Indonesian Journal of Science & Technology

Journal homepage: http://ejournal.upi.edu/index.php/ijost/

A Systematic Review of the IoT in Smart University: Model and Contribution

Senny Luckyardi[1,2], Ratih Jurriyati[1], D. Disman[1], Puspo Dewi Dirgantari[1]*

[1]Universitas Pendidikan Indonesia, Indonesia

[2]Departemen Manajemen, Universitas Komputer Indonesia, Indonesia

*Correspondence: E-mail: sennyluckyardi@upi.edu

ABSTRACT

The objectives of the review were to identify different implementation aspects of the Internet of Things (IoT) in Smart Universities (SU) from diverse studies, amplify the theories behind the IoT utilization and model in SU; as well as offer recommendations for future research in this area. This study employed a systematic literature review (SLR) technique, conducting comprehensive searches of the most relevant articles to the research question published from 2018 to 2022. Following a review of peer-reviewed journals, a total of 69 refereed articles were chosen and analyzed. The findings of this study suggest that the technology model needs to be aligned and integrated with organizational processes. IoT utilization should meet the adoption readiness of a university. The results also revealed that the creation of SU can be divided into three categories: behavior, learning, educational technology, and physical facilities. However, the literature related to IoT utilization and model is still incoherent and lacking in theoretical frameworks that reflect on specific circumstances such as SU. SU research is still in its early stages, with more work to be done in terms of identifying technology model adoption. The review also contributed to serving as inspiration and a point of reference for institutions as they work with the smart university initiative to create a teaching and learning environment that is more effective and efficient.

ARTICLE INFO

Article History:

Submitted/Received 27 Jul 2022
First Revised 30 Aug 2022
Accepted 18 Oct 2022
First Available Online 19 Oct 2022
Publication Date 01 Dec 2022

Keyword:

Internet of things,
Smart university,
Systematic literature review,
Technology.

1. INTRODUCTION

The ability of an object to exhibit the intelligence that has been placed in it is usually referred to as being "smart" (Chulling *et al*., 2009). The word "smart" is emblazoned on the phone to demonstrate its intelligence and to demonstrate how many activities or aspects of daily life it can help through various services offered (Nie, 2013). The term "smart" has expanded to encompass a wider range of topics than just a single item, such as "smart cities", "smart university", "smart grids", “smart home”, “smart app”, “smart harvesting”, “smart material”, “smart fashion”, and so on (Liu *et al*., 2014; Amin *et al*., 2022; Anh, 2022; Pechsiri & Puengsungwan, 2023; Castiblanco *et al*., 2021; Shaffiyah *et al*., 2022; Luckyardi *et al*., 2022; Chaihang & Puengsunwan, 2021). The meaning or definition of a smart university at this time has not been narrowed to a general understanding (Cocoli *et al*., 2014). Various researchers who have built smart universities have presented this definition based on different approaches.

Smart universities are an established trend because of the development of digital universities through the use of appropriate technology tools and the provision of services globally. This is based on the technological strategy adopted by a university. To connect disparate systems, the internet uses cloud computing and IoT service providers (Kwok, 2015). IoT services are created by transforming ordinary university-related things into intelligent ones by adding sensors and thorough intelligence to enable rational decision-making in the academic setting. To improve university performance and graduate quality and to support all stakeholders in an adaptive environment including three factors: teaching, management, and service (Rehman *et al*., 2008), smart universities develop a centralized digital neural system (DNS) that directs the full learning cycle across the university ecosystem and facilitates the development of appropriate applications or services.

The Internet of Things (IoT) has grown in prominence recently since it provides global networks for connecting objects and gadgets to the Internet infrastructure. Thus, the IoT makes it possible for items and people to connect at any time and everywhere, which leads to the identification of the combination of intelligence and knowledge, as well as the global production of new knowledge. A smart university comes with an interactive educational environment, access to global content, and adaptive learning based on the data collected and analyzed within the network. The IoT is currently present in many universities as security cameras, temperature control devices, access devices to buildings, electricity, and heating systems for supporting educational process (Thapwiroch *et al*., 2021). The elements that make up the internet of things namely: Artificial intelligence, sensors, and connectivity (Rehman *et al*., 2008).

Based on the adoption strategy for the smart city concept, it is claimed that smart universities and smart cities share several issues in common. The same paradigm is being used by smart universities to adapt contemporary technology to support various users (students, staff, and visitors) carrying out various duties in multifunctional structures. In other words, smart colleges are compared to small towns that are autonomous in terms of their users, connections, activities, and quantity of functions (Atif *et al*., 2015).

The main idea behind a "smart university" is to build institutions of higher learning by making efficient use of resources (Al Shimmary *et al*., 2015), employing various forms of intelligence to deliver high-quality instruction (Torres *et al*., 2015), and intelligent services to the university community and the environment, thereby cutting costs and simplifying daily life, giving better and simpler (Azarmi *et al*., 2010). To automatically enable reporting to all parts of

DOI: https://doi.org/10.17509/ijost.v7i3.51476
p- ISSN 2528-1410 e- ISSN 2527-8045

university life, including learning, social interaction for work collaboration, intelligent building management, and smart environment, a variety of sensor technologies are used to apply intelligence.

Smart University is a concept that aims to modernize and integrate all the processes in a university with Information and Communication Technology (ICT). The modernization and integration of ICT are intended not only to improve the performance of the process but also to improve the quality of the graduates and administration processes (Bolaji & Adeoye, 2022; Shah, 2022; Akinoso, 2023; Bolaji & Jimoh, 2023; Arciosa, 2022; Dwiana *et al*., 2022; Rachmawati, 2019; Jadhav *et al*., 2022; Daramola, 2023).

To achieve the title of Smart University, the Smart University designer must be aware and provide close attention to the maturity of the characteristics of "Intelligence" such as self-learning, self-organization, inference, anticipation, adaptation, and detection. In addition, the title of Smart University must be maintained by continuously making improvements to narrow the gap and become an even smarter university. Multiple standard models can be referenced to achieve the title of Smart University (see **Figures 1-3**).

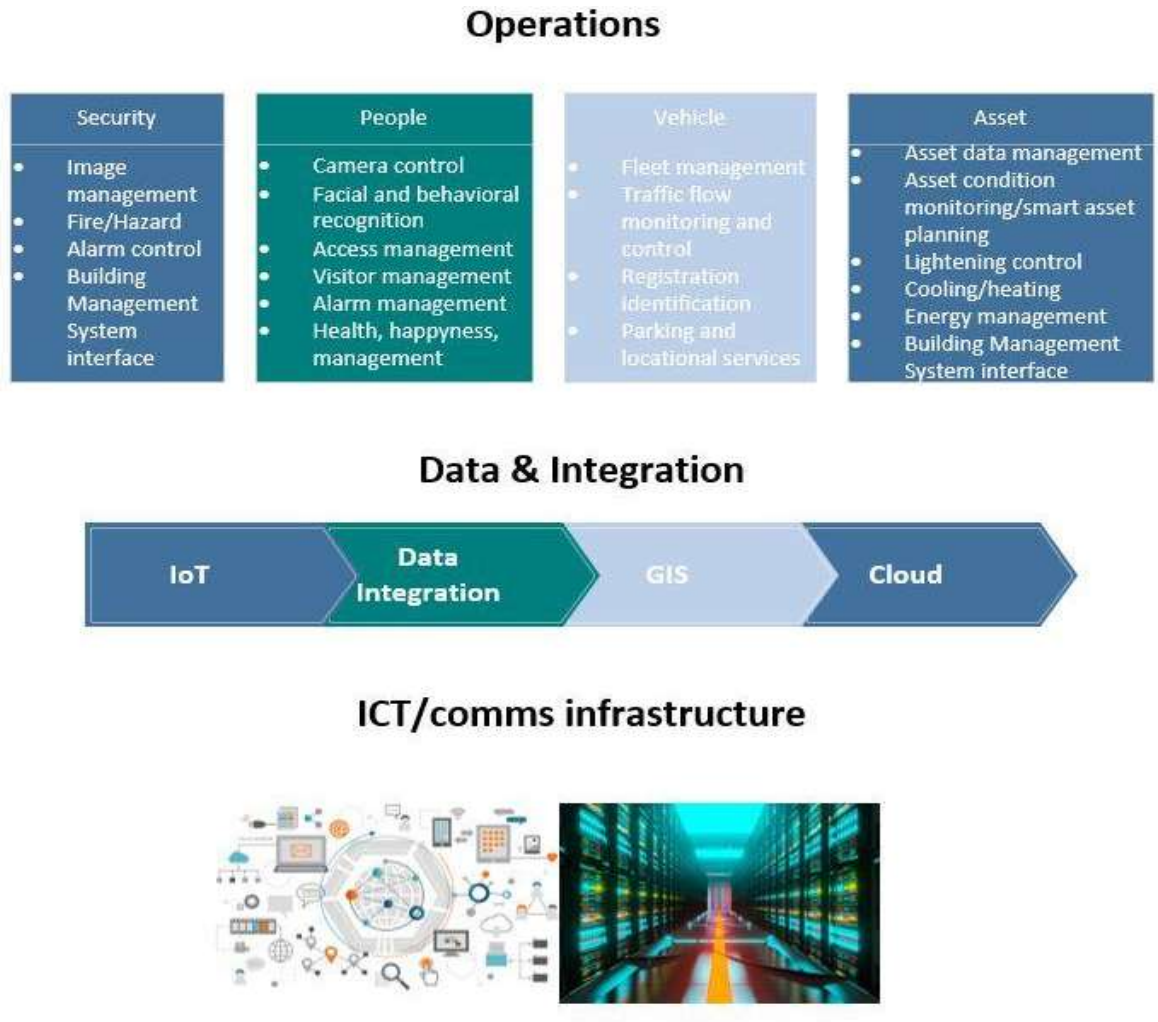

Figure 1. Typical structure of technology-driven smart-university (Dong *et al*., 2020).

