Smart Campus Implementation in Universiti Tun Hussein Onn Malaysia: Towards a Conceptual Framework

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Abstract. Smart campus concepts have been implemented in many universities throughout the world in recent years. This concept aims to enhance campus-wide management as well as activities in a smart way. The smart campus is derived based on the smart cities concept where it converts the traditional campus into a smart campus. The implementation of the smart campus can provide multiple benefits for the campus community and the stakeholders. However, different stakeholders have different perspectives and needs toward smart campus implementation. This study describes the conceptual framework for the smart campus implementation in UTHM based on the synthesized literature review. From the literature, we find out that academic, research, student experience and services are the pillars that are suitable for smart campus implementation in UTHM. These pillars also matched with the top management role in UTHM. The result from the pilot study shows that the Cronbach’s Alpha coefficient is 0.993. Thus, the proposed conceptual framework can be used to proceed further with this research.

1. Introduction

In recent years, smart campus concepts have been introduced and implemented to enriched the quality of life in the campus environment. This was also implemented to reduce the cost of running a campus [1]. Smart campuses can be defined as devices and applications that create new experiences, services and facilitate operational efficiency of a campus [2]. The concept of the smart campus is originally derived from the smart city concepts and experiences where it converted a traditional campus into a smart campus [3]. This concept helps to improve better experiences to the campus community and provide diversification modes of teaching to the students and lecturers through the enhanced learning process. The smart campus implementation also offers campus management with various tools to efficiently manage the campus.

Recently, the Universiti Tun Hussein Onn Malaysia (UTHM) started the smart campus adoption project. The project includes realigning current systems as well as proposing new systems and services towards smart campuses. As we can see there are various technologies developed to make the campus smart enough to be a smart campus. Different stakeholders have different kinds of intelligence that they need on campus [4]. Not only depending on the intelligence of the technology, but the implementation of the smart campus should also consider the quality of experience of the campus community. Infrastructure is one of the aspects that need to be considered in developing a smart campus so that it can give services that are beneficial for the campus community [6]. The smart connected campus should also provide flexible, fast and timely delivery of responses to the students, staff, faculty, visitors and management authorities with better features [5].
University campuses should focus carefully on the framework for the implementation of the smart campus so that each of the stakeholders can get benefits from it. Therefore, this paper aims to propose a conceptual framework that is suitable for the implementation of smart campus in UTHM.

2. Related works
There is no definite framework for a smart campus but its characteristics resemble much of a smart city concept [7]. The basic idea of a smart campus is an effort of the university to integrate a set of advanced technology to improve the performance of the university, the quality of the graduates and also ease of life through the provision of information technology services that is valuable, dynamic and user-oriented [8]. Space-time constraints of traditional campuses can be avoided by implementing the smart campus which utilizes the most advanced methods such as cloud computing and cloud storage, basic digital information and networks, and also creating the virtual education environment [20]. However, the development of the smart campus also should consider the needs of the stakeholders on a campus. Students are the most important targeted user and numerous stakeholders in any campus [21].

We summarize that the main domain for the implementation of smart campus is learning, environment, campus life, research and administration [7], [8], [9], [10], [11], [12], [13], [14], [15], [16].

3. Research method
This study synthesized and analyzed the literature from the previous studies to propose a smart campus conceptual framework for UTHM. We search the literature on different prominent research databases such as IEEExplore, Scopus and ScienceDirect according to the development and implementation 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) so that we can review the recent literature according to the implementation of the smart campus. We also applied the inclusion and exclusion criteria to choose the suitable literature that can be used as the main references to analyze the development and implementation of a smart campus.

To evaluate the proposed conceptual framework, we adopt the UTAUT2 model [32] and conducted a pilot study on 43 respondents. The questionnaires of the pilot study were distributed through an online survey to the respondents.

