A Survey on Smart Campus Implementation in Malaysia

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Abstract— **Universities around the world are actively implementing smart campuses. A smart campus is a campus environment capable of providing efficient technology and infrastructure in providing services to support and improve the teaching process, research, and student experience. It comprises initiatives to better support and enhances the better experience in the teaching and learning process and other services in the campus environment. To successfully implement the initiatives, a framework is required to define the scope of the implementation. Several universities in Malaysia are currently developing initiatives to implement their smart campus. This paper surveyed the literature and resources from universities in Malaysia to identify smart campus initiatives implemented following the smart campus domain. Due to the lack of resources available in the prominent database of indexed journal articles, the main source of review is based on official university sources such as official websites and so on. The result shows that all universities implemented all smart campus domains. Smart Management domain has the highest number of 58% of the overall initiatives. The second highest domain is Smart Learning at 13%, followed by Green Campus at 10%. We also identify that there is new domain of smart campus that was introduced. The new domain is Smart Research. Based on the survey, most universities in Malaysia are actively improving their work processes and the environment by implementing smart campus.**

Keywords— **Smart campus; smart campus domain; Malaysian universities.**

I. INTRODUCTION

A smart campus is a campus environment capable of providing efficient technology and infrastructure in providing services to support and improve the teaching process, research, and student experience. The smart campus is defined as students, stakeholders, and the environment who communicate intelligently with the campus [1]. Technology-driven, smart city concept adoption and implementation of an organization or business process are the three approaches to describe smart campus [2], [3]. A smart campus that uses technology intelligence will provide better experiences and benefits to the students and stakeholders.

Apart from giving better experiences, the smart campus implementation will also reduce the campus operational costs. Classroom allocation can be enhanced based on the students' attendance instead of enrolments, which results in the potential savings of 52% in room costs [4]. The space-time constraints in the traditional campus environment can be avoided by utilizing advanced methods such as the Internet of Things, cloud computing and cloud storage, digital information and networks, and creating a virtual education environment [5], [6]. A smart campus can be applied in classrooms, cafeteria, parking space, and transportation.

Recently, the smart campus has been implemented throughout many universities around the world. However, each university has its own goals to achieve with different initiatives. Therefore, we conducted a survey on the current smart campus implementation by universities in Malaysia to identify their initiatives, based on the identification [2], [3].

A Framework is essential and works as a guideline in the development of a smart campus. There are six domains that universities should cater to implement a smart campus, which are smart learning, green campus, smart management, smart healthcare, smart governance, and smart community [2], [3]. This section will describe each domain used in the development of a smart campus and its benefits.

A. Smart Learning

The Smart Learning domain focuses on the enhancement of conventional teaching and learning on campus [1]. It is to improve the interaction between lecturers and students, thus increasing knowledge transfer. Among the improvements are to support the student's self-learning, creating varieties of

teaching and learning techniques without limited by distance and time, and provide evaluations based on the student's achievement in learning competency [2], [3]. A campus is a smart learning campus if it has virtual labs, automatic translation systems, and cooperative, adaptive, and gamification learning [7]. Some higher institutions apply the Virtual Learning Environment system (VLE) in their campus environment to boost positive attitude in knowledge achievement and to encourage active learning within the campus area [8]. Precision teaching based on big data applications and artificial intelligence technology is used as a vital standard to measure the education's efficiency and as a guideline to create interactive and productive learning in classrooms [9]. Smart learning could encourage innovative talents among students [10] and boost their learning quality by creating time-efficient, interactive, sustainable, user-friendly, and cooperative surroundings [11]. The campus with a conducive learning environment will provide lecturers multitude of resources to deliver their knowledge to the students.