DOI:https://doi.org/10.17509/ijost.v7i3.51476
p- ISSN 2528-1410 e- ISSN 2527-8045

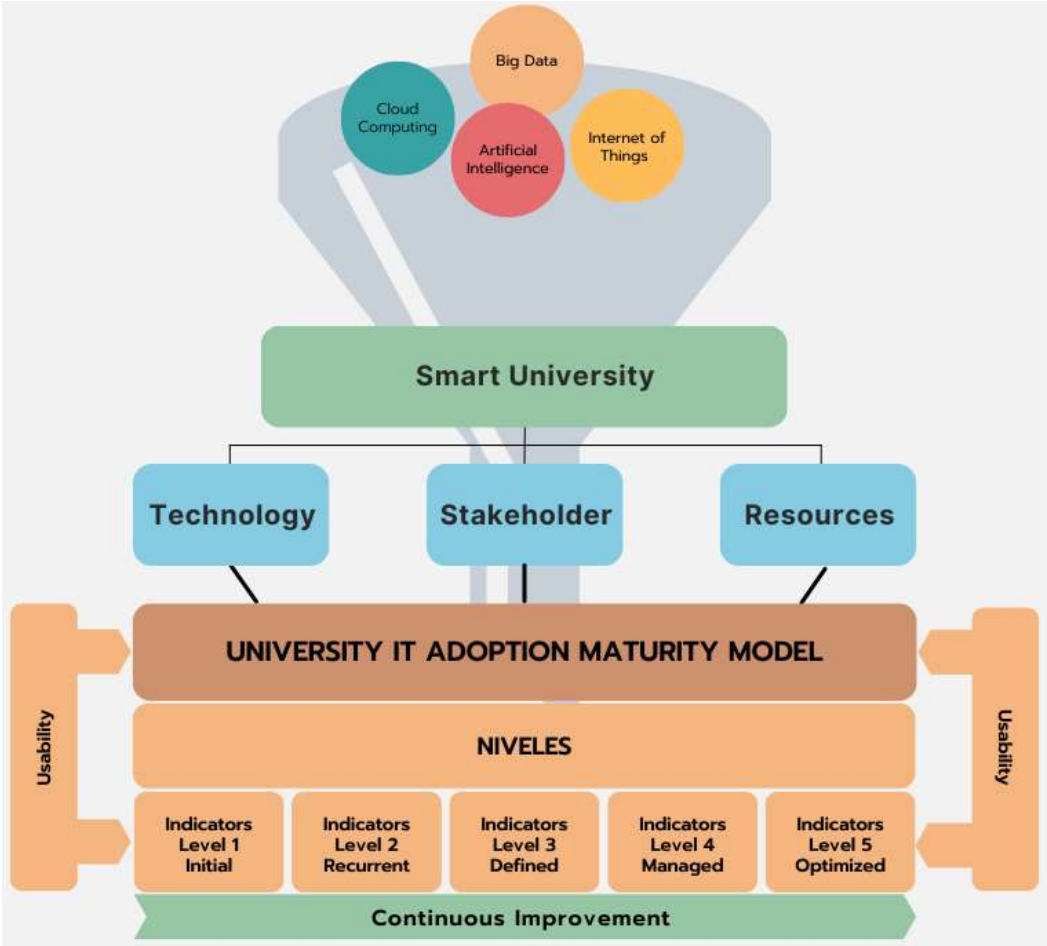

Figure 2. Projection of IT adoption maturity model.

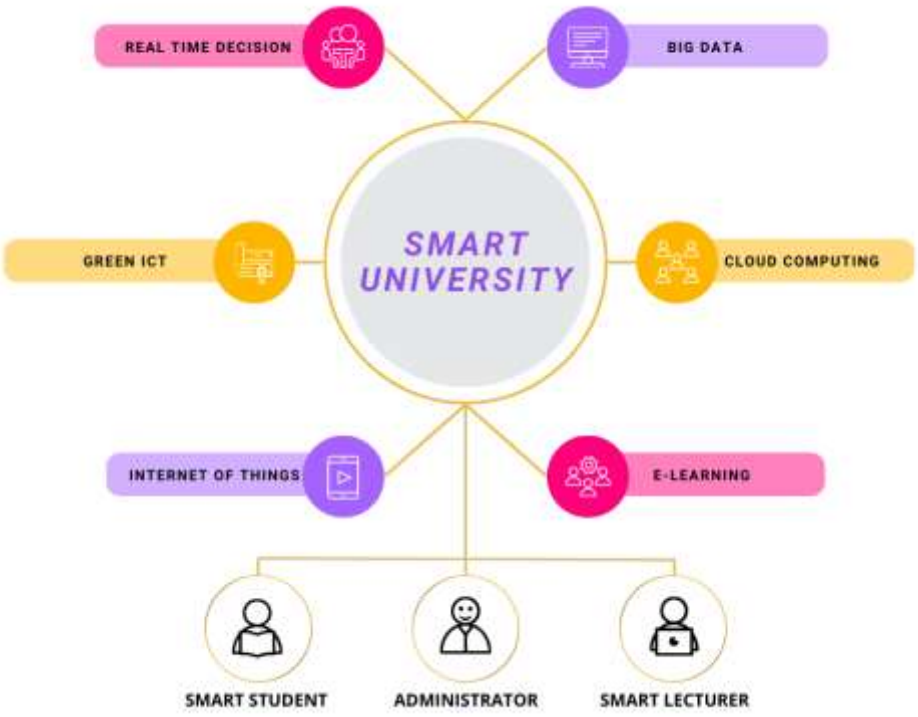

Figure 3. Components of Smart University (Mbombo & Cavus, 2021).

DOI:https://doi.org/10.17509/ijost.v7i3.51476
p- ISSN 2528-1410 e- ISSN 2527-8045

In the Operations section, there are four components, namely, Security, People, Vehicle, and Assets. Security is part of supporting the security of company data and operations to maximize company performance. In the Security section, there are four components, namely image management, fire/hazard, alarm control, and building management system interface. In the People section, there are six components, namely camera control, facial and behavioral recognition, access management, visitor management, alarm management, health, and happiness management. In the Vehicle section, there are four components, namely fleet management, traffic flow monitoring and control, registration identification, and parking and locational services. In the Asset section, there are six components to discuss asset data management, asset condition monitoring/smart asset planning, lighting control, cooling/heating, energy management, and building management system interfaces.

Figure 2 describes that for the continuous improvement of IT adoption, a university should prepare its readiness which is categorized into several levels. The levels are awareness, exploration, adoption, early implementation, mature implementation, and growth. This emphasizes the necessity to align the IT adoption with the level of maturity considering 3 elements: strategy (e.g purpose, advocacy, implementation), structure (models, governance, scheduling, evaluation), and supports (technical, pedagogical, incentives).

As shown in the models above in **Figures 1-3**, they all incorporate the use of the latest technology to optimize all kinds of processes. But more importantly, the technology used primarily aims to replace the traditional (or manual) processes that are considered vital such as databases, accessibility to information, teaching and learning activity, security, and safety, as well as the university management process.

The evolution and application of technology have significantly altered the educational landscape. One of them is to create a smart university by bringing a developed country and a smart environment to employ technology for the benefit of humanity. In this scenario, technology would take the place of human labor so that people might perform more intelligent duties. Computers and internet networks can be used to solve a variety of issues in higher education. These issues may be caused by university workers, students, or lecturers (Kettlewell *et al*., 2019). The internet of things can help with issues in education, such as allowing students to learn more successfully in a university setting by using eBooks instead of textbooks (Kettlewell *et al*., 2019; Fadillah *et al*., 2022; Adebayo & Ochayi, 2022). The IoT system will assist in detecting student presence in the classroom and can automatically extract student attendance information, increasing time savings. The system for using the internet to carry out university operations will gain a lot, especially if the IoT system is reliable when combined with cloud computing.