4. Proposed UTHM smart campus conceptual framework

![Proposed UTHM Smart Campus Conceptual Framework](image-url)
Suitable domains or pillars are needed to ensure the effectiveness of the smart campus implementation. By applying the suitable domains or pillars, the smart campus can provide better coexistence between the university and the stakeholders. It also will facilitate the management of the resources in the campus adequately and build comfortable places for learning [3]. There are three main broad areas of focus in the smart campus to ensure efficient operations and functionalities which are sustainability, infrastructure and experience. The first area, sustainability focuses on the management of resources and environment such as energy, water, waste management and emissions. The second area which is infrastructure gives focus on the development and management of campus infrastructure such as building management system, cloud and data centre, smart parking, automated transportation and also sensors. Lastly, the user experiences are focused on end-user utility and experience such as health, safety, intelligent access control and smart cafeteria [17]. From these broad areas, we propose four pillars of smart campus which will support all smart campus initiatives and objectives in UTHM.

Figure 1 shows the proposed conceptual framework for the development of the smart campus in UTHM. Based on the literature of previous studies, the conceptual framework for the development of smart campuses in UTHM can be formed through four pillars which are Academic, Research, Student Experience and Services. Also, there are Enablers to support the four pillars of smart campus. Each of these pillars gives different focus and benefits to the stakeholders of the campus.

4.1. Enablers
In this proposed framework, Enablers are the foundation for the smart campus pillars. The enablers include financial, infrastructure, rules, social and technology. Financial is one of the most important enablers because every activity and initiative in a smart campus requires financial resources. Another important enabler is infrastructure. For instance, building and IT infrastructures such as building sensors, high-speed Internet connectivity and cloud services should be ready before any implementation of smart campus takes place. Also, rules, regulation and policies should be formed to support smart campus initiatives. This will enforce the scope of smart campuses and also regulate any activities related to smart campuses. Another enabler is the campus community themself. Campus communities should be fully ready to accept smart campus to ensure the effectiveness of the implementation. Last but not least is the technology related to smart campus. All technology which supports the implementation of smart campus such as the Internet of Things (IoT), cloud computing, data science and so on should be ready.

4.2. Academic pillar
This pillar focuses on the main business of the university which is education. This includes the enhancement of facilities, infrastructure and academic resources that are needed for the teaching and learning as well as supporting the academic management. Therefore, we can consider three main areas in this pillar which are Smart Teaching and Learning, Smart Academic Management and Smart Academic Resources. Table 1 shows the applications and the related topics for the academic that has been studied in the previous research.

| Areas                      | Topics                                           | References                |
|----------------------------|--------------------------------------------------|---------------------------|
| Smart Teaching and Learning| Virtual Learning, Collaborative Environment,     | [4], [22], [19], [27],   |
|                            | Smart Laboratories                               | [4], [12], [20], [23],   |
|                            |                                                  | [25], [26], [30]         |
| Smart Academic Management  | Smart E-Card, Student, Attendance System         | [12], [25], [26]         |
| Smart Academic Resources   | Online Repositories, Intelligent Library         | [6], [7], [28]           |
|                            | Management System                               |                           |

The Smart Teaching and Learning area will provide support to varieties of teaching and learning processes such as blended learning, micro-credentials, online and virtual classes. Various teaching and learning methods could enhance the learning experience for students especially when online and distance education is needed for example during the pandemic time.
The Smart Academic Resources will cover the enhancement of the storage of the academic resources and provide students access to the academic resources so that the resources provided by the lecturers can be accessed on the same shared data centre.

The Smart Academic Management covers the convenience of the academic management such as time-tableing, course registration and class location help the students to manage their time, schedule their time table and also reduce the time taken to locate the classes.

For this pillar, the system that has been developed and available in UTHM such as UTHM Academic Online Resources (AUTHOR), UTHM Massive Open Online Courses (MOOC), Sistem Maklumat Akademik Pelajar (SMAPOnline), Class Attendance System, Student Assessment System and e-Project Online. There are also several systems and applications to be developed under this pillar. Therefore, in this framework, the academic pillar is focusing on the achievement of the students in learning experiences, the communication with the lecturers and students, the effectiveness of the academic resources and student’s acceptance and quality of experience.

