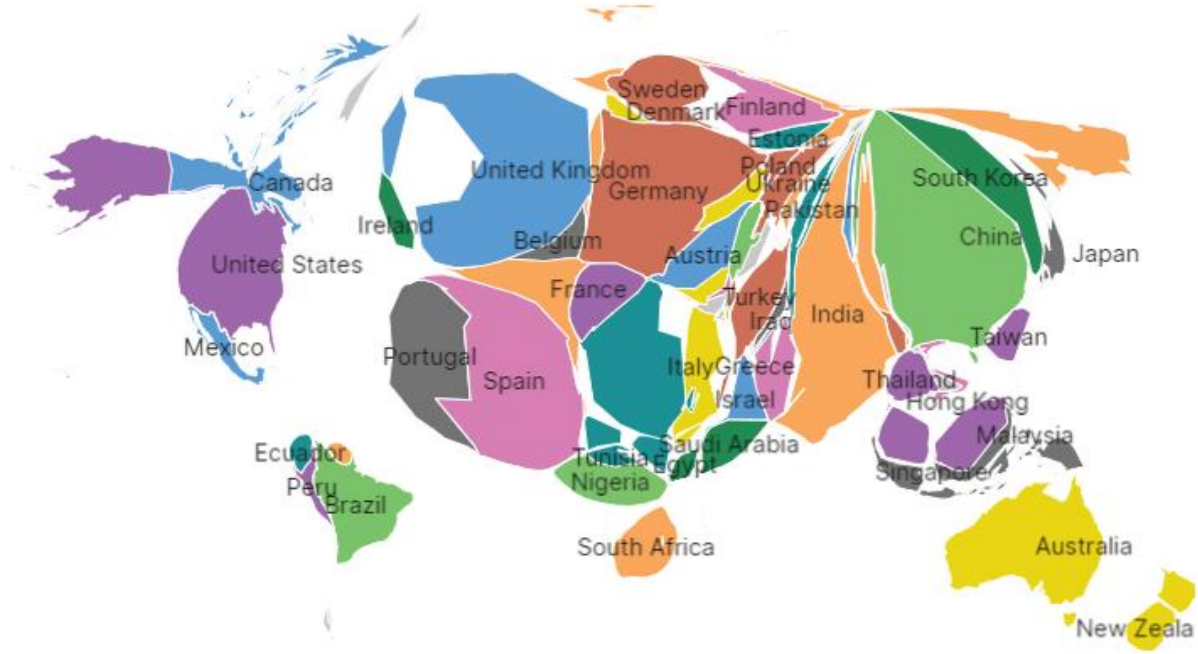

Figure 1. Country in which the article was published about Smart Campus with Digital Twin

According to Figure 1, such remarkable studies were conducted by China, United Kingdom, India United States, Germany, Spain, Australia, Italy, Hong Kong and Portugal, published 47, 38, 28, 27, 19, 18 and 14 editions, respectively. The inclusion of these countries accounts for only 60 percent of all publications of Smart Campus research with Digital Twin and IOT. Other countries accounted for 40 percent of publications. The focus of the print search is the identification of smart campus technology and digital twin indicators.

3. Methodology

3.1 Smart Campus vs. Digital Twin Structure with IOT and Environmental Monitoring

Gephi is a social networking analysis tool used to visualize the strength of connections between nodes. (Majeed et al., 2020) Shows a combination of all 30 nodes , 40 edges. As shown in figure 2.