Users can access apps with cloud computing without any geographic, temporal, or physical restrictions (Malik *et al*., 2018). Because it has many advantages for lecture activities and offers a variety of alluring facilities for instructors and students to support learning, cloud computing is very helpful for universities. For instance, it can display computing resources for lessons and laboratories on demand and following user needs. When students demand more flexible course delivery based on their individual needs, cloud computing makes this possible. It also enables professors to develop lesson plans that are tailored to each student's needs (Malik *et al*., 2018). Google docs, Email, Google Classroom, Blogs, and Dropbox are a few examples of cloud computing in the educational space that will benefit the learning system.

DOI:https://doi.org/10.17509/ijost.v7i3.51476
p- ISSN 2528-1410 e- ISSN 2527-8045

The demand for cloud computing is growing as more advanced technology is developed. There are several providers from whom you can pick to suit these needs. Verify that the chosen service already possesses an official certificate and a current ISO standard. The utilization of cloud computing is tremendously beneficial in many areas of life. Science and technology are always evolving. The simplicity of data access, level of security, adaptability, and scalability are some benefits of using cloud computing.

By adopting a smart university, all the data already present at the institution is incorporated. The data is easily retrieved and kept in one big data set after the institution enters it into the database. In addition, it is simple for academic institutions to integrate and synchronize their data with Directorate General of Higher Education in Indonesian (known as DIKTI). Universities can also develop integrated systems, where each system is connected to the others, in addition to the ability to integrate data, to enable the interchange of data and information throughout the university environment. Based on these two skills, universities can use their current resources to implement control systems for students, staff, lecturers, and other stakeholders without having to physically visit the affected areas. With these capabilities, it can be inferred that the smart university concept can raise a university's standard.

We used the Systematic Literature Review (SLR) to perform a literature study to better comprehend the idea and application of IoT in smart universities. SLR was created for software engineering and is widely used in pharmacy and medicine. By tracking the outcomes of earlier investigations, SLR has become the de facto strategy for finding answers. Many methods regarding SLR have been also supported by machine such as VOSviewer that has been well-used and documented (Al Husaeni & Nandiyanto, 2022). Summarizing the findings of prior research, highlighting gaps in the literature, or offering a framework for a particular study topic are some of the most frequent motivations for doing an SLR. In this essay, we provide a summary of the prerequisites for the growth of smart colleges, focusing on the traits, enabling technology, and developed applications. We investigated a variety of works of literature that were published in journal databases from 2018 to 2022, including IEEExplore, Scopus, SpringerLink, and ScienceDirect.

Based on the aforementioned methodology, we conclude that the fundamental concept of an IoT in smart university is an effort by universities to integrate a set of advanced intelligence technologies to improve performance, graduate quality, and ease of life through the provision of valuable, dynamic, and user-oriented information technology services to support automation and real-time reporting. The period covers broader topics as well as learning activities, such as social interaction, the environment, office administration, energy conservation, etc. This article's goal is to identify different implementation aspects of smart universities from diverse studies. In this work, we employed a qualitative, systematic review methodology.

2. METHODS

This study employs the funnel paradigm, a systematic approach that follows pre-established steps or protocols for conducting research. The three primary steps of a systematic review are to discover, analyze, and evaluate prior research that is pertinent to a given area of interest. Because they attempt to combine relevant study findings, the findings examined are extensive. Steps in a systematic literature review include developing research questions, looking for literature reviews, choosing and filtering relevant articles, analyzing, and synthesizing qualitative findings, conducting quality control, and reporting late. It aims to find everything published on a specific area or topic of inquiry (Tight, 2019). Detailed

DOI: https://doi.org/10.17509/ijost.v7i3.51476
p- ISSN 2528-1410 e- ISSN 2527-8045

information on the way how to search using a search engine is reported elsewhere (Azizah *et al*., 2021). To examine and offer solutions for higher education in the form of models for integrating IoT for business activities, a qualitative method is employed. Following a thorough analysis of the available literature, several papers were found to be the primary sources. Formulating research questions that will be relevant to the topic of systematic review research is the first step in a systematic review:

(i) Is there an IoT model for a smart university that is generally accepted?
(ii) What are the innovative contributions from universities?

These are the two key questions that underpin this study. We used a specific search string to run a search on a database of well-known journals associated with previously published studies to be able to respond to these research inquiries and the results are shown in **Table 1**. Next, we used inclusion and exclusion criteria to choose qualified candidates for the upcoming articles (**Table 2**). Applying the inclusion and exclusion, we obtained 1,172 articles that matched and served as our primary source of information for solving SLR. We created a funnel diagram to depict the reference selection process after identifying pertinent references for our research. This helped us uncover references that were consistent with our research (**Figure 4**).

Based on the **Figure 4**, the funnel diagram was used to pick the reference sources that we obtained. In the first stage, we searched for databases from several database sources, including EBSCOhost, Springerlink, ProQuest, and ScienceDirect, where we obtained a total of 1,172 references. The following step is to choose the references with duplicates; after making the selection, we found 744 instances of duplication, including the identical study theme, aims, and abstracts. The title and abstract of each study will be screened in the subsequent round of selection, and we once more discovered that 278 papers did not meet our research goals. Following the processes, our sources limited their selection to only 150 studies. The next stage is full-text screening when we carefully study the research emphasis and context as well as the research's quality to determine whether it is acceptable to use as a reference. After this stage, we had 81 studies that we were unable to use. Thus, based on this selection, we discovered that just 69 studies were appropriate for us to employ and apply to our research.

Table 1. Related study finding results.

Database Journal	Article founds
EBSCOhost	548
ProQuest	212
Springerlink	53
ScienceDirect	359
Total	**1,172**

Table 2. Inclusion and exclusion criteria.

	Criteria
Inclusion criteria	- Articles in peer review papers - The article discusses the concept of a smart university or technology in a smart university - Articles are written in English - articles are open access
Exclusion criteria	- Book, book title, and theses - Non-peer-reviewed research articles, white papers, and technical reports - Editorial, abstract, or short paper (less than 4 pages) - Articles use smart university as a case study

DOI: https://doi.org/10.17509/ijost.v7i3.51476
p- ISSN 2528-1410 e- ISSN 2527-8045

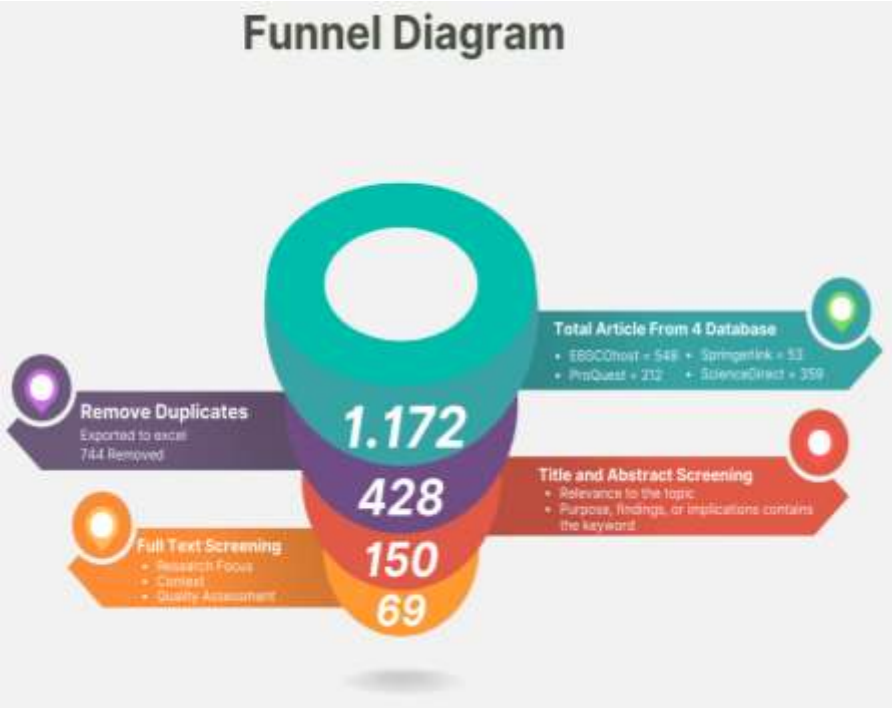

Figure 4. Funnel diagram.

