STUDENT PERCEPTION STUDY ON SMART CAMPUS: A CASE STUDY ON HIGHER EDUCATION INSTITUTION

Mohd Faizal Mustafa[1], Mohd Rizal Mohd Isa[2], Ummul Fahri Abdul Rauf[3], Mohd Nazri Ismail[4], Mohd Afizi Mohd Shukran[5], Mohammad Adib Khairuddin[6], Norshahriah Wahab[7], Noor Zuraidin Mohd Safar[8]*

[1,2,4,5,6,7]Faculty of Defence Science and Technology, National Defence University of Malaysia, Kuala Lumpur, Malaysia

[3]Centre for Defence Foundation Studies, National Defence University of Malaysia, Kuala Lumpur, Malaysia

[8]Faculty of Computer Science and Information Technology, Universiti Tun Hussein Onn, Johor, Malaysia

E-mail: mohdfaizal@upnm.edu.my[1], rizal@upnm.edu.my[2*] (corresponding author), ummul@upnm.edu.my[3], m.nazri@upnm.edu.my[4], afizi@upnm.edu.my[5], adib@upnm.edu.my[6], shahriah@upnm.edu.my[7], zuraidin@uthm.edu.my[8]

DOI: https://doi.org/10.22452/mjcs.sp2021no1.1

ABSTRACT

With the current development of science and technology, big data technology, the Internet of Things (IoT), cloud computing, and mobile Internet in Malaysia, it is time for smart campuses to be established and Higher Education Institution (HEI) should not have left behind. The smart campus is the upgraded version of a digital university, providing a better academic environment to the lecturers and students. A smart campus enhances education, research, design, and delivering the appropriate higher learning modules to pursue the latest developments in ICT technology that can drive future educational growth and innovation. In short, the smart university is to construct a safe and secure, stable, environmentally-friendly, and energy-saving campus. However, so far, there is no standard smart campus concept to follows. This research paper evaluates the student's perceptions on the smart campus from the various application. A total of 912 students from local HEI have participated as valid observations for data analysis. The results show the students have selected 11 applications as high impact based on the Relative Importance Index for smart campus implementation. Future work could focus on the feedback from the staff and lecturers' points of view to propose a solid conceptual smart campus framework.

Keywords: Student perception, smart campus, higher education institution

1.0 INTRODUCTION

A traditional campus consists of educational buildings such as libraries, classrooms, residential halls, cafeterias, student centres, computer labs, and administration offices. These facilities were built to provide students with an exclusive study environment where they would spend most of their campus life.

Nowadays, in the Fourth Industrial Revolution (IR 4.0) era, most of these facilities are equipped with advanced computer technology and networking to suit each university's requirement and is called Smart Campus [5], [11]. Christopher Ziguras [2] defines a smart campus for the university's data sharing and advances networking infrastructure, an extension, and improvement of a digital campus. The smart campus uses a combination of the latest technologies such as emerging technologies, the Internet of Things (IoT), embedded computing, cloud computing, mobile applications, Big Data, smart business, and social networks. A smart campus's primary purpose is to provide a better academic environment for students and lecturers. Moreover, with the smart campus, the university will save costs and improve operational efficiency. The smart campus is the upgraded version of a digital university, providing a better academic environment to the lecturers and students. Kwok [9] defines a smart campus as an enhanced education, research, design, and delivery of the appropriate higher learning modules to pursue the latest ICT technology developments that can drive future educational growth and innovation. Veeramanickam and Mohanapriya [9], on the other hand, mentioned that the smart campus would have an integrated campus environment in the teaching and learning process using developed applications. It uses different application service systems as the carrier and mixes teaching, scientific research, management, and campus life. In short, the smart campus is to construct a safe and secure, stable, environmentally friendly, and energy-saving campus.

The objective of this research paper is to evaluate the student's perception on the implementation of smart campus applications in higher education institutions. The outcome of this study can be used to define the smart campus concept for higher education institutions. Hence, the research questions shall be answered through this study is; What is the student's perception of implementing smart campus applications in higher education institutions?

This research paper is divided into five sections and begins with the introduction. The second section is on the selected literature review on smart campus elements and applications. It is then followed by the third section on the methodology adopted in this research paper. The fourth section is on the data analysis from the conducted survey. The fifth and last section is on the conclusion and future works.

2.0 LITERATURE REVIEW

2.1 The Internet of Things (IoT)

The Internet of Things (IoT) is a smart technology that connects all devices and all working processes through RFID sensors, QR Codes, real-time tracking positions for application such as intelligent identification, location, and management of goods. By implementing IoT at HEI, staff and students can utilize laboratory resources and equipment with the latest technology. Higher management and support levels need to learn to use the latest technology on IoT goodness. Furthermore, lecturers can also manage time with students, students, classes, and attendance systems more efficiently.

2.2 IoT in Education

2.2.1 Smart Learning

The Conservative learning environment has two major parties involved in the learning systems, the lecturers who demonstrate and the students who observe and study. Classic teaching and learning processes required both parties to be in a similar place and time, which is a challenge for both parties to make themselves available [1].