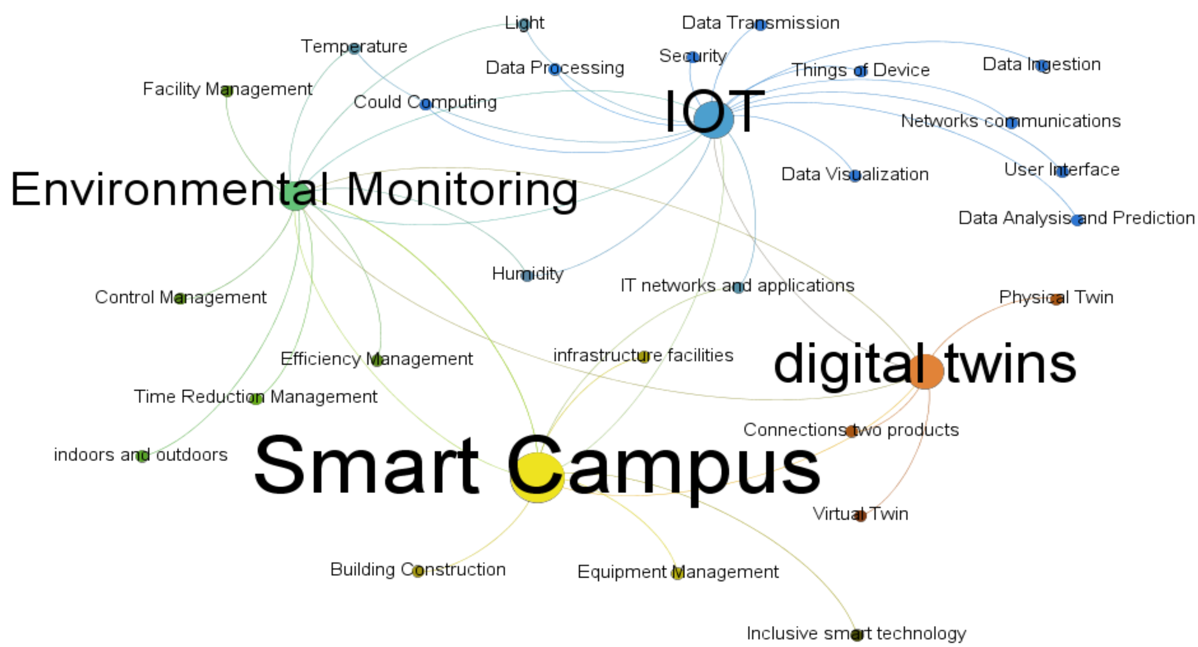

Figure 2. Modular Display Network Smart Campus with Digital Twin with IOT and Environmental Monitoring

According to Figure 1, in this case the researchers considered it an important part of drafting a plan for a smart campus. Students on smart campuses include campus facilities isolating and analyzing big data for education teaching and improving the environment such as temperature brightness and water measurements. Research can promote the success of smart campuses. IOT through an application is able to provide Smart Campus with sustainable convenience.(Zaballos et al., 2020)

3.2 The Digital Twin Deployment

Facility modeling of Smart Campus Vocational College with Digital Twin for Sustainable Comfort Monitoring is an R&D laboratory where everything related to people's interactions with the social and technological changes of their environment is carried out. It focuses on the Internet of Things, the digital connection of everyday objects to the internet. In fact, it is a space for the development of innovation initiatives. The laboratory is based on design, prototyping and scaling the products and services of the future for society and the business world.(Zaballos et al., 2020) As shown in Figure 3 and Figure 4.

Figure 3. Show location building modeling Smart Campus Vocational College
Origin: The author created the model manually.

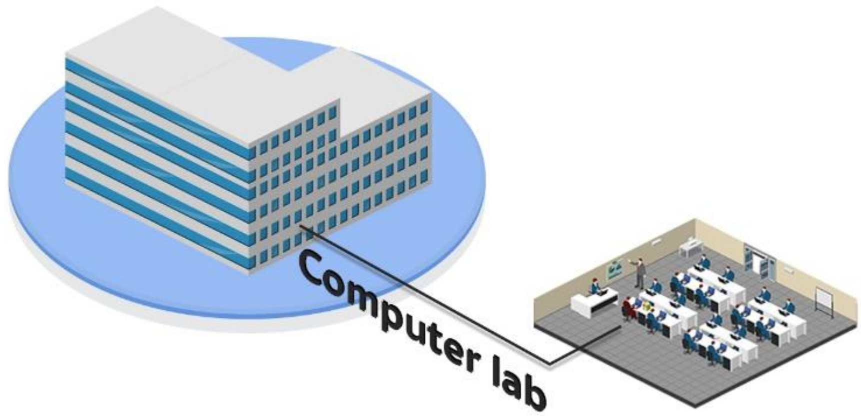

Figure 4. Show laboratory modeling Smart Campus Vocational College
Origin*:* The author created the model manually**.**

Site modeling case studies focused on co- build rooms in the medium center of the laboratory. IoT measuring environmental monitoring in the case is used for repeated inspection of impartially perceived comfort. In addition, it is responsible for storing information in the database and communicating with the visualization platform to perform predictive analysis of the comfort of the monitored area. By displaying information in a virtual classroom format and taking into account energy monitoring.(Fortes et al., 2019)

3.3 The design links smart campus vocational college elements with environmental monitoring. As shown in Figure 5

*Figure 5***.** Element link Smart Campus Vocational College

The Smart Campus Vocational College element Link To coordinates text communication between servers and sensors. The protocol consists of a database that stores data and retrieves data from IOT safes: IOT works by controlling temperature brightness and water through the screen with the application.