3. RESULTS AND DISCUSSION

3.1. Smart University Model

There are at least 6 intelligence domains that a university must possess to claim that it possesses the qualities of a smart institution: iLearning, management, governance, iGreen, iHealth, and iSocial. The explanations of intelligence domains are:

(i) iLearning (Gubbi *et al*., 2013; Abougalala *et al*., 2020; Kwok, 2015; Li & Wong, 2021). Learning focuses on the lecturer and student roles as the main actors in the classroom instruction process. The use of ICT has a huge impact on how the learning process develops. In the field of iLearning, university systems need to be able to: 1) foster collaborative learning between lecturers and students; 2) give each student an equal amount of time to learn; 3) make sure that independent learning is done following accepted standards; and 4) evaluate the level of learning competency (self-assessment). As stated by Tuul, Banzragch, and Saizmaa, the objective of developing e-learning, according to the majority of respondents, was to guide knowledge building, offer students information, and engage in discussions or e-forums (Tuul *et al*., 2016).

(ii) iGovernance (Adwan *et al*., 2018; Alrashed, 2020; Kwok, 2015). The goal of iGovernance is to address stakeholders' needs while focusing on responsible university governance. Smart university systems in this area can at least: 1) support internal and external campus governance at various stakeholder levels; 2) create, monitor, carry out, and evaluate short, medium, and long-term work plans; 3) use governance processes to optimize, analyze root causes, and improve preventive and corrective actions; and 4) offer management workflows that support automated reporting and scheduling, logging, and configuration change adaptation.

(iii) iGreen (Adwan *et al*., 2018; Alrashed, 2020; Asadi *et al*., 2019; Bhat & Bashir, 2018; Blass & Hayward, 2014; Bukhari *et al*., 2021; Bukhari *et al*., 2021; Bukhari *et al*., 2021). The "green university" perspective, which considers the degree of carbon pollution in the university environment, is the focus of iGreen. This

DOI: https://doi.org/10.17509/ijost.v7i3.51476
p- ISSN 2528-1410 e- ISSN 2527-8045

is consistent with the problem of air pollution-induced climate change. Intelligent energy creation and consumption, environmentally conscious building management and the use of sensor technologies for precise reporting are some of the qualities that smart institutions must have in the iGreen area. The adoption of green universities falls into two categories which are technology adoption and policy adoption (Thomson & Belle, 2015).

(iv) iHealth (Adwan *et al*., 2018; Byrne *et al*., 2015; Kwok, 2015). The university students' health is the main emphasis of iHealth. Ensuring, monitoring, and sustaining the health of the university community as a whole is the essence of iHealth. To promote the development of a healthy environment, this domain is associated with iGreen. The iHealth system's essential capabilities for smart campuses include the following: The following are provided to university residents: 1) health services available 24/7; 2) an intelligent information system that can report the state of health on the university, for example reporting of unusual disease-related events; 3) proactive or preventive health services; and 4) tracking and recording of university health status generally.

(v) iSocial (Al Shimmary *et al*., 2015; Alrashed, 2020; Blass & Hayward, 2014; Carius, 2020; Cesur *et al*., 2019; Kwok, 2015; Lazar *et al*., 2020). Today's growing reliance on social networking technology is the reason iSocial was created. There is no denying that people utilize today's social networks to log their daily profiles, status updates, and emotions. A social process that naturally takes place is the interaction between students or between students and lecturers. The social process at a university includes collaborative learning, one of the iLearning domain's key areas of interest. A smart campus system must at the very least be able to: 1) identify student profiles so that they can be grouped according to student interests; 2) perform sentiment analysis based on data stored on social networks; and 3) improve services at the appropriate time and location based on student interests to fulfill the iSocial domain.

(vi) iManagement (Adwan *et al*., 2018; Alrashed, 2020; Civilcharran & Maharaj, 2016; Coccoli *et al*., 2014; Coccoli *et al*., 2014). In a university, general management is the emphasis of iManagement. The university's buildings and infrastructure as well as the community (workers, lecturers, students, and visitors) are some things that iManagement pays attention to. This comprises smart building management systems, such as automatic lighting controls, doors that may be opened only with the proper authorization, and others. Smart university systems must have a variety of capabilities, including 1) facial recognition to deter crime or record people in specific locations; 2) tracking human movement or mobilization to determine the distribution of people at specific times; 3) smart cards to provide parking permits and non-cash transactions; and 4) record attendance at a teaching and learning activity.

3.2. Smart University Feature

Three stages, traditional campus, e-campus, and digital campus must be completed for a university to transform into a smart campus. In the past, a university's teaching and learning processes were combined in a single room or class, where the study material is delivered while instructors and students must interact face-to-face in the same space. The process of teaching activities grows while technology in the educational environment does. Technology-

DOI: https://doi.org/10.17509/ijost.v7i3.51476
p- ISSN 2528-1410 e- ISSN 2527-8045

savvy colleges are evolving into e-campuses or digital campuses. Using the most typical example (namely using the internet to disseminate the subject matter to be studied) includes the use of smart campus online learning, which was created based on a digital campus and is considered the highest accomplishment of an academic information system in a university. A smart campus can quickly adapt to changes to meet user expectations, as well as numerous bits of intelligence built into the systems that support it (Asadi *et al*., 2019). **Table 3** is a table of differences between a digital campus and a smart campus. There are several advantages of smart universities, namely:

(i) Promote smart energy management by reducing electricity consumption through automatic lighting control and university hotspots along corridors and rooms based on the movement of people in the area (Kwet & Prinsloo, 2020).
(ii) Provide an interactive and creative environment that is conducive to increasing social interaction of the entire university community, especially for lecturers and students.
(iii) Using accumulated data to produce useful applications (Kwok, 2015) to improve business process automation.
(iv) Facilitate technology and equipment inventory (Adwan *et al*., 2018).
(v) Provide real-time disaster response and warning services through the effectiveness of the monitoring system through consistent monitoring of disturbances, temperature, humidity, and smoke in the university area to create a safe learning environment.
(vi) University map information services that make it easier for visitors to reach certain locations from their starting point (Lazar *et al*., 2020).

Then, there are the characteristics of smart universities that have been put forward by several researchers, namely:

(i) provides a comprehensive intelligent environment and integrated information services via dashboards for students and lecturers, while services can be customized based on user roles (Li & Wong, 2021).
(ii) There is a link between fostering creativity and collaboration through integrated information services using computer networks to access available applications and services (Malik *et al*., 2012; Meng *et al*., 2020).
(iii) The availability of exchange of data and ideas between the university and the external environment using an integrated intelligent and information service platform
(iv) Efficient management of energy and water (Miah *et al*., 2017; Min-Allah & Alrashed, 2020).

Table 3. Differences between digital universities and smart universities.

	Digital Universitas	**Smart Universitas**
Technical Environment (Fortes *et al*., 2019; Gan *et al*., 2016; Hemsley & Oplatka, 2006; Hidayat & Sensuse, 2022)	Local area network internet	IoT, Cloud Computing, wireless networks, mobile terminals, RFID
Application (Rehman *et al*., 2008; Byrne *et al*., 2015; Hinojo *et al*., 2019; Hughes *et al*., 2018; Hwang, 2014; Kannadhasan *et al*., 2020; Klyap & Klyap, 2016; Meng *et al*., 2020)	Learning resources in digital form, distance learning, digital library, and network management.	an intelligent system using sensors, interoperability, and control ability
System management (Klyap & Klyap, 2016; Koper, 2014; Krull & Duart, 2017; Malik *et al*., 2012)	Isolated	system sharing, intelligence, and push.

DOI: https://doi.org/10.17509/ijost.v7i3.51476
p- ISSN 2528-1410 e- ISSN 2527-8045

3.3. IoT Model in Smart University

It is impossible to separate the presence of a smart university from the function or support of technology, particularly ICT. There are 7 (seven) main technologies that have emerged from studies about the deployment of smart campuses, as shown in **Table 4** (Hidayat & Sensuse, 2022).

Three elements of the IoT model applied in the smart university ecosystem are artificial intelligence, sensors, and connectivity. **Figure 5** shows the journal we used to answer the research questions concerning the IoT model in the SU domain. There were 2 articles describing smart education, 2 articles describing physics, 2 articles describing the environment, and 2 articles describing mechanics. 3 articles describe information systems. 4 articles describe interactive technology, 4 articles describe distributed learning, 4 articles describe smart education, and 4 articles describe smart E-learning. From 31 papers, it is suggested that AI and machine learning are frequently used interchangeably. Machine learning is an AI technique for supervised and unsupervised classification and profiling, such as determining the themes in written assignments or predicting a student's likelihood of failing a course or getting accepted into a program. Machine learning is described as an area of artificial intelligence that contains software able to recognize patterns, generate predictions, and apply the newly discovered pattern.

One form of contactless technology, RFID, can store data and offers several advantages to support smart universities, such as visitor authentication, recording professor and student attendance, tracking the movement of people and objects to expedite evacuation during emergencies, room security, electrical equipment automation, catalog information recording, and support for self-service lending services (Carius, 2020). The IoT is a novel idea in information technology that is based on a wide-ranging network. Through a smart system, the IoT can link individuals, tools, gadgets, and buildings on campus. The IoT enables real-time searches for the precise location of an object or person (Musselin, 2018).