4.3. Research pillar

This pillar concerns all of the research activities such as research management, publication, innovation and also the ability of the campus to commercialize the research [18]. Three main areas can be included in this pillar: Smart Research Management, Smart Publication Management and Smart Innovation Management. Table 2 shows the areas and topics by previous studies related to the research.

| Areas                      | Topics                                             | References   |
|----------------------------|----------------------------------------------------|--------------|
| Smart Research Management  | Optimization and Analytics Data Center,             | [12], [19], [25] |
|                            | Reporting Research, Research Materials,             |              |
|                            | Research Tools                                     |              |
| Smart Innovation Management| Smart Economy, Innovation, Patentability,           | [15], [27]   |
|                            | Commercialization                                  |              |
| Smart Publication Management| Article Publication, Reporting Research,           | [27]         |

Smart Research Management is an initiative that enhances the research process. This includes research grant management, fund management, research staff management and research reporting. Smart Publication Management focuses on the research publication process. This includes internal and external publication as well as report and article repositories for future references. Smart Innovation Management involves the enhancement of innovation process management. It includes product patent search and registration, copyright, etc.

For this pillar, systems and applications that have been developed and implemented in UTHM are Organizational Research Knowledge Experts Dashboard (ORKED) and Sistem Maklumat Penerbitan Universiti (SMPU). Several systems or applications related to this pillar are currently under development. These systems and applications facilitate and enhance the management of research and innovation related activities among researchers thus reducing managerial works.

4.4. Student experience pillar

This pillar helps to understand a student's current situation and provide students with proper guidance and required management promptly [19]. Also, in this pillar, activities and initiatives are implemented to enhance the students' quality of experience in the smart campus. There are four areas suggested to be included in this pillar: Smart Student and Smart Transportation. This pillar also concerns students' point of view which students intelligently interact with the smart campus initiative so that the technology will give benefits to the students. Table 3 shows the areas and the topics for student engagement based on previous studies.
Table 3. Student Experience Pillar

| Areas                  | Topics                                                                 | References                  |
|------------------------|------------------------------------------------------------------------|-----------------------------|
| Smart Student          | Student ID, authentication, authorization, student activity, accommodation | [4], [12], [20], [19], [30] |
| Smart Transportation   | Bus tracking, smart parking, intelligent signage, navigation           | [12], [15], [25], [27]     |

The Smart Student area concerns the enhancement of students’ identification that can be used in various digital transactions. It also covers students’ curricular activities management and reporting. This area also focuses on the smart management of accommodation such as hostels and housing.

The Smart Transportation area focusing on the enhancement of students’ transportation services. Services included in this area are bus tracking, smart parking, vehicle rental, intelligent navigation and so on.

In UTHM, among systems and applications that have been developed related to this pillar is Sistem Maklumat Pelajar (SMP) and Shuttle Bus Tracking System. Several systems and applications that are related to this pillar are also being developed.

4.5. Services pillar

This pillar focuses on the services that are provided on the campus. It also concerns the enhancing of the governance, administration, security, health and sustainability of the smart campus. Five domain areas are included in this pillar which are Smart Sustainability, Smart Administration & Governance, Smart Security & Surveillance, Smart Health & Well Being and Smart Infrastructure. Table 4 shows the areas and topics of previous studies related to this pillar.