B. Green Campus

Green Campus is a domain that concerns environmental-friendly practices and promotes sustainable solutions on campus [12], [13]. This domain focuses on the environmental effects in pollution, promotion and protection of green areas, waste and grey waters management, indoor and outdoor buildings, and continuous food systems support through food and beverage purchases [14], [15]. The smart campus environment is associated with campus management towards water, waste, and energy resources [16], [17]. It is associated with people's interaction on campus with the environment to reduce power consumption and practice conserving manners. Energy-efficient in computing is also considered in this domain [18]. The smart environment implementation is to monitor and protect the environment and manage sustainable resources [19]. For example, imposing technology in the water management system helps optimize water usage on campus by determining sufficient water for storage, daily use, and watering the plants [20]. Implementing efficient and environmental-friendly buildings that include sensor technology can reduce power consumption and provide accurate reporting to the management department [2], [21], [22]. It could also enhance the building's indoor quality, such as lightings, noise levels, ventilation, and thermal comfort [13], [22].

C. Smart Management

The smart Management domain focuses on enhancing the management of the campus. The infrastructural networks such as parking and pedestrian areas, vehicle and cycling networks such as public transportation and bikes and cars sharing, encourage and inducement for sustainable transport, waste and consignment transportation logistic, knowledge on sustainable mobility, and mobility planning by staff and students are included in Smart Management domain [9]. For example, face recognition technology is used to enhance campus security to prevent crime in specific areas. The technology is also capable of estimating people's distribution at certain times by tracing the movement of stakeholders on campus. Besides that, it is also can be used to control entry specific places on the campus [23].

Another example is implementing a smart card system to provide parking permits with cashless payment and record attendance in the teaching and learning process [2]. This domain also helps the students plan their time to use campus public transportation by checking on the transportation schedule and trace its location. The students can know the bus departure time and decide on which bus stop they should head to waiting for the bus, not only depending on the real-time bus schedule but also the estimated time of the bus arrival [24]. The location-based services framework consists of three components; an Android application for users to identify their current locations to connect to services available, a user's web application to identify services available on campus, and a manager's web application to determine the coverage areas services available [25].

D. Smart Healthcare

The Smart Healthcare domain focuses on the overall health aspects of the campus community. The Green Campus domain is related and aligned with the Smart Healthcare domain to ensure a healthy environment realization. A smart campus is capable of providing healthcare services to the campus community at any time and anywhere. An intelligent system is implemented to provide information on the health level, provide proactive and preventive healthcare services, and keeping health status records [2]. The use of IoT and actuators will be able to help monitor the patients' health and take fast actions when needed [26]. The campus also implements an online booking system for the students to make an appointment to see a doctor and be able to conduct check-ups remotely to save the student's time [1].

E. Smart Governance

The Smart Governance domain reflects on high-level university governance that is responsible for fulfilling the stakeholders' needs. This domain emphasizes the involvement of internal and external campus governance at various stakeholders' levels. It also stresses out the enhancement of the governance process and enhancement of organizational performance. This could be realized by improving preventive and corrective actions as well as root cause analysis and optimization. The smart governance system also supports automated reports and schedules, logging, and adapt capabilities on configuration changes by performing management workflow [2]. It also can establish, monitor, implement, and assess short, medium, and long-term work plans. Also, smart governance is able to identify patterns and evaluate multiple areas using artificial intelligence techniques to generate reports using predictive analytics [26]. This domain gives technical support to the financial decision-making that will enhance financial management, which is more open and transparent [27].

F. Smart Community

The smart Community domain focuses on the social well-being of the campus community [18], [26], [28]. This domain handles interactions among campus residents that include students, academic staff as well as non-academic staff. With the advancement of social media technology, it is undeniable that this domain is vital. This domain also can enhance interpersonal communication between the campus residents by implementing the intelligent system [29]. Collaborative learning initiatives are one of the focuses in the Smart

Learning domain and part of the Smart Community domain. The system in this domain can find students' profiles. With that, the system can group them based on their interests, accomplish sentiment analysis according to the data stored on social networks, and enhance the services at the right time and location [2], [3]. This domain helps understand the student's current situation and can provide them with proper guidance and management on time.