Cloud computing is a complete system that efficiently maintains, integrates, and combines all types of information, offers data services, and facilitates information sharing. On a cloud computing platform with IaaS, PaaS, and SaaS service levels, databases and applications should be developed for campus environments. From the perspective of e-learning, cloud computing can facilitate the deployment of virtual labs to assist students and lecturers with carrying out tasks in ad hoc settings or by utilizing omnipresent devices through mobile services (Malik *et al.*, 2018). Users can have a variety of experiences thanks to augmented reality (AR) technology, one of which is the ability to provide a map of a specific area rather than a standard view. A route to a site, including calculating the distance to that location, can be displayed in real-time when AR is combined with various sensors located within the university location.

Table 4. Smart university technology.

No	Technology
1	Radio-frequency identification (RFID) (Rehman *et al.*, 2008; Al Shimmary *et al.*, 2015)
2	Internet of Things (IoT) (Coccoli *et al.*, 2014; Fortes *et al.*, 2019)
3	Cloud Computing (Nie, 2013; Nie, 2013; Malik *et al.*, 2018)
4	3D visualization technology; Augmented Reality (Cocoli *et al.*, 2014)
5	Sensor technology (motion, temperature, light, humidity, etc.) (Fortes *et al.*, 2019)
6	Mobile technology (including NFC, QR code, and GPS) (Adwan *et al.*, 2018; Byrne *et al.*, 2015; Gan *et al.*, 2016; Krull & Duart, 2017; Kwet & Prinsloo, 2020; Miah *et al.*, 2017; Tikhomirov *et al.*, 2015)
7	Web service (Civilcharran & Maharaj, 2016)

DOI: https://doi.org/10.17509/ijost.v7i3.51476
p- ISSN 2528-1410 e- ISSN 2527-8045

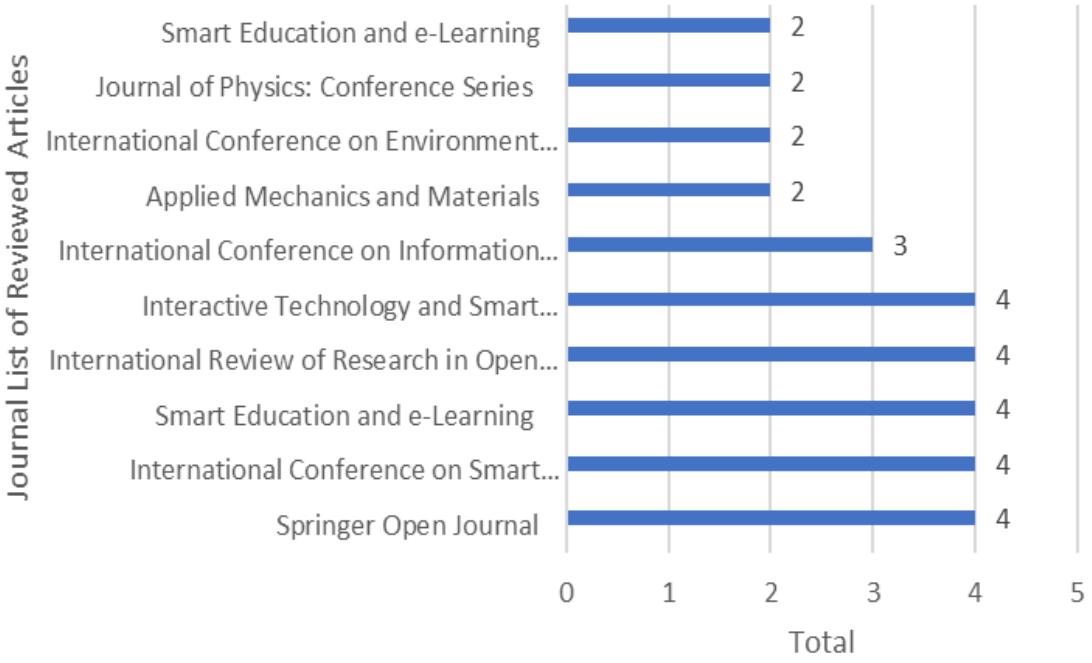

Figure 5. Journal list of reviewed articles.

With the help of intelligence systems, creating an intelligent university with real-time automation and reporting procedures is not sufficient. It is advisable to include sensors that can recognize an event or a state change. According to a set of defined objectives, intelligent university sensors are housed in a range of strategic locations.

Smart university sensors can be used, among other things, to detect human movement, changes in the weather or humidity, the capacity of the water and waste systems, and location to direct a search to a specific spot. Most sensors are installed using wireless technology to support practicality (Rodriguez *et al.*, 2019).

Mobile phones, tablets, computers, and other similar gadgets are now powerful tools in life and should be used in education to raise standards, satisfy the needs of students, and cut expenses. The development of mobile learning, which enables learning to be done anywhere and at any time, the recording of attendance and access to the door to enter or exit the room using contactless technology (Bluetooth, Quick response code, NFC, RFID), embedded in the mobile phone, the creation of location-based services, and the development of mobile social networks are just a few of the capabilities offered by mobile device technology to support smart university (Al Shimmary *et al.*, 2015).

A range of heterogeneous and distinct information is managed and given unified access through the usage of web services. Web services link multiple, more diversified applications in smart campuses to produce the right service on demand. Web services with direct access to IoT resources can likewise be used as IoT services (Fortes *et al.*, 2019; Hidayat & Sensuse, 2022).

3.4. Smart University Applications

Various applications are built to realize a smart campus. These applications are indirectly part of the smart campus model. **Table 5** presents the smart campus applications based on previously conducted studies and grouped into 6 domains on the iCampus model (Azarmi *et al.*, 2010; Cesur *et al.*, 2019).

DOI: https://doi.org/10.17509/ijost.v7i3.51476
p- ISSN 2528-1410 e- ISSN 2527-8045

Table 5. Smart university technology.

Domain	Smart University Technology
iLearning (Gubbi *et al.,* 2013; Abougalala *et al.,* 2020; Kwok, 2015; Li & Wong, 2021)	Smart Learning Management System Personalized Learning Assessment Smart Classroom Library Management System
iSocial (Al Shimmary *et al.,* 2015; Alrashed, 2020; Blass & Hayward, 2014; Carius, 2020; Cesur *et al.,* 2019; Kwok, 2015; Lazar *et al.,* 2020)	Market Management System News Management System
iManagement (Adwan *et al.,* 2018; Alrashed, 2020; Civilcharran & Maharaj, 2016; Coccoli *et al.,* 2014; Kwok, 2015)	People Identification Smart Attendance Safe Learning Environment Smart Parking Campus Geographic Information System Bathroom Management System
iGovernance (Adwan *et al.,* 2018; Alrashed, 2020; Kwok, 2015)	Teaching Management System Financial System Office System
iHealth (Adwan *et al.,* 2018; Byrne *et al*., 2015; Kwok, 2015)	Health Facilities
iGreen (Adwan *et al.,* 2018; Alrashed, 2020; Asadi *et al.,* 2019; Bhat & Bashir, 2018;Blass & Hayward, 2014; Bukhari *et al.,* 2021; Byrne *et al.,* 2015; Kwok, 2015)	Smart Building Waste and water management

The explanations are the following:

(i) Smart Learning Management System. A service that enables lecturers and students to engage both directly and indirectly to support teaching activities is the management of online learning activities based on web technologies and/or mobile devices (mobile), often known as the Learning Management System (LMS). The requirements for capturing information about teaching activities, such as the core curriculum, session plan, class attendance, and project group formation, as well as the availability and completion of tasks, should be met by LMS (Al Husaeni & Hadianto, 2022). Additionally, LMS should be able to control and manage the primary instructional process data (Adwan *et al*., 2018; Byrne *et al*., 2015). Additionally, engagement and communication are crucial for the effectiveness of online learning. To maintain or enhance the quality of learning outcomes, careful planning is required. This includes increasing teamwork among colleagues while receiving regular guidance from lecturers to ensure that the learning process stays on the right track, as well as establishing a consistent and timely network communication between lecturers and students to maintain the quality of knowledge construction following its standards.

(ii) Personalized Learning. Creating plans and learning maps, gathering data, researching learning resources, planning learning activities, and carrying out all of these tasks personally or alone are all included in the broad concept of personalized learning. Adaptive learning, which refers to fulfilling the changing requirements of students and providing feedback on accomplishing current educational goals in intelligent learning environments, should be used in conjunction with personalized learning to support the learning

DOI: https://doi.org/10.17509/ijost.v7i3.51476
p- ISSN 2528-1410 e- ISSN 2527-8045

objectives. All of the objects relevant to personal learning can be connected in that situation. Learning objectives, plans, maps, activities, competency levels, performance or achievement of learning outcomes, reflections, etc. are a few examples of these objects. The use of mobile device technology services may enhance individualized learning and enable remote access.