Table 4. Services Pillar

| Areas                          | Topics                                                                 | References                  |
|--------------------------------|------------------------------------------------------------------------|-----------------------------|
| Smart Sustainability           | Energy, Water, Waste Management, Emissions, Renewable Sources          | [4], [12], [15], [17], [24], [26], [27], [28], [29] |
| Smart Administration & Governance | Educational Administration, Admissions and Employment Management, Financial | [4], [17], [19], [27]     |
| Smart Infrastructure           | Building Management System, Smart Parking, Sensors, Cloud and Data Center, Communication System, Smart Classroom, Smart Laboratories | [4], [12], [17], [20], [23], [24], [25], [26] |
| Smart Health & Well Being      | Health and Wellness                                                    | [15], [17], [24]           |
| Smart Security & Surveillance  | Surveillance, Smart Visitor Management, Access Control, Cybersecurity, Disaster Management | [4], [12], [17], [20], [25], [27] |

This pillar focuses on the services that are provided on the campus. It also concerns the enhancing of the governance, administration, security, health and sustainability of the smart campus. Five domain areas are included in this pillar which are Smart Sustainability, Smart Administration & Governance, Smart Security & Surveillance, Smart Health & Well Being and Smart Infrastructure. Table 4 shows the areas and topics of previous studies related to this pillar.

Smart Sustainability is an area that focuses on enhancing smart campus sustainability. It also concerns the green and environmentally friendly campus. This includes smart management of resources such as electricity and water as well as smart waste management.
Smart Administration & Governance is the area that focuses on the enhancement of governance and administrative process of the smart campus. This means technologies and tools that facilitate governance and administration such as data mining, data analytics, data visualization and decision support systems should be implemented to support decision making.

Smart Security and Surveillance area focus on enhancing and supporting security and crime prevention on the campus. This includes the usage of smart surveillance using CCTV and the smart identification of suspicious activities.

Smart Health & Well Being is the area concerning the enhancement of support systems for healthy lifestyles such as smart trainers to help students or staff do their daily or weekly exercise. This area also focuses on health care management such as keeping track of health records and managing appointments with medical officers.

Last but not least is the Smart Infrastructure area which focuses on the enhancing and the management of crucial smart campus infrastructure. This includes the implementation of a smart building, smart classroom, smart laboratories, smart parking, cloud services and so on.

For this pillar, UTHM had taken several initiatives by implementing smart environmental and resources management such as building smart electricity meter, smart decision making such as Dashboard KPI and smart administration such as Total Campus Integrated System (TCIS), E-Office, E-Cuti, E-Claim, E-Kursus and many more.

This pillar’s initiatives provide convenience systems and applications to the campus community as they can organize their schedule, get the information from the main sources, provide a safe environment to the faculties and campus and also enhance their health-care services. These initiatives are not only beneficial towards the campus community but also being an environmentally friendly campus.

A pilot study was done before distributing the questionnaire to the respondents. We conducted a pilot study on 43 respondents belonging to UTHM students. The data collected from the pilot study were analysed by using SPSS to identify the Cronbach's Alpha coefficient for each construct. The reliability is good if the coefficient is found equal to or greater than 0.70 [31]. The result shows that the Cronbach’s Alpha coefficient is 0.993 which is greater than 0.70. Thus, the questionnaire is reliable to proceed further with this research.

5. Conclusion
The development of the smart campus should consider all of the factors that influence the daily activities of the campus. Not only depending on the infrastructure of the campus but the development of a smart campus also should be more focusing on its benefits towards the campus community and stakeholders as well as providing a balanced interaction between the campus and the environment.

We conclude that the proposed conceptual framework for UTHM is aligned with the literature and the available systems and applications. It is important as a guideline to implement a smart campus. The proposed pillars which are academic, research, student experience and services are adequate for smart campus implementation in UTHM. These pillars also matched with the top management role in UTHM. These pillars will play an important role in the achievement of the smart campus.

Although there are many strategies to develop the smart campus, there are also a few restrictions that need to be considered when developing the applications for the smart campus such as financial, duration and rules. The listed smart areas in each of the proposed pillars should be planned properly and prioritized based on the needs of the stakeholders and its benefits in the future.

Future work of this research is to evaluate the effectiveness and acceptance of the proposed conceptual framework towards smart campus implementation in UTHM. Data will be collected by distributing questionnaire based on UTAUT2 model [32] to the respondents.

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