3.4 Design Smart Campus Vocational College App
In the Smart Campus Vocational College environmental monitoring application, a display shows the functions of temperature, lighting, and water consumption. As shown in Figure 6.

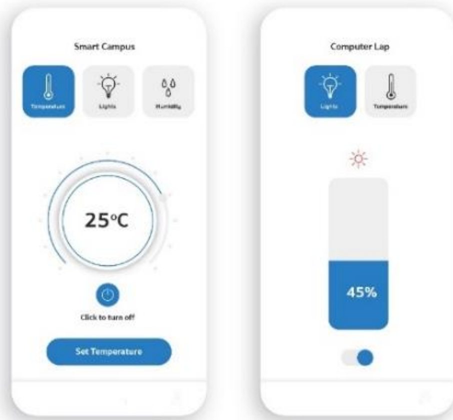

Figure 6. Smart Campus Vocational College App

Functional control with the Smart Campus Vocational College Consists of 1) checking the temperature of the room, 2) checking the brightness, 3) monitoring the amount of water. In the functioning of the application is a monitoring of the facilities of smart campuses.

4. Results

The findings of the Smart Campus Vocational College with Digital Twin for Sustainable Comfort Monitoring demonstrated data processing operating according to architecture. Efficient components were able to monitor sustainable performance by adopting IOT and Digital Twins technology to create a convenient examination. There is a performance status in display through mobile apps.

This study designed the Vocational College's Smart Campus Application. Using IOT technology the platform recognizes the function of attending classes. Intelligent classroom architectures use IOT technologies designed in smart classrooms which are sent to the environmental device controllers of a given classroom. As a result of this we designed functional modules and cloud service layers of intelligent education data deployed IOT and Digital Twins technology to create higher throughput and reduced application delays. (Liu et al., 2021a) This proposed study plans to be tested and implemented by adopting predictive models with digital twins based on deep learning leveraging data on IoT data availability to monitor sustainable comfort.

Compliance with some other requirements such as data reliability is affected by inaccuracies in mobile application displays. Data security and privacy protection is applied to store data influenced by the restrictions. In addition, requirements related to the low cost of use maintenance and operation of system prototypes and the possibility of management by their own colleges have only been partially amended.(Fialho et al., 2022)

5. Discussion

In this article, a discussion of the findings for the theory which is the final stage of the process of designing the Smart Campus Vocational College with Digital Twin for Sustainable Comfort. Different IOT and Digital Twins link elements are created gradually and flexibly for specific functions. Scalable structures also promote the development of real-time data display applications combined with IOT technology. Flexibility in selecting IoT and Digital Twins components is important for existing systems.

In addition, the benefits of this approach also include flexibility in integration. Availability of a single data source reduced human error However, the authors emphasize that this mechanism will not fit more complex models with many sensors. Therefore, sensors are selected that can be optimized for the Smart Campus environment and can be used effectively. This is because it requires the manual creation of virtual objects that replace physical sensors to detect emotions. It is an ever-changing state, causing detection discrepancies during operation regarding the transition from conventional maintenance to automated intelligent processes. This can affect service performance by eliminating the ongoing detection and reporting process by the user create.

Results showed that the previously reported limitations of the IOT components used in the design influenced the reporting accuracy with the Digital Twin, causing low accuracy and inaccuracies in the reporting position and the number of sensors to be measured. However, advances in research and new technologies, such as remote exploration technology and processing power, and distributed calculations can overcome these things. In addition, the cost of IoT components is gradually falling, allowing for mass distribution.

6. Conclusion

The findings of this study relate to practice and research as they enhance understanding of complex issues related to the Smart Campus Vocational College. The proposed model points to the methodological direction of future studies focused on the management of fire systems' temperature control and indoor water control systems, but the principles used in the development of the prototype are scalable to other systems of buildings and laboratories.

Due to digital transformation in the industry, it remains a developing field of investigation. Such advances can support researchers and policymakers in developing tools, guidelines and standards for smart maintenance and smart campuses. Implementing the findings also involves improving understanding of technology, procedures, and policies related to the implementation of IoT Digital Twins and environmental monitoring through the application for use in Smart Campus Vocational College. Knowing the most likely scenarios for maintenance issues at the enterprise level points to areas that may be improved through the application and IoT within the Digital Twins forecast guidelines to create sustainable comfort.

In addition, understanding the requirements, challenges, and expected benefits of implementing intelligent systems will provide a more realistic picture of the necessary procedures and resources for owners and staff of vocational colleges to use in planning the digital transformation of services for smarter sourcing. The findings of this article contribute to improving decision-making throughout the project's lifecycle and driving the organization towards the Smart Campus Vocational College.

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