(iii) Assessment. Learning objectives and student outcomes can be aligned through assessment, which is a crucial learning component (Ihechu *et al.*, 2023). The assessment offers many characteristics, including the ability to create recommendations based on behavior and academic advancement. The tests that serve as the foundation for evaluating a person's capability can be created using a variety of models, including essays, practice questions, multiple choice, matching, and short answers. Automated grading, and performance reports that provide statistics on student learning outcomes and score distribution. Analyzing student characteristics and offering individualized learning support are the results of a thorough data analysis using the notion of conceptual multi-tenancy data mining. Analysis of learning outcomes using statistics. Based on the study of learning activities, methods, behaviors, learning styles, and other associated records, recommended learning techniques are given. Putting students into groups based on how they study.

(iv) Smart Classroom. A virtual classroom (VC) notion is introduced when LMS is used to enhance the educational process to take the place of actual classrooms. Additionally, as a group, VCs should be able to simulate a classroom setting by showing slideshows (created using standard PowerPoint) that are synced with narration from a recording and/or streaming videos that are organized in a table. The VC's more extensive version includes text and image pages that represent the content on the whiteboard as well as windows (in video form) that show classroom activity. Students can interact through VCs using any mobile device, tablet, computer, or other helpful equipment as their access medium. By creating a hybrid of virtual and physical worlds, one may enhance the quality of VC and create a sense of "being there" to enhance teaching and learning. By adhering to many VC-organized teaching procedures, students also appear to be able to control their study environment on their own through the use of VC (Singh & Miah, 2020).

(v) Library Management System. The Internet of Things has supported the new library management method (IoT). Information is obtained by libraries using electronic tags that combine library cards, cell phones, and other physical objects. It is possible to develop the usage of RFID as an electronic label to enhance library services including self-service book checkout and return shelf and book catalog storage information, and cart storage. Members of the library can also search for books that other users are currently borrowing at the same moment (Sudaryat *et al.*, 2022; Purnomo *et al.*, 2022).

(vi) Market Management System. Every user initiative on the network system can be completely displayed by market management. The benefit is that each user can compare similar products laterally to choose following their unique request character, which is very consistent with how students use university network resources rationally. Additionally, users can freely browse relevant products on the page,

DOI: https://doi.org/10.17509/ijost.v7i3.51476
p- ISSN 2528-1410 e- ISSN 2527-8045

select products, and continue with ordering operations, such as selecting a payment method and a shipping method, among other things (Hemsley & Oplatka, 2006).

(vii) News Management System. It is used to make it easier for users to check information quickly on digital campus platforms, supplement information browsing, download apps, participate together in the topic, reply to comments, location campus operations, make asynchronous information sharing (e-mail, bulletin boards, discussion forums, newsgroups), and share information synchronously (chat, whiteboard, group browsing) (Poorrezaei & Pich, 2018).

(viii) People Identification. Using RFID, it collects information from all visitors to the campus, including tourists, faculty/staff, and students. By authenticating and verifying campus visits, these records are used to manage campus security (Sulkowski *et al*., 2021).

(ix) Smart Attendance. It keeps track of students and faculty members'/staff members' attendance to keep an eye on their presence on campus (Thomson & Belle, 2015).

(x) Safe Learning Environment. It accurately and intelligently records infrastructure facilities, provides on-campus access to control facilities, and facilitates campus monitoring and surveillance (Tight, 2019; Haristiani & Rifa'i, 2020).

(xi) Smart Parking. Visitors to the school are well-served by smart parking management. Smart parking systems can support the following capabilities: information on available parking or parking slots, parking usage limitations, and disaster information concerning automobiles in the parking area (Tikhomirov *et al*., 2015; Tuul *et al*., 2016; Sudarjat, 2022).

(xii) Campus Geographic Information System. Universities may manage space and information attribute more effectively, intuitively, and thoroughly by offering geographic-based services, and they can pinpoint the precise location of campus resources. Services that are based on geography use a variety of sensors, including RFID, WSN, and GPS. To help a visitor, get to a specific place or location based on his current location and the path to take, the campus can offer information utilizing maps or augmented reality technologies through this service. Additionally, by installing sensors at various locations around the campus, it will be possible to properly track visitor movement and even the movement of commodities.

(xiii) Bathroom Management System. By continuously analyzing the level of water usage in the bathroom, it automatically identifies water management using RFID. Results of the analysis are presented in real time for further use. Information about the condition of the restroom that students can access can be known through the analysis (Miah *et al*., 2017).

(xiv) Teaching Management System. The administration of the institution makes use of these programs to keep an eye on how the teaching process is being carried out. This application offers management the primary ability to generate reports about the transaction teaching process, including the realization of teaching hours, the realization of the course syllabus, the percentage of teaching (attendance of lecturers and students), the percentage of course graduation, the feedback or student satisfaction level, and the occupancy of classroom use.

DOI: https://doi.org/10.17509/ijost.v7i3.51476
p- ISSN 2528-1410 e- ISSN 2527-8045

(xv) Financial System. There is no doubt that keeping track of finances is part of managing the institution as an enterprise. The expansion of an organization's financial capacities can be used to gauge some aspects of its progress. An application dashboard that may offer services like financial monitoring is necessary for university management. The application's primary function as a management tool is the presentation of information on financial transactions, including the balance sheet, activity plan, budget, periodic financial growth, investment value, and asset value owned by the institution.

(xvi) Office System. ICT typically supports a variety of operational functions involving a variety of university entities. The electronic mail service (e-mail), which is available to both students and instructors, as well as digital notice boards, are two straightforward examples of office applications utilized in smart campuses. The management of official letters, management of management review meetings, teleconferences, videoconferences, and application sharing are just a few of the specific services that office applications can offer to the university administration. They can also support the creation of reports regularly using information from the database.

(xvii) Health Facilities. The university can provide a health facility in the university environment to take care of in case there are students, lecturers, or stakeholders who need treatment (Adwan *et al*., 2018).

(xviii) Smart Building. A smart building is created using a variety of sensors, which play a crucial role in supporting the automation process in a building. The various functions that can be built into a smart building service are supported by these sensors, including turning off equipment (lights, air conditioners, or projectors) in an empty room, detecting carbon dioxide (CO2) levels in specific areas, adjusting temperatures, measuring humidity and pollution around the building and open space, improving energy efficiency, and producing alternative energy. Smart building services should be able to produce information for university management, including those on energy usage (consumption), real-time warnings, trends of energy and space usage, etc (Hughes *et al*., 2018; Hwang, 2014; Rahmat, 2021; Rahmat, 2022; Paramita *et al*., 2016; Kurniawan, 2022).

Waste and Water Management. The institution should be able to effectively manage water and trash to support the idea of a green university. Thus, several sensors and intelligent systems are required to assist the construction of a smart building to provide waste management services and water. To allow for a decision to be made as a follow-up when improper conditions were discovered, this service at the very least can report the water and waste conditions in the university area in real-time (Rodriguez *et al*., 2019).

4. CONCLUSION

The body of knowledge about smart universities keeps expanding. Every year during the past five years (2018-2022), more research has been published. The smart university concept has been realized through the implementation of many apps, and iCampus has become a well-known smart campus model. The suggested domain in the iCampus design highlights that the smart campus development area supports all areas of campus life, including the environment, buildings, social life, health, and university governance, in addition to supporting the learning and teaching process. We can see that the primary function of a smart

DOI: https://doi.org/10.17509/ijost.v7i3.51476
p- ISSN 2528-1410 e- ISSN 2527-8045

university is to offer dynamic services following user wants by utilizing a variety of intelligence systems, based on the understanding and definitions that have been provided. Therefore, one of the keys to creating a smart university is service computing, which encompasses science and technology research, service innovation, and using IT and computing technologies to model, construct, and manage business solutions, scientific applications, and updated services (Mbombo & Cavus, 2021). The development of technology to improve interaction and interoperability across apps and domains is a further problem.

5. ACKNOWLEDGMENT

We would like to convey our highest appreciation to Universitas Komputer Indonesia, especially the Rector of Universitas Komputer Indonesia Prof. Dr. Ir. H. Eddy Soeryanto Soegoto, MT who has funded the research.

6. AUTHORS' NOTE

The author(s) declare(s) that there is no conflict of interest regarding the publication of this article. The authors confirmed that the data and the paper are free of plagiarism.

7. REFERENCES

Abougalala, R. A., Amasha, A., Areed, M. F., Alkhalaf, S., and Khairy, D. (2020). Blockchain-enabled smart university: A framework. *Journal of Theoretical and Applied Information Technology*, *98*(17), 3531-3543.