The smart learning environment is an alternative solution to all of these conventional learning barriers. There are four levels of smart learning concepts that memorize intelligent systems' recursive and sustainable existence: learning, evaluation, interaction, and analysis. The smart learning system's main determinants are considering student aspirations, knowledgeable talent, and knowledge levels to create a transparent learning environment for the lecturers [16].

A smart learning atmosphere makes available an overall, interoperable and continuous learning architecture to participate and exchange three primary measurements of learning resources: learning partners, learning contents, and learning services [16], [20]. The classic smart learning environment consists of student preservation systems, real-time learning, users' distribution and assessment of ultimatums, interactive recycling lectures, and online course materials [12].

Over the previous decades, teaching and learning have historically been restored towards applying forwarding thinking technologies. A methodology that shows students build their performance through social networks across campus provides a context-based foundation for instructional learning experiences. The methodology uses mobile sensing and learning technologies with web servers built to achieve a holistic learning environment (u-learning). Instead, additional requirement assessment in terms of student behavior and content.

2.2.2 Smart Classroom

A Smart Classroom is an intelligent class that integrates creative teaching and learning strategies with new pedagogy into evolving technologies. This smart classroom concept's system requirement is needed to ensure active interactions among students and lecturers to interact virtually without neglecting the course objectives [6].

Smart classroom concepts have proven to influence internet-based learning, such as e-learning, m-learning, and many distance education systems, or a smart environment designated with a collection of resources that interact with the students and lecturers [23]. As part of interactive learning, smart classrooms are a place for students to learn and work together. In order to achieve specific cooperative tasks, lecturers encourage students to work in small groups. In this context, students are encouraged to guide each other to cope with difficult challenges.

The traditional classroom layout is all the students sat in front of the desk, and the lecturer delivers their presentation. Traditional learning can be adjusted into collaborative learning in the smart classroom concept, especially when students need to work together in a group where the classroom layout is played a part to facilitate active pedagogy implementation. In having proper interaction and concentration, the smart classroom creates an atmosphere that facilitates the transformation from traditional classroom models to active classes where the layout most suitable for a group of four to six students [24] .

Moreover, this smart classroom concept can be enhanced. All laptops, tablets, and projectors are connected to create a gateway to enable students to engage more in collaborative learning and inspire active interaction between students and lecturers.

2.2.3 Smart Laboratories

In the laboratory, IoT is utilized to allocate appropriate time and takes full advantage of the available resources to retains energy. For example, to enter the smart lab, students are required to have an RFID tag. All the lights automatically switch on as entering the lab, and each student will be assigned a specific device. The system tracks the usage of the labs and opens more labs when it is necessary. It is also able to shut down any unoccupied or suspicious computers. Air conditioners are also automatically switched on only when the temperatures are out of range. Eventually, generate efficient and effective lab management and power control facilities [25].

2.3 IoT in Waste and Water Management

At present, the university has seen as small towns with arrears of population, size, and exciting events, which will impact the environment. However, most university development still fails in following the necessary guidelines in Malaysia to achieve a sustainable environment. Besides, many of the universities that have existed in Malaysia for decades have also faced the challenge of constructing the old building system (facilities and utility services) into the acceptable level of sustainability needs [8].

Waste and water management are known to be amongst the essential services in buildings and universities. The use of IoT to access these services can have a significant financial and environmental impact. Many studies on waste management, for example, Folianto, Low and Yeow, [3], suggested that garbage and waste trucks be provided with sensors to collect real-time data for analysis. Hence, using the data collected to plan a better cleaning schedule for garbage collection with an efficient pick-up route to minimize travel costs.

Sharma, Singha and Dutta [13], propose a Smart bin system that determines the garbage level in the waste bin to monitor the capacity and notify the cleaners once it is maximum depending on various forms of waste. The system used wireless networks to collect data and transmit it to the central server. A thorough evaluation of the Smart bin has been evaluated in the real world, where data is collected from the experimental setup to determine the extent of the garbage volume. With this information, waste management companies and cleaning services can make better decisions to improve efficiency while at the same time lowering costs.

Smart water meter initiatives increase consumer understanding, boost infrastructure management efficiency, and provide early warning of irregular detection of a fluid existence outside the tank and changes in pressure in the pipeline. However, most of the proposed water management methodologies lack a standard model, a decent user interface to manage heterogeneous nodes, and several linked pipelines.

2.4 IoT in Safer Campus

Nowadays, the world is becoming smarter. The strengthening of the use of smart technology in our daily lives seems a bit overwhelming to some. On the contrary, opportunities for success and transformational transformation are thanks to the development of smart technology. It helps us cope with problems we do not want to face and look at issues in our daily lives.

Like any CCTV, smart CCTV works by providing real-time surveillance video. However, where the regular camera is only recorded, smart CCTV can understand the feed and make sense of the recorded image,. It provides data and algorithms that allow smart CCTV to detect specific behaviors, store them, and evaluate them.