II. MATERIAL AND METHOD

This study synthesizes and analyses the literature review from previous studies to get a clear view of the latest smart campuses in Malaysia. We search the literature on the prominent indexed journal database such as IEEExplore, Scopus, and ScienceDirect according to the development of the smart campus by using different keywords such as "smart campus" or "smart university" and "framework" or "construct" or "pillars" or "implementation" or "development". The publication date has been limited to the last 5 recent years (2016-2020) to review the recent literature according to the implementation of the smart campus. We also applied the inclusion and exclusion criteria to choose the relevant literature that can be used as the primary references to analyze smart campus development. However, due to the lack of resources available in the prominent database of indexed journal articles, the main source of review is based on official university sources such as official websites. Also, only five universities are included in this review.

III. RESULT AND DISCUSSION

From the review, several universities in Malaysia are actively implementing smart campus initiatives. Each university campus has its missions and visions to achieve. Suitable domains are required to ensure the success of smart campus implementation and give benefits to all stakeholders.

Table I shows the initiatives and related domains that universities in Malaysia have implemented. The universities included in this research are Universiti Tun Hussein Onn Malaysia (UTHM) [30], Universiti Malaya (UM) [31], Universiti Malaysia Pahang (UMP) [32], Universiti Putra Malaysia (UPM) [33], and Universiti Tenaga Nasional (UNITEN) [34].

TABLE I
SMART CAMPUS INITIATIVE

DOMAIN	CAMPUS	INITIATIVE
SMART LEARNING	UTHM	**Smart Teaching and Learning** • UTHM Massive Open Online Courses (MOOCs) • UTHM Academic Online Resources (AUTHOR) • Smart Classroom
	UM	• Sistem Aplikasi E-Learning Universiti Malaya (SPeCTRUM)
	UMP	• Knowledge & Learning Management System (KALAM) • UMP Open CourseWare

SMART LEARNING	UPM	• PUTRA VDI Smart Desktop for Student Lab
		• PUTRA Edu-Cloud
		• PUTRA Future Classroom
		• PUTRA VR Teaching
		• PUTRA BYOD
		• PUTRA Live
		  ○ Video on-demand & live stream
		  ○ Training content providers

	UNITEN	**Smart Education** • Problem Based Learning Classroom • Green Screen and Filming Studio • Virtual Laboratory
GREEN CAMPUS	UTHM	• Energy@UTHM • Greening@UTHM
	UM	**Smart Room/Smart Building** • Electrical Usage Monitoring • Internet of Lighting-iOL
	UMP	• Real-Time Campus Climate Surveillance & Intelligence through IoT Device • IoT enabled seamless lighting system for smart campus system • Cloud-based intelligent waste management robots for open spaces
	UPM	• Green@UPM
	UNITEN	**Smart Facility** • Smart Street Lighting System **Smart Energy** • Rooftop photovoltaic (PV) • Smart Chiller Using Video Analytics
SMART MANAGEMENT	UTHM	**Smart Administration** • Total Campus Integrated System • Sistem Maklumat Penerbitan Universiti • SAGA Century Financial System • Integrated Attendance System • Student Assessment System • E-Latihan Industri • Application for Admission • E-Office • E-Cuti • E-Kursus • E-Prestasi • E-Payment Portal • Access Control System (ACS) • Online Bookstore • Kaseya Helpdesk • MyUTHM App **Smart Transportation** • UTHM Public Shuttle Tracking **Smart Student** • Sistem Maklumat Akademik Pelajar (SMAP Online) • Residential College Application System (eHapp) • Convocation Queue Management System (CQMS)