Adebayo, A. E., and Ochayi, O. A. (2022). Utilization of internet services among students of polytechnic institutions in Kwara State. *Indonesian Journal of Multidiciplinary Research, 2(*1), 27-42.

Afify, M. K. (2020). Effect of interactive video length within e-learning environments on cognitive load, cognitive achievement and retention of learning. *Turkish Online Journal of Distance Education*, *21*(4), 68-89.

Akinoso, S.O. (2023). Motivation and ICT in secondary school mathematics using unified theory of acceptance and use of technology model. *Indonesian Journal of Educational Research and Technology*, *3*(1), 79-90.

Al Husaeni, D. F., and Nandiyanto, A. B. D. (2022). Bibliometric using Vosviewer with Publish or Perish (using google scholar data): From step-by-step processing for users to the practical examples in the analysis of digital learning articles in pre and post Covid-19 pandemic. *ASEAN Journal of Science and Engineering*, *2*(1), 19-46.

Al Husaeni, D. N., and Hadianto, D. (2022). The influence of spada learning management system (LMS) on algorithm learning and programming of first grade students at Universitas Pendidikan Indonesia. *Indonesian Journal of Multidiciplinary Research, 2(*1), 203-212.

Al Shimmary, M. K., Al Nayar, M. M., and Kubba, A. R. (2015). Designing smart University using RFID and WSN. *International Journal of Computer Applications*, *112*(15), 34-39.

Al-Adwan, A. S., Al-Madadha, A., and Zvirzdinaite, Z. (2018). Modeling students' readiness to adopt mobile learning in higher education: An empirical study. *International Review of Research in Open and Distributed Learning*, *19*(1), 221-241.

DOI: https://doi.org/10.17509/ijost.v7i3.51476
p- ISSN 2528-1410 e- ISSN 2527-8045

Alghamdi, A., and Shetty, S. (2016). Survey toward a smart campus using the internet of things. *2016 IEEE 4th international conference on future internet of things and cloud (FiCloud)*, 235-239.

Alrashed, S. (2020). Key performance indicators for smart campus and microgrid. *Sustainable cities and society*, *60*, 102264.

Amin, M. H., Sajak, A. A. B., Jaafar, J., Husin, H. S., and Mohamad, S. (2022). Real time water quality monitoring system for smart city in Malaysia. *ASEAN Journal of Science and Engineering*, *2*(1), 47-64.

Anh, D. H. M. (2022). Mesh network based on MQTT broker for smart home and IIoT factory. *ASEAN Journal of Science and Engineering*, *2*(2), 173-180.

Arciosa, R. M. (2022). Information communication technology (ICT)-based instructional software and its effectiveness in teaching high school geometry. *Indonesian Journal of Teaching in Science*, *2*(1), 51-60.

Asadi, Z., Abdekhoda, M., and Nadrian, H. (2019). Understanding and predicting teachers' intention to use cloud computing in smart education. *Interactive Technology and Smart Education*, *17*(1), 14-27.

Atif, Y., Mathew, S. S., and Lakas, A. (2015). Building a smart campus to support ubiquitous learning. *Journal of Ambient Intelligence and Humanized Computing*, *6*(2), 223-238.

Azizah, N. N., Maryanti, R., and Nandiyanto, A. B. D. (2021). How to search and manage references with a specific referencing style using google scholar: From step-by-step processing for users to the practical examples in the referencing education. *Indonesian Journal of Multidiciplinary Research, 1*(2), 267-294.

Berdnikova, L. F., Mikhalenok, N. O., Frolova, V. A., Sukhacheva, V. V., and Krivtsov, A. I. (2020). Human resource management system development at smart university. In *Smart Education and e-Learning 2020*, 327-337.

Bhat, S. A., and Bashir, M. (2018). Measuring ICT orientation: Scale development and validation. *Education and Information Technologies*, *23*(3), 1123-1143.

Blass, E., and Hayward, P. (2014). Innovation in higher education; will there be a role for "the academe/university" in 2025?. *European Journal of Futures Research*, *2*(1), 1-9.

Bolaji, H. O., and Jimoh, H. A. (2023). Usability and utilization of ICT among educational administrators in secondary students in public school. *Indonesian Journal of Educational Research and Technology*, *3*(2), 97-104.

Bolaji, H.O. and Adeoye, M.A. (2022). Accessibility, usability, and readiness towards ICT tools for monitoring educational practice in secondary schools. *Indonesian Journal of Multidiciplinary Research, 2*(2), 257-264.

Bukhari, E., Dabic, M., Shifrer, D., Daim, T., and Meissner, D. (2021). Entrepreneurial university: The relationship between smart specialization innovation strategies and university-region collaboration. *Technology in Society*, *65*, 101560.

Byrne-Davis, L., Dexter, H., Hart, J., Cappelli, T., Byrne, G., Sampson, I., and Lumsden, C. (2015). Just-in-time research: a call to arms for research into mobile technologies in higher education. *Research in Learning Technology*, *23*, 1-10.

DOI: https://doi.org/10.17509/ijost.v7i3.51476
p- ISSN 2528-1410 e- ISSN 2527-8045

Carius, A. C. (2020). Network education and blended learning: Cyber university concept and higher education post COVID-19 pandemic. *Research, Society and Development*, *9*(10), e8209109340.

Castiblanco, P. A., Ramirez, J. L., and Rubiano, A. (2021). Smart materials and their application in robotic hand systems: A state of the art. *Indonesian Journal of Science and Technology*, *6*(2), 401-426.

Cesur, R., Torkul, O., Cedimoğlu, İ. H., and Seda, U. Ç. A. R. (2019). Intelligent campus implementation for smart cities. *Sakarya University Journal of Science*, *23*(6), 1218-1224.

Chaihang, S., and Puengsunwan, S. (2021). Smart moving-spiral-clothesline for urban society. *ASEAN Journal of Science and Engineering*, *1*(1), 33-38.

Civilcharran, S., and Maharaj, M. S. (2016). Uncovering web search strategies in South African higher education. *SA Journal of Information Management*, *18*(1), 8.

Coccoli, M., Guercio, A., Maresca, P., and Stanganelli, L. (2014). Smarter universities: A vision for the fast-changing digital era. *Journal of Visual Languages and Computing*, *25*(6), 1003-1011.

Daramola, F.O. (2023). Utilization of ICT resources for teaching among some selected lecturers in colleges of education in Kwara State. *ASEAN Journal of Educational Research and Technology*, 2(1), 1-10.

Dong, Z. Y., Zhang, Y., Yip, C., Swift, S., and Beswick, K. (2020). Smart campus: Definition, framework, technologies, and services. *IET Smart Cities*, *2*(1), 43-54.

Dwiana, O., Muktiarni, M., and Mupita, J. (2022). Improved information literacy of elementary school students about living pharmacies through information and communication media (ICT). *ASEAN Journal of Science and Engineering Education*, *2*(3), 193-198.

Fadillah, P. Nandiyanto, A. B. D., Kurniawan T., and Bilad, M. R. (2022). Internet literature: Increasing information competence in the learning process of students of class 7 middle school. *Indonesian Journal of Educational Research and Technology*, *2*(2), 81-86.

Fortes, S., Santoyo-Ramón, J. A., Palacios, D., Baena, E., Mora-García, R., Medina, M., ... and Barco, R. (2019). The campus as a smart city: University of Málaga environmental, learning, and research approaches. *Sensors*, *19*(6), 1349.

Gan, C. L., and Balakrishnan, V. (2016). An empirical study of factors affecting mobile wireless technology adoption for promoting interactive lectures in higher education. *International Review of Research in Open and Distributed Learning*, *17*(1), 214-239.

Gubbi, J., Buyya, R., Marusic, S., and Palaniswami, M. (2013). Internet of Things (IoT): A vision, architectural elements, and future directions. *Future generation computer systems*, *29*(7), 1645-1660.

Haristiani, N., and Rifa'i, M. M. (2020). Combining chatbot and social media: Enhancing personal learning environment (PLE) in language learning. *Indonesian Journal of Science and Technology*, *5*(3), 487-506.

Hemsley-Brown, J., and Oplatka, I. (2006). Universities in a competitive global marketplace: A systematic review of the literature on higher education marketing. *International Journal of Public Sector Management*, 19(4), 316-338

DOI:https://doi.org/10.17509/ijost.v7i3.51476
p- ISSN 2528-1410 e- ISSN 2527-8045

Hidayat, D. S., and Sensuse, D. I. (2022). Knowledge management model for smart campus in Indonesia. *Data*, *7*(1), 1-42.

Hinojo-Lucena, F. J., Aznar-Díaz, I., Cáceres-Reche, M. P., and Romero-Rodríguez, J. M. (2019). Artificial intelligence in higher education: A bibliometric study on its impact in the scientific literature. *Education Sciences*, *9*(1), 1-9.