Smart CCTV is so innovative in its intelligence that it acts as a robot with the efficiency of human thought. In a way, some see it as a step towards a way of life where everything helps them predict future events. Sure, it is a bit worrying. However, it is fair to say that experts may compensate inmates with technology development [22].

2.4.1 Video Surveillance

Old-style closed-circuit security cameras require physical contact with expensive switch arrangements and are almost awkward in some areas. At Smart Campus, wherever an electrical point is accessible, the smart IP video cameras and use wireless connections to link them could be installed. Distribute video surveillance to places that have never been able to reach, including hundreds of meters outside the core network [28].

2.4.2 Smart Locks and Access Control

The associated keys make it easy to control who has access to hundreds of buildings on campus. Combine them with other Smart Campus systems — smart ID card readers, video surveillance, perimeter controls— and enable monitoring every person who comes and always goes. Use a behavior-based alarm to warn campus safety if someone tries to enter the building during rush hour or even if the door has been left open. In the residence hall, make sure everyone who enters the building at night is a resident [26].

2.4.3 Tracking Assets

University can use extensive wireless coverage with location-based services for device tracking. Attach Bluetooth feeds to projectors, TV screens, laboratory equipment, and vehicles, and specify precise locations on campus. Use geofencing to deliver details if assets move outside a specific area [27].

2.4.4 Tracking People

Human monitoring uses similar concept of asset tracking above. Use a smart campus ID card to track students' locations in buildings during emergency exits. Alternatively, use an appropriate medical alert wrist to alert the student to the exact location with a seizure or other medical emergency [27].

2.5 IoT in Energy Efficiency and Cost Saving

Smart campus objectives are to monitor and manage energy (e.g., electricity, gas), water, and waste management embrace from the fitting of IoT-based services. The observation from environmental surroundings, such as temperature, humidity, pressure, and standard lighting, directly impacts buildings' energy depletion. For instance, smart sensors at campus would control lights and turn them off immediately once there is no motion detected in the rooms and corridors. Furthermore, smart panels will allow individuals to control and monitor utilities, especially on electricity and air-conditioning for the classroom based on the specific class schedule. In conclusion, this smart campus solution will save and sustain energy consumption over time and eventually save much money for the university.

2.6 IoT in Mobile Application

Mobile applications (mobile applications) are application platforms or software applications intended to run on mobile devices such as phones/tablets or smartphones. Applications initially envisaged for support of competencies such as Email, calendar, and contact databases. However, public demand for mobile applications sparked rapid growth in other areas such as mobile games, factory computers, GPS and location-based services, order tracking, and tickets online. So far, there are many applications presented. Mobile users usually downloaded their app from an app distribution platform operated by mobile operating system owners, such as the App Store (iOS) or the Google Play Store [7].

Moreover, the Mobile App can be downloaded on a mobile device and from the mobile app store or the Internet. Additionally, mobile applications that typically assist users by connecting them to Internet services often gain access to desktop or laptop computers or assist them by making it easier to use the Internet on their mobile devices.

Mobile application (App) is a mobile technology that has grown and been widely used all over the world. This innovative mobile artifact resembles the mobile industry's obsolete business model and creates new opportunities in the mobile market.

2.6.1 Smart Attendance System

Captivating attendance is well thought-out the most time overwhelming process, particularly in classes with many students. RFID technology enables programmatic and continuous attendance tracking for students and staff to save time and overwhelmed human miscalculations although recording student attendance [15]. Smart attendance systems, such as exclusively recognize individual students constructed on their unique tag identifiers. With such techniques, the system can generate a report of attendees for a particular course with a data-centric student attendance database system.

2.6.2 QR-Code

The QR code (shortened from the Quick Speed Code) is a feature of the first matrix barcode (or two-dimensional barcode) designed for Japan's automotive industry. Barcode is an optically machine-readable label committed to the material that records the information associated with the item. It has initially been original; however, his former patentee did not choose to exercise that privilege. In recent times, the QR Code system has multiplied outside the remarkable automotive industry for easy-to-readability and greater storage capacity associated with standard UPC barcodes. The code consists of a black module (square dots) arranged in a square grid on a white background [4]. The encoded information can consist of four types of standard ("mode") data (numeric, alphanumeric, byte/binary, kanji) or refine the connection, almost all types of data.

The QR code is conveyed by an imaging device, such as a camera. It is algorithmically configured by the underlying software using Reed-Solomon's inaccuracy to allow the image to be applied as interpreted. The extracted data is from contemporary patterns in both horizontal and vertical components of the image.

2.6.3 Occupancy Detection and Tracking

This service would deliver students a campus map to contribute them direct their way everywhere on campus. For example, the map may show students the least populated areas, nearby canteens, nearby toilets, available library chairs, free laboratory stations, or specific room locations.

2.6.4 Achieve Efficient Parking

Every working day, staffs and visitors occupy an unsatisfying expanse of time to discover an available car parking lot. The use of sensing technology in parking lots and entrances will help staff and visitors find connected parking.

2.7 IoT in Smart Library

Introducing IoT-based smart library system as an aggregate unconventional to available library systems could have an enormous prospective in accumulation more significance to their services and contribution ironic library proficiencies to users. Furthermost, libraries use RFID technology to look after books from being stolen and distribute and return books. Smart libraries can automatically authenticate users, reply to their request for information, dispute and return books, and even locating books using location-based service, for case in point, distributing location specifics on the user's smartphone.

2.8 Recent Smart Campus Frameworks in HEI

Currently, there are no standard elements or components of a smart campus to follows. Each university may have its smart campus initiatives depends on its requirement. For instance, Universiti Tenaga Nasional (UNITEN) has developed a smart campus framework for their university called the 'UNITEN Smart University Framework' [17] to help achieve UNITEN's 2025 Strategic Plan milestones. The framework comprises six main elements: Smart Energy Generation, Smart Energy Management, Smart Mobility, Smart Access and Security, Smart Education, and Smart Connectivity (shown in the Fig. 1).

Fig. 1: UNITEN smart campus concept [17]

The framework's main objective is to improve campus life using smart technologies to integrate multiple application platforms towards convenient and healthy students' lifestyles. The framework starts with mobile apps development for bus schedules, available parking spaces, and an interactive campus map of the nearest food location on offer at nearby cafes and restaurants. Furthermore, they plan to have a cashless campus initiative throughout the campus.

Similarly, with UNITEN, Universiti Malaya (UM) has established its smart campus initiatives to support and create a conductive integrated platform/environment based on the UM ECO Campus blueprint's core areas. The UM smart campus concept (UM smart, sustainable campus) [18] has started in 2004, focusing on converting the standalone system to a web-based application. Some of the first phase initiatives include the UM Mobile Apps, Vehicle Tracking, and QR code Attendance, primarily moving towards the Big Data, Machine Learning, Predictive Monitoring, and Artificial Intelligence initiatives (as shown in Fig. 2 below).

Fig. 2: UM smart campus concept [18]

2.9 Summary

Based on a thorough literature review study from multiple publications such as journals, articles, proceedings, and websites related to smart campus, several elements and applications can be the layout for selection and further analyses (as shown in Table 1 below). There are five elements and applications that have been selected to evaluate which of the application have a higher impact to focus on for the smart campus development.

Table 1: Demographic Study on Student's Academic Background

Elements	Applications	Citation
• Smart Learning • Smart Classroom • Smart Laboratories • Smart Libraries	• Cloud-based Education • Distance Learning • Online Integrated Information • Research Collaboration Interactive Cloud Sharing Platform • Separate Online Platform between Students and Lecturers • Online Appointments between Students and Lecturers • Virtual Reality Application	[29], [44], [32], [1], [16], [20], [12], [82] , [90], [92], [30], [23], [6], [31], [32], [33], [34], [35], [36], [37], [38], [39], [40], [41], [42], [43], [44].
Smart Card	• Door access for lecture rooms, offices and libraries • eWallet • Library Book Loan System • Attendance records	[45], [46], [47], [48], [4], [49], [15], [50], [51]
Smart Sensor	Video Surveillance: • Vehicles monitoring – Number Plate Recognition • Human monitoring – Face Recognition	[22], [52], [53], [54], [55], [56], [57], [58], [59], [60], [61], [62], [63], [64], [65], [66]
Smart Energy	• Energy Sustainability • Energy Management System • Smart Streets Lights • Maintenance Automation Control • Electric bicycles	[8], [3], [13], [68], [69], [71], [72], [73], [74], [75], [76], [67], [77], [78], [79], [80], [81], [42], [82], [83], [84], [85], [86]
Smart Apps	• Smart Attendance System • QR-Code • Occupancy Detection and Tracking • Achieve Efficient Parking	[7], [87], [88], [15], [4], [50], [89], [79], [38], [92], [93], [94], [95], [96], [97], [98], [99], [100], [44], [101], [4], [102], [103], [104], [105], [106], [107]

Elements	Applications	Citation
• Smart Learning • Smart Classroom • Smart Laboratories • Smart Libraries	• Cloud-based Education • Distance Learning • Online Integrated Information • Research Collaboration Interactive Cloud Sharing Platform • Separate Online Platform between Students and Lecturers • Online Appointments between Students and Lecturers • Virtual Reality Application	[29], [44], [32], [1], [16], [20], [12], [82] , [90], [92], [30], [23], [6], [31], [32], [33], [34], [35], [36], [37], [38], [39], [40], [41], [42], [43], [44].
Smart Card	• Door access for lecture rooms, offices and libraries • eWallet • Library Book Loan System • Attendance records	[45], [46], [47], [48], [4], [49], [15], [50], [51]
Smart Sensor	Video Surveillance: • Vehicles monitoring – Number Plate Recognition • Human monitoring – Face Recognition	[22], [52], [53], [54], [55], [56], [57], [58], [59], [60], [61], [62], [63], [64], [65], [66]
Smart Energy	• Energy Sustainability • Energy Management System • Smart Streets Lights	[8], [3], [13], [68], [69], [71], [72], [73], [74], [75], [76], [67], [77], [78], [79], [80],

	• Maintenance Automation Control • Electric bicycles	[81], [42], [82], [83], [84], [85], [86]
Smart Apps	• Smart Attendance System • QR-Code • Occupancy Detection and Tracking • Achieve Efficient Parking	[7], [87], [88], [15], [4], [50], [89], [79], [38], [92], [93], [94], [95], [96], [97], [98], [99], [100], [44], [101], [4], [102], [103], [104], [105], [106], [107]

3.0 METHODOLOGY

This paper adopts a quantitative method from a survey conducted on public university students. The quantitative data are then analyzed using the Statistic Packages for Social Sciences (SPSS) tool for descriptive statistics and analysis, including frequency, standard deviation, and mean.

Students can access the smart campus survey (voluntary sampling) using Google Docs. The survey was published online for two weeks starting from 4th November 2020 to 18th November 2020. The total number of students is around 3000, and about 912 students have responded to the survey. The participants are ranging from Foundation, Diploma, and Degree students. To ensure a fair number of students participate in the survey, the student academic advisor has helped promote this survey to their respective faculties and academic centers.

Altogether there are 15 questions asked. Questions 1-4 on the academic information of the student. The rest of the questions are about their understanding and opinion on Smart Campus. Part of the survey questions are on a four-point scale. The scale starts with 1 for Completely Disagree to Scale 4 for Totally Agree.

3.1 Relative Important Index (RII) Analysis

The Relative Importance Index formula is as below:

$$\frac{\sum w}{AN} = \frac{4n_4 + \ 3n_3 + \ 2n_2\ 1n_1}{4N} \tag{1}$$

Where:

w – is the weight given to each factor by the students (in this case ranging from 1 to 4)
N - is the total number of students (in this case is 912)
A – Highest weight (in this case is 4)

4.0 RESULTS AND DISCUSSION

This section shares the data gathered from the survey and then discussed the outcomes related to the research questions poses earlier.

4.1 Demographic Analysis

In this section, the students' academic background is captured. There are three (3) questions to study the students' demographics details. The three questions are as follows:

- What is the student’s level of study/studied?
- Which Faculty/Centre are studying/studied?
- What is the student’s year of study?

Table 2 contains all the demographics details from the questions above. Based on Table 2, it can be concluded that more than half of the total number of students, which are 624 students (69%), were from the Degree Programme, follows by Foundation Programme with 164 students (18%) and Diploma 95 students (10%). While the rest of the students are from the Master program, with ten students (1%), nine students (1%) are alumni, seven students (1%)

leave the answer blank. The least number of respondents are from the Ph.D. program, with only three students. This outcome is expected as the number of students enrolled in a degree program are higher than for foundation and diploma.

Meanwhile, Table 2 shows the number of students according to their year of study/studied. It is interesting to see the number of students from each year of studies are quite similar and not too far off each other. Most of the students are from the first year, with 200 students (22%) and 197 students from the second year (22%). Besides, 183 students (20%) are third-year students, 160 students (17%) in their fourth year, and 157 students (17%) are from the foundation. While the small number of students are in their fifth year, with only eight students (1%) and six students (1%) leave the answer blank.

On the other hand, as seen in Table 2, the majority of the students are from faculty of studies and management (213 students), follows closely by students from faculty of science and technology (209 students) and faculty of engineering (203 students). Moreover, 137 students were from foundation center, 62 students from agility academy, 61 students from other faculty/center, and 5 students from graduate school, which are reasonable as the number of students enrolled in these faculties/centers is fewer than other main faculties (studies and management, engineering, science and technology, and medicine and health). In the survey, only 19 students are from the faculty of medicine and health. This presumably because their students are busier than the students in other programs. Furthermore, they did not find the survey interesting to participants as it is not under their study area.

4.2 Research Question

<u>What is the student's perception of implementing smart campus applications in the HEI?</u>

In this section, through a thorough literature survey in Literature Review, we selected the five (5) common smart campus elements: smart card, smart classroom, smart energy, smart sensor, and smart learning. Each of these elements has its application. Therefore, there are eighteen (18) applications for the student to rate. This question aims to determine which application the student thought is most important in the university.
The survey uses a four-point Likert scale [29]. Scale 1 is for Not Important, and Scale 4 is for Very Important. The four scale options were as follows (Not Important, Slightly Important, Important, and Very Important). The responses from each application are collected and analyzed using the Relative Importance Index (RII). Finally, all these applications are placed in a group table to determine their ranking based on RII value.

Question A: In your opinion, how important is the use of Smart cards for the following scenario?

In this question, the students were asked to rate the importance of smart cards used in the following applications:

A1. Attendance records for lectures, exams, official university events, etc.

A2. Book loan system in the library.

A3. Access to lecture rooms, offices, libraries, etc.

A4. Cashless payment transaction for foods, feeds, bookstores, etc.

The results are shown in the Table 3 below. Based on the results below, the students have decided that smart cards should capture attendance records for lectures, exams, official university events, etc., which rank first with the RII of 0.8136. The second place is to use a smart card for library book loan system with a 0.8128 RII value that is not too far behind the first rank. Next, with an RII value of 0.7744, smart card usage to access lecture rooms, offices, libraries came third. Finally, the smart card for cashless payment transactions came last with an RII value of 0.7664, which showed that this application should be the least priority for smart campus development; presumably, the students prefer other alternative payment modes.

Table 3: RII calculations for Question A.

App.	**No. of Responses**				**Weighted total**	**RII**
	1	*2*	*3*	*4*		
A1	20	65	490	337	2968	0.8136
A2	7	48	566	291	2965	0.8128
A3	18	102	565	227	2825	0.7744
A4	44	128	464	276	2796	0.7664

Table 2: Demographic Study on Student's Academic Background

Faculty	**Programme**	**Year**							
		Foundation	***1***	***2***	***3***	***4***	***5***	***Blanks***	**Total**
Fitness Academy	Diploma	0	14	28	18	1	0	0	61
	Degree	0	0	0	1	0	0	0	1
Engineering	Foundation	15	1	0	0	0	0	0	16
	Degree	0	53	52	35	47	0	0	187
Studies and Management	Foundation	9	0	0	0	0	0	0	9
	Diploma	0	2	6	10	0	1	1	20
	Degree	0	19	22	31	102	0	0	174
	Master	0	1	0	0	0	0	0	1
	PhD	0	0	1	1	0	0	0	2
	Alumni	0	0	0	1	0	1	2	4
	Blanks	0	0	1	2	0	0	0	3
Medicine and Health	Degree	0	2	3	6	6	0	0	17
	Master	0	0	0	0	0	1	0	1
	PhD	0	0	0	0	0	1	0	1
	Foundation	2	0	0	0	0	0	0	2
Science and Technology	Degree	1	83	50	61	2	3	0	200
	Master	0	1	1	1	0	0	0	3
	Alumni	0	0	0	3	0	0	1	4
Others	Foundation	4	1	0	0	0	0	0	5
	Diploma	0	5	6	0	0	0	0	11
	Degree	0	11	21	12	0	0	0	44
	Master	0	1	0	0	0	0	0	1
Foundation Center	Foundation	125	4	2	0	0	0	1	132
	Diploma	2	0	0	0	0	0	0	2
	Degree	1	0	0	0	0	0	0	1
	Alumni	0	0	0	0	0	1	0	1
	Blanks	1	0	0	0	0	0	0	1
Graduate School	Diploma	0	1	0	0	0	0	0	1
	Master	0	1	3	0	0	0	0	4
Blanks	Blanks	0	0	1	1	0	0	1	3
								All Total	912

Question B: In your opinion, what is the level of importance of Smart Classroom for the following scenario?

Next, the students were asked to rate the importance of setting up a smart classroom for the following application:

B1. Research Collaboration for discussion, presentation, sharing ideas and knowledge between universities, companies, and other research agencies.

B2. Interactive cloud sharing platform between students and lecturers.

B3. Distance learning, e.g., online teaching and learning materials, teleconferencing, cloud storage, and online courses.

B4. Virtual reality application facility in the computer lab.

The results in the Table 4 below show the response rate for each application in the smart classroom element. The results can be seen with an RII value of 0.8259, and most students agree that smart classrooms should be implemented for research collaboration purposes. The second application that was voted most influential in implementing the smart classroom is the interactive cloud sharing platform with an RII of 0.8218. The distance learning application came third with 0.8194 RII value and in the last place is the virtual reality application with RII of 0.7908 which has been voted as the least essential application to be implemented with smart classroom initiative.

Table 4: RII calculations for Question B.

App.	**Number of Responses**				**Weighted total**	**RII**
	1	***2***	***3***	***4***		
B1	6	36	545	325	3013	0.8259
B2	2	47	550	313	2998	0.8218
B3	17	58	492	345	2989	0.8194
B4	14	78	565	255	2885	0.7908

Question C: In your opinion, what is the level of importance of Smart Energy for the following scenario?

In this question, the students were asked which application in the Smart Energy element is most important. The four applications are as follows:

C1. Energy sustainability, e.g., solar energy, building design, and carbon capture storage

C2. Development of energy management system, e.g., automated monitoring for air conditioning, lights, and devices

C3. Smart streetlights. Only switch on when insufficient lighting.

C4. Electric bicycles on campus for the short-distance journey.

As shown in the Table 5 below, based on the student's feedback, the energy sustainability application is the most important in the smart energy element, with an RII value of 0.8344. The second application to be priorities is to develop the energy management system with a 0.8325 RII value. Next is the 'Smart Streets Lights', which came in third with an RII value of 0.3237, and the least priority application is the use of electric bicycles with only 0.7725 RII value.

Table 5: RII calculations for Question C.

App.	**Number of Responses**				**Weighted total**	**RII**
	1	***2***	***3***	***4***		
C1	5	41	507	359	3044	0.8344
C2	4	30	539	339	3037	0.8325
C3	7	56	510	339	3005	0.8237
C4	40	163	384	325	2818	0.7725

Question D: In your opinion, what is the level of importance of Smart Sensor for the following scenario?

The next question is to determine the level of importance of the Smart Sensor application from the student's perspective. There two applications are as follows:

D1. Monitor and track the movement of vehicles in/out of campus using number plate recognition

D2. Monitor and tracking the staff/students/visitor's location within the campus through university CCTV footage using face recognition

Table 6: RII calculations for Question D.

App.	**Number of Responses**				**Weighted total**	**RII**
	1	***2***	***3***	***4***		
D1	17	110	465	320	2912	0.7982
D2	23	107	521	261	2844	0.7796

The outcome from the student’s feedback in Table 6 above shown that to monitor vehicles' movement in/out of campus using number plate recognition is the priority in the smart sensor element with a 0.7982 RII value. Meanwhile, the application on monitoring the movement of staff/students/visitors within the campus through university CCTV footage using face recognition with an RII value of 0.7796 is the least priority.

Question E: In your opinion, what is the level of importance of Smart Learning for the following scenario?

The next question is on the level of importance in each application of the smart learning element. The four application are as follows:

E1. All lecture notes and teaching materials can be accessed through the Internet (cloud-based)

E2. Online integrated information system for course registration, exam schedule, grade review, counselling, appointment, and workflow.

E3. Separate online platform for determining and discussing course content between students and lecturers

E4. Make online appointments between lecturers and students.

The results in Table 7 below show the student's feedback on the importance of applying the smart learning element. The students have decided that applying all lecture notes and teaching material through the Internet is the most important with an RII value of 0.8539. Next, in second place, is the online integrated information system for course registration, exam schedule, and RII of 0.8322. The third place is to separate online platforms from determining and discussing course content between students and lecturers with an RII of 0.8120. The last place decided as the least priority with 0.7988 RII value is making online appointments between lecturers and students.

Table 7: RII calculations for Question E.

App.	**Number of Responses**				**Weighted total**	**RII**
	1	***2***	***3***	***4***		
E1	3	28	468	413	3115	0.8539
E2	5	23	551	333	3036	0.8322
E3	9	47	565	291	2962	0.8120
E4	14	85	522	291	2914	0.7988

Conclusions: As for the conclusion, the Table 8 shows the compilation of all applications from every element. The applications are sorted in descending order from highest RII values (most important) to the lowest RII values (least Important). The impact level of each application is measured using the Akadiri algorithm [14], as shown in Table 9.

Table 8: RII values for all applications with impact level

No	Element	Application	RII	Impact Level
1	Smart Learning	All lecture notes and teaching materials can be accessed through the Internet (cloud-based)	0.8539	H
2	Smart Energy	Energy Sustainability (Solar Energy, Building Design, Carbon Capture Storage)	0.8344	H
3	Smart Energy	Development of Energy Management System (Automated Monitoring: Air Conditioning, Lights, Devices)	0.8325	H
4	Smart Learning	Online integrated information system (course registration, exam schedule, grade review, counseling appointment, workflow)	0.8322	H
5	Smart Classroom	Research Collaboration (communication and interaction between universities, companies, and other agencies for research purposes)	0.8259	H
6	Smart Energy	'Smart Street Lights'	0.8237	H
7	Smart Classroom	Interactive Cloud Sharing platform between friends and lecturers	0.8218	H
8	Smart Classroom	Distance learning (Online teaching and learning materials, Teleconferencing, Cloud Storage, online courses, etc.)	0.8194	H
9	Smart Card	Attendance records at lectures, examinations, and official university events	0.8136	H
10	Smart Card	Library Book Loan System	0.8128	H
11	Smart Learning	Separate online platform for determining and discussing course content between students and lecturers	0.8120	H
12	Smart Learning	Make online appointments between lecturers and students	0.7988	H-M
13	Smart Sensor	Monitoring the movement of vehicles in/out of campus (Number Plate Recognition)	0.7982	H-M
14	Smart Classroom	Virtual Reality application facility in the laboratory	0.7908	H-M
15	Smart Sensor	Monitoring the movement of staff/students/visitors within the campus through university CCTV footage (Face Recognition)	0.7796	H-M
16	Smart Card	As the access to lecture rooms, offices, libraries	0.7744	H-M
17	Smart Energy	Use of electric bicycles on campus	0.7725	H-M
18	Smart Card	As an eWallet function to pay for food, fees, bookstores, and other cashless transactions on campus	0.7664	H-M

Table 9: The impact level based on RII value

Range of RII values	Impact Level
0.8 <= RII <= 1	High (H)
0.6 <= RII <= 0.8	High-Medium (H-M)
0.4 <= RII <= 0.6	Medium (M)
0.2 <= RII <= 0.4	Medium-Low (M-L)
0 <= RII <= 0.2	Low (L)

Based on the Table 8, the students have chosen 11 applications to be high impact and are most important in implementing the smart campus. As expected, students have decided smart learning (rank 1) is the most crucial element of a smart campus. Presumably, this is because the students are from the academic background. The least important element is the smart card for e-Wallet features. The table also shows that from the 11 high-impact applications: three applications are from smart learning element, three applications are from smart energy element, three applications are from smart classroom element, and two applications are from smart card element. Interestingly, the students not only choose the application focuses on academic to be high impact; the application under the smart energy element is also essential (rank 2 and 3).

5.0 CONCLUSION AND FUTURE WORKS

This research paper focuses on the evaluation of student's perception on the implementation of smart campus applications in HEI. The results shown that the students have decided smart learning is the most important element of a smart campus. The least important element is the smart card for e-Wallet application. As for the future work, staff and lecturers should be considered to take part in this study for achieve the overall respondents. Furthermore, the outcome from this study can be used to define the smart campus concept for higher education institutions.

REFERENCES

[1] A. Abuarqoub, H. Abusaimeh, M. Hammoudeh, D. Uliyah, M. Abuhashim, S. Murad, M. Al-Jarrah, F. Al-Fayez, "A Survey on Internet of Things Enabled Smart Campus," in 2017 IEEE International Conference on Future Networks and Distributed Systems (ICFNDS'17), 1–7, 2017, https://doi.org/10.1145/3102304.3109810.

[2] C. Ziguras, S-F. Law, "Recruiting international students as skilled migrants: the global 'skills race' as viewed from Australia and Malaysia," Globalisation, Societies and Education, 4:1, 59–76, 2006, doi: 10.1080/14767720600555087.

[3] F. Folianto, Y. S. Low, W. L. Yeow, "Smartbin: Smart waste management system," in 2015 IEEE 10th International Conference on Intelligent Sensors, Sensor Networks and Information Processing (ISSNIP), 1–2, 2015, https://doi.org/10.1109/ISSNIP.2015.7106974.

[4] F. Masalha, N. Hirzallah, "A Students Attendance System Using QR Code," International Journal of Advanced Computer Science and Applications, 5:3, 75–79, 2014, https://doi.org/10.14569/ijacsa.2014.050310.

[5] H. Aldowah, S. UI Rehman, S. Ghazal, I. Naufal Umar, "Internet of Things in Higher Education: A Study on Future Learning," Journal of Physics: Conference Series, 892, 2017, https://doi.org/10.1088/1742-6596/892/1/012017.

[6] H. Bargaoui, R. Bdiwi, , "Smart classroom: Design of a gateway for ubiquitous classroom," in 2014 International Conference on Web and Open Access to Learning (ICWOAL), 1–4, 2015, https://doi.org/10.1109/ICWOAL.2014.7009206.

[7] H-Y. Wang, C. Liao, L-H. Yang, "What Affects Mobile Application Use? The Roles of Consumption Values," International Journal of Marketing Studies, 5:2, 11–22, 2013, https://doi.org/10.5539/ijms.v5n2p11.

[8] K.H. Yap, Achieving Sustainable Campus in Malaysia University, Masters Thesis, Universiti Teknologi Malaysia, 2011.

[9] L. Kwok, “A vision for the development of i-campus” Smart Learning Environments, 2:2, 1–12, 2015, doi: https://doi.org/10.1186/s40561-015-0009-8.

[10] M. R. Veeramanickam, M. Mohanapriya, “IoT enabled Futures Smart Campus with effective E-learning,” International Journal of Engineering Technology, 3:4, 81–87, 2014, https://doi.org/10.5176/2251-3701.

[11] M. Sari, P. Ciptadi, R. Hardyanto, “Study of Smart Campus Development Using Internet of Things Technology,” IOP Conference Series: Materials Science and Engineering, 190, 1–5, 2017, doi: 10.1088/1757-899X/190/1/012032.

[12] N. Aion, L. Helmandollar, M. Wang, J.W.P. Ng, “Intelligent campus (iCampus) impact study” in Proceedings 2012 IEEE/WIC/ACM International Conference on Web Intelligence and Intelligent Agent Technology Workshops (WI-IAT), 1–6, 2012, https://doi.org/10.1109/WI-IAT.2012.261.

[13] N. Sharma, N. Singha, T. Dutta, “Smart Bin Implementation for Smart Cities,” International Journal of Scientific & Engineering Research, 6:9, 787–791, 2015, ISSN 2229-5518.

[14] O. Akadiri, Development of a Multi-Criteria Approach for the Selection of Sustainable Materials for Building Projects, Ph. D