Domain	University	Initiatives
SMART MANAGEMENT	UM	**Cashless** • ePay • eWallet • UMPoint • UM Conference • eDonation • eProcurement **Student Information System** • PRINTIS **Mobile Based Vehicle Tracking** • Bus/shuttle tracking • Department vehicle tracking **Mobile based student and staff eProfile** • Virtual Matric Card **QR Code** • Staff Attendance • E-Meeting • UM Conference • E-Scroll (graduates verification) **Barcode** • E-Card convo
	UMP	**Academic Management** • UMP smart robe tracking system • Multimodal biometrics system: fusion of face and dynamic signature for authentication system **Facility Management** • Smell-print recognition for restroom odour quality level • Real-time campus climate surveillance and intelligence through IoT device • Cloud based public bus location tracking and notification application for mobile device • UMP smart storage and retrieval system • IoT based automation system for smart office • Smart Pigeon Hole **Security** • Smart vehicle monitoring • Smart vehicle speed detection • Car tracker • Real-time gender recognition
	UPM	• PUTRA Apps • PUTRA Visitor • PUTRA Smart Library • PUTRA Helpdesk • PUTRA IoT • PUTRA Event • PUTRA Drive • PUTRA Bus • PUTRA Future Datacenter • UPMNet 4.0 • PUTRA Cloud • PUTRA Room • UPMKB Access • PUTRA COME
SMART MANAGEMENT	UNITEN	**Smart Mobility** • Electric bus • Electric bicycle **Smart Security** • Video Analytics **Smart Lifestyle** • Cashless payment
SMART HEALTHCARE	UTHM	• E-Klinik Panel
	UM	N/A
	UMP	• UMP smart healthcare monitoring system
	UPM	N/A
	UNITEN	N/A
SMART GOVERNANCE	UTHM	**Smart Decision Making** • Dashboard KPI Universiti • UTHM Workspace
	UM	**Big Data Analytic** • ICT security monitoring analysis and forensic **Big Data + Predictive Monitoring + Machine Learning + Artificial Intelligence** • Centralised management with alarm and predictive monitoring and machine learning • Multi devices integration and communications
	UMP	• Sustainability Self-Assessment Quantifier (SSA-Q)
	UPM	• PUTRA Data Analytica • PUTRA Voting
	UNITEN	**Smart Security** • Video Analytics
SMART COMMUNITY	UTHM	• UTHM Community
	UM	N/A
	UMP	**Student Affair** • UMP mass rapid identification system
	UPM	• PUTRA ID @ UPMID • PUTRA Community • PUTRA Premium Hotspot • PUTRA Face • PUTRA VID • PUTRA VID Smartpartnership • PUTRA Comm
	UNITEN	**Smart Lifestyle** • UNITENLife app

Table 1 shows the Smart Campus initiatives implemented by each respective university categorized by each domain discussed in section I. In general, all universities had taken many initiatives towards Smart Learning, Green Campus, Smart Management, and Smart Governance domain. Meanwhile, only UTHM and UMP have taken the initiative for the Smart Healthcare domain on its campus. For the Smart Community domain, only UM has not stated any initiatives.

A total of 112 initiatives were identified in smart campus implementation by the respective universities. Fig. 1 shows the number of smart campus initiatives that have been built on each domain by the universities [30]–[34].
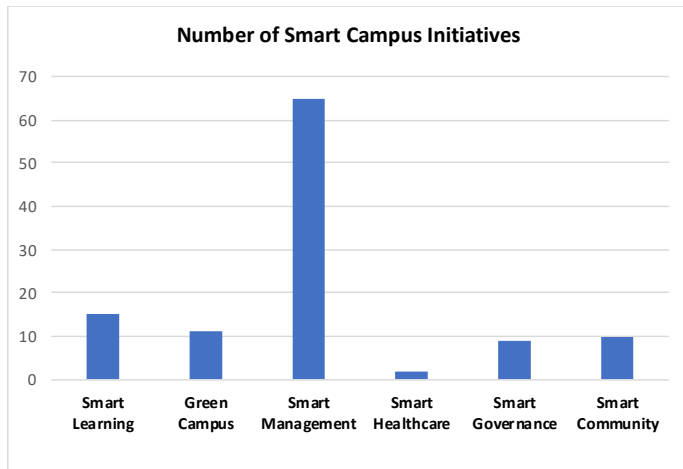

Fig. 1 Number of Smart Campus Initiatives

Fig. 1 shows that the Smart Management domain has the highest number of initiatives of 58% from overall initiatives that the universities have implemented as it was the main focus in starting the smart campus initiative due to the need for restructuring and enhancing management procedures. The next focused domain was the Smart Learning domain with 13%, followed by the Green Campus domain at 10% of the total initiatives implemented. Smart Community domain falls in the fourth rank with 9%, followed closely by Smart Governance at 8%. The least focused was Smart Healthcare at 2%.

From the survey, there are new domains implemented by UTHM and UPM. The new smart campus domain developed by UTHM is called Smart Research, concerning enhancing the research activities using Organizational Research Knowledge Experts Dashboard (ORKED) system and Sistem Maklumat Penerbitan Universiti (SMPU) initiatives. This domain focuses on improving the work process of research-related activities at the university. The research management processes can be enhanced and at the same time provide capability towards participation in research innovation by getting support from research support systems [35]. These domains will transform the universities' future by providing new systems and tools and enhancing available tools, systems, and processes.

IV. CONCLUSION

Each smart campus domain gives different contributions to the campus stakeholders. These domains enhanced the campus productivity and efficiency to the stakeholders, especially the students. Each university included in this survey implemented the smart campus initiative based on targeted domains. Most universities focused on the Smart Management domain in the early implementation of smart campus initiatives because they need to re-align the university's directions and goals. The success of the Smart Management domain will strongly support the implementation of other smart campus domains. Smart Learning domain ranked second place in developing smart campus initiatives. It is because of the universities' nature as

a higher learning institution. Smart Learning will further enhance the learning experience among students and support the academic staff in delivering knowledge. Green Campus domain ranked third in the domain list. Sustainable green technology is essential on the university campus to manage resources smartly. Apart from the existing smart campus domains, the survey found another smart campus domain: the Smart Research domain.

Each initiative comes with user-friendly applications that improve the role of stakeholders. It also creates conducive environments in the teaching and learning process and saves time, cost, and energy. Although there are slight differences in each campus environment, the university can enhance and improvise the domains accordingly to their campus needs.

However, there were some challenges faced during the implementation of the smart campus. All stakeholders should give a full contribution to make the development of the smart campus a success. Feedbacks from stakeholders are vital in the implementation of the smart campus.

Based on the survey, it is concluded that most universities in Malaysia are actively improving their work processes and the environment by implementing smart campuses. Also, universities included in the survey follow the suggested six domains: smart learning, green campus, smart management, smart healthcare, smart governance, and smart community [2], [3].

REFERENCES

[1] E. M. Malatji, "The development of a smart campus - African universities point of view," in *8th International Renewable Energy Congress (IREC)*, Amman, Jordan, 2017, pp. 1-5, doi: 10.1109/IREC.2017.7926010.

[2] W. Muhamad, N. B. Kurniawan, Suhardi and S. Yazid, "Smart campus features, technologies, and applications: A systematic literature review," in *2017 International Conference on Information Technology Systems and Innovation (ICITSI)*, Bandung, Indonesia, 2017, pp. 384-391, doi: 10.1109/ICITSI.2017.8267975

[3] J. W. P. Ng, N. Azarmi, M. Leida, F. Saffre, A. Afzal and P. D. Yoo, "The Intelligent Campus (iCampus): End-to-End Learning Lifecycle of a Knowledge Ecosystem," in *2010 Sixth International Conference on Intelligent Environments*, Kuala Lumpur, Malaysia, 2010, pp. 332-337.

[4] T. Sutjarittham, H. Habibi Gharakheili, S. S. Kanhere and V. Sivaraman, "Data-Driven Monitoring and Optimization of Classroom Usage in a Smart Campus," in *2018 17th ACM/IEEE International Conference on Information Processing in Sensor Networks (IPSN)*, Porto, Portugal, 2018, pp. 224-229, doi: 10.1109/IPSN.2018.00050.

[5] J. Cao, Z. Li, Q. Luo, Q. Hao, and T. Jiang, "Research on the construction of smart university campus based on big data and cloud computing," in *2018 International Conference on Engineering Simulation and Intelligent Control (ESAIC)*, Hunan, China, 10 – 11 Aug. 2018, pp. 351-353, doi: 10.1109/ESAIC.2018.00088.

[6] A. Abuarqoub, H. Abusaimeh, M. Hammoudeh, D. Uliyan, M. Abu-Hashem, M. Sharefa, M. Al-Jarrah, and F. Al-Fayez, "A Survey on Internet of Things Enabled Smart Campus Applications," in *International Conference on Future Networks and Distributed Systems*, Association for Computing Machinery: Cambridge, United Kingdom, July 2017, pp. 1-7.

[7] D. Rico-Bautista, Y. Medina-Cárdenas, and C. D. Guerrero, "Smart University: A review from the educational and technological view of internet of things," *International Conference on Information Technology & Systems* Springer, Cham, Feb. 2019, pp. 427-440.

[8] R. Charanya and M. Kesavan, "Analysis of Factors Influencing the Virtual Learning Environment in a Sri Lankan Higher Studies Institution," in *2019 International Research Conference on Smart Computing and Systems Engineering (SCSE)*, Colombo, Sri Lanka, 2019, pp. 240-244, doi: 10.23919/SCSE.2019.8842719.

[9] W. Liang, "Analysis of the Application of Artificial Intelligence Technology in the Construction of Smart Campus," in *2020 International Wireless Communications and Mobile Computing (IWCMC)*, Limassol, Cyprus, June 2020, pp. 882-885, doi: 10.1109/IWCMC48107.2020.9148200.

[10] Z. Y. Dong, Y. Zhang, C. Yip, S. Swift, and K. Beswick, "Smart campus: Definition, framework, technologies, and services," *IET Smart Cities*, vol. 2, no. 1, pp. 43-54, 2020.

[11] V. Ahmed, K. Abu Alnaaj, and S. Saboor, "An investigation into stakeholders' perception of smart campus criteria: the American university of Sharjah as a case study," *Sustainability*, vol. 12 no. 12, 5187, 2020.

[12] V. Subbarao, K. Srinivas and R. S. Pavithr, "A survey on internet of things based smart, digital green and intelligent campus," in *2019 4th International Conference on Internet of Things: Smart Innovation and Usages (IoT-SIU)*, Ghaziabad, India, 2019, pp. 1-6, doi: 10.1109/IoT-SIU.2019.8777476.

[13] Y. Li, H. Chen, W. Shao, S. Jing, F. Chiu and H. J. Su, "Practices of innovative technology and education for sustainability in Taiwan sustainable campus program," in *2017 Pacific Neighborhood Consortium Annual Conference and Joint Meetings (PNC)*, Tainan, Taiwan, 2017, pp. 15-22, doi: 10.23919/PNC.2017.8203517.

[14] J. Mazutti, L. Londero Brandli, A. Lange Salvia, B. M. Fritzen Gomes, L. I. Damke, V. Tibola da Rocha, and R. d. Santos Rabello, "Smart and learning campus as living lab to foster education for sustainable development: an experience with air quality monitoring," *International Journal of Sustainability in Higher Education*, vol. 21 no. 7, pp. 1311-1330, 2020.

[15] T. M. John, E. G. Ucheaga, J. A. Badejo and A. A. Atayero, "A Framework for a Smart Campus: A Case of Covenant University," in *2017 International Conference on Computational Science and Computational Intelligence (CSCI)*, Las Vegas, NV, USA, 2017, pp. 1371-1376, doi: 10.1109/CSCI.2017.239.

[16] E. M. Malatji and S. B. Kwesi Ntsaluba, "Smart energy generation for a smart campus," in *2018 International Conference on Intelligent and Innovative Computing Applications (ICONIC)*, Plaine Magnien, Mauritius, 6-7 December 2018, pp. 1-5, doi: 10.1109/ICONIC.2018.8601285.

[17] T. P. Fei et al., "SWM: Smart waste management for green environment," in *2017 6th ICT International Student Project Conference (ICT-ISPC)*, Skudai, Malaysia, 2017, pp. 1-5, doi: 10.1109/ICT-ISPC.2017.8075303.

[18] W. Villegas-Ch, X. Palacios-Pacheco, and S. Luján-Mora, "Application of a Smart City Model to a Traditional University Campus with a Big Data Architecture: A Sustainable Smart Campus," *Sustainability*, vol. 11, no. 10, p. 2587, 2019.

[19] P. Fraga-Lamas, M. Celaya-Echarri, P. Lopez-Iturri, L. Castedo, L. Azpilicueta, E. Aguirre, ... , and T. M. Fernández-Caramés, "Design and experimental validation of a LoRaWAN fog computing based architecture for IoT enabled smart campus applications," *Sensors*, vol. 19, no. 15, 3287, 2019.

[20] A. Anirudh, V. K. Pandey, J. S. Sodhi, and T. Bagga, "Next Generation Indian Campuses going SMART," *International Journal of Applied Business and Economic Research.*, vol. 15, no. 21, pp. 385-398, 2017.

[21] C. Huang, "On study of building smart campus under conditions of cloud computing and internet of things," *IOP Conference Series: Earth and Environmental Science*, vol. 100, no. 1, pp. 012-118, IOP Publishing, Dec. 2017.

[22] B. Anthony, M. A. Majid and A. Romli, "An agent based Green assessment system architecture for sustainable practice implementation among IT practitioners in university campuses," in *2017 8th International Conference on Information Technology (ICIT)*, Amman, 2017, pp. 17-25, doi: 10.1109/ICITECH.2017.8079910.

[23] A. Anirudh, V. K. Pandey, J. S. Sodhi, and T. Bagga, "Next generation Indian campuses going SMART," *International Journal of Applied Business and Economic Research,* vol. 15, pp. 385-398, 2017.

[24] T. Sutjarittham, H. H. Gharakheili, S. S. Kanhere and V. Sivaraman, "Realizing a Smart University Campus: Vision, Architecture, and Implementation," in *2018 IEEE International Conference on Advanced Networks and Telecommunications Systems (ANTS)*, Indore, India, 2018, pp. 1-6, doi: 10.1109/ANTS.2018.8710084.

[25] A. Rusli and D. K. Halim, "Towards an Integrated Hybrid Mobile Application for Smart Campus Using Location-Based Smart Notification," in *2019 International Conference on Engineering, Science, and Industrial Applications (ICESI)*, Tokyo, Japan, 2019, pp. 1-6, doi: 10.1109/ICESI.2019.8863022.

[26] N. Min-Allah, and S. Alrashed, "Smart campus - A sketch," *Sustainable Cities and Society*, vol. 59, 102231, 2020.

[27] S. Yuxia, "Researches on the construction of the smart campus system with respect to the Higher Vocational Colleges in the information age—taking Dalian Vocational and Technical College as an example," *Journal of Physics: Conference Series*, IOP Publishing, vol. 1437, no. 1, p. 012043, Jan. 2020.

[28] C. Prandi, L. Monti, C. Ceccarini and P. Salomoni, "Smart Campus: Fostering the Community Awareness Through an Intelligent Environment," *Mobile Netw Appl*, vol. 25, pp. 945–952, 2020. https://doi.org/10.1036-019-01238-2.

[29] Z. N. Kostepen, E. Akkol, O. Dogan, S. Bitim and A. Hiziroglu, "A Framework for Sustainable and Data-driven Smart Campus," in *Proceedings of the 22nd International Conference on Enterprise Information Systems - Volume 2: ICEIS*, 2020, pp. 746-753. DOI: 10.5220/0009406807460753

[30] Sustainable Campus Office@UTHM. Retrieved from https://scu.uthm.edu.my/introduction/.

[31] UM Smart Campus Initiatives 2018-2019. (2019, May 19). Retrieved from https://ptm.um.edu.my/um-smart-campus-initiatives-2018-2019.

[32] Perlaksanaan Inisiatif Smart Campus di UMP. Retrieved from https://ptmk.ump.edu.my/index.php/services-1/smart-campus.

[33] Smart Campus. Retrieved from https://idec.upm.edu.my/kampus_pintar-3771?L=en.

[34] Smart Univercity. Retrieved from https://uniten.edu.my/research/smart-univercity/

[35] Z. Jiang, "Research on Information Construction of New Campus Based on Computer Intelligent Campus," *Journal of Physics: Conference Series,* IOP Publishing, vol. 1648, no. 4, p. 042020, 2020.