Hughes, C., Costley, J., and Lange, C. (2018). The effects of self-regulated learning and cognitive load on beginning to watch and completing video lectures at a cyber-university. *Interactive Technology and Smart Education*, *15*(3), 220-237.

Hwang, G. J. (2014). Definition, framework and research issues of smart learning environments-a context-aware ubiquitous learning perspective. *Smart Learning Environments*, *1*(1), 1-14.

Ihechu, K. J. P., Olutola, A. T., and Olatoy, R. A. (2023). Insecurity and assessment practices in university. *Indonesian Journal of Multidiciplinary Research, 3*(1), 49-56.

Jadhav, P., Gaikwad, H., Patil, K. S. (2022). Teaching and learning with technology: Effectiveness of ICT integration in schools. *ASEAN Journal of Science Education*, *1*(1), 33-40

Kannadhasan, S., Shanmuganantham, M., Nagarajan, R., and Deepa, S. (2020). The role of future e-learning system and higher education. *International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)*, *12*(2), 261-266.

Kettlewell, J., das Nair, R., and Radford, K. (2019). A systematic review of personal smart technologies used to improve outcomes in adults with acquired brain injuries. *Clinical Rehabilitation*, *33*(11), 1705-1712.

Klyap, M., and Klyap, M. (2016). Innovative directions of the higher education of Ukraine. *Studia Universitatis Vasile Goldiș Arad, Seria Științe Economice*, *26*(4), 54-66.

Koper, R. (2014). Conditions for effective smart learning environments. *Smart Learning Environments*, *1*(1), 1-17.

Krull, G., and Duart, J. M. (2017). Research trends in mobile learning in higher education: A systematic review of articles (2011–2015). *International Review of Research in Open and Distributed Learning*, *18*(7), 1-23.

Kurniawan, T. (2022). Stairs designed for people with special needs. *Indonesian Journal of Community and Special Needs Education, 2*(1), 59-64.

Kwet, M., and Prinsloo, P. (2020). The 'smart'classroom: A new frontier in the age of the smart university. *Teaching in Higher Education*, *25*(4), 510-526.

Kwok, L. F. (2015). A vision for the development of i-campus. *Smart Learning Environments*, *2*, 1-12.

Lazar, I. M., Panisoara, G., and Panisoara, I. O. (2020). Digital technology adoption scale in the blended learning context in higher education: Development, validation and testing of a specific tool. *PloS One*, *15*(7), e0235957.

Li, K. C., and Wong, B. T. M. (2021). Research landscape of smart education: a bibliometric analysis. *Interactive Technology and Smart Education*, 19(1), 3-19.

DOI:https://doi.org/10.17509/ijost.v7i3.51476
p- ISSN 2528-1410 e- ISSN 2527-8045

Liu, Y. L., Zhang, W. H., and Dong, P. (2014). Research on the construction of smart campus based on the internet of things and cloud computing. *Applied Mechanics and Materials*, *543*, 3213-3217

Liu, Y. L., Zhang, W. H., and Dong, P. (2014). Research on the construction of smart campus based on the internet of things and cloud computing. *Applied Mechanics and Materials*, *543*, 3213-3217.

Luckyardi, S., Soegoto, E. S., Jumansyah, R., Dewi, N. P., and Mega, R. U. (2022). A bibliometric analysis of climate smart agriculture research using vosviewer. *Moroccan Journal of Chemistry*, *10*(3), 488-499

Malik, M. E., Naeem, B., and Munawar, M. (2012). Brand image: Past, present and future. *Journal of Basic and Applied Scientific Research*, *2*(12), 13069-13075.

Malik, M. I., Wani, S. H., and Rashid, A. (2018). Cloud computing-technologies. *International Journal of Advanced Research in Computer Science*, *9*(2), 379-384.

Mbombo, A. B., and Cavus, N. (2021). Smart university: A university in the technological age. *TEM Journal*, *10*(1), 13-17.

Meng, Q., Jia, J., and Zhang, Z. (2020). A framework of smart pedagogy based on the facilitating of high order thinking skills. *Interactive Technology and Smart Education*, 17(3), 251-266

Miah, S. J., Gammack, J., and Hasan, N. (2017). Extending the framework for mobile health information systems Research: A content analysis. *Information Systems*, *69*, 1-24.

Min-Allah, N., and Alrashed, S. (2020). Smart campus—A sketch. *Sustainable Cities and Society*, *59*, 102231.

Musselin, C. (2018). New forms of competition in higher education. *Socio-Economic Review*, *16*(3), 657-683.

Nie, X. (2013). Research on smart campus based on cloud computing and internet of things. *Applied Mechanics and Materials*, 380, 1951-1954.

Paramita, B., Kamilia, I., Nurhidayat, M. I., and Ocktaviyane, R. (2016). Optimization of design and planing VHS building using chronolux. *Indonesian Journal of Science and Technology*, *1*(2), 170-184.

Pechsiri, T., and Puengsungwan, S. (2023). Energy harvesting based on living plants for smart farming. *ASEAN Journal of Science and Engineering*, *3*(1), 47-56.

Purnomo, G. W. Pratiwi, Y., and Putri, K. H. (2022). Analysis usage behavior for information system of university library. *Indonesian Journal of Multidiciplinary Research*, *2*(2), 421-428.

Rachmawati, R. (2019). Utilization and quality of information system for administration services based on ICT in Patehan, Kraton, Yogyakarta. *Indonesian Journal of Science and Technology*, *4*(1), 55-63.

Rahmat, A. (2021). Standards for dimensions of space and environment in buildings for people with special needs (i.e. Wheelchairs, crutches, canes for the visually impaired). *Indonesian Journal of Community and Special Needs Education, 1*(1), 19-24.

DOI: https://doi.org/10.17509/ijost.v7i3.51476
p- ISSN 2528-1410 e- ISSN 2527-8045

Rahmat, A. (2022). Creating good environment and building for people with special needs: From definition to application of guiding and warning blocks. *Indonesian Journal of Community and Special Needs Education, 2*(1), 39-44.

Rodríguez Jiménez, C., Sanz Prieto, M., and Alonso García, S. (2019). Technology and higher education: A bibliometric analysis. *Education Sciences*, *9*(3), 169.

Shaffiyah, I., Dwiyanti, V., Masek, A. (2022). Smart city and society 5.0: Involvement of information technology in the development of public service systems in Indonesia. *ASEAN Journal of Community Service and Education*, *1*(1), 31-42.

Shah. S., S. (2022). Teaching and learning with technology: Effectiveness of ICT integration in schools. *Indonesian Journal of Educational Research and Technology*, *2*(2), 133-140.

Singh, H., and Miah, S. J. (2020). Smart education literature: A theoretical analysis. *Education and Information Technologies*, *25*(4), 3299-3328.

Sudarjat, H. (2022). Parking area for people with special needs: Standard design in Indonesia. *Indonesian Journal of Community and Special Needs Education, 2*(1), 53-58.

Sudaryat, M. R., Firdaus, M. F. Y., Salsabila, A. A., Romlah, S., Mardiatunnisa, M., and Praja, W. N. (2022). Utilization of electronic community library as a localhost-based digital library in optimizing learning resources. *Indonesian Journal of Multidiciplinary Research, 2*(2), 291-298.

Sułkowski, Ł., Kolasińska-Morawska, K., Seliga, R., and Morawski, P. (2021). Smart learning technologization in the Economy 5.0—The Polish perspective. *Applied Sciences*, *11*(11), 5261.

Thapwiroch, K., Kumlue, A., Saoyong, N., Taprasan, P., and Puengsungewan, S. (2021). Easy-mushroom mobile application using the Internet of Things (IoT). *Indonesian Journal of Educational Research and Technology, 1*(2), 1-6.

Thomson, S., and van Belle, J. P. (2015). Antecedents of green IT adoption in South African higher education institutions. *Electronic Journal of Information Systems Evaluation*, *18*(2), 173-187.

Tight, M. (2019). Systematic reviews and meta-analyses of higher education research. *European Journal of Higher Education*, *9*(2), 133-152.

Torres-Sospedra, J., Avariento, J., Rambla, D., Montoliu, R., Casteleyn, S., Benedito-Bordonau, M., and Huerta, J. (2015). Enhancing integrated indoor/outdoor mobility in a smart campus. *International Journal of Geographical Information Science*, *29*(11), 1955-1968.

Tuul, S., Banzragch, O., and Saizmaa, T. (2016). E-learning in Mongolian higher education. *International Review of Research in Open and Distributed Learning*, *17*(2), 181-197.

DOI: https://doi.org/10.17509/ijost.v7i3.51476
p- ISSN 2528-1410 e- ISSN 2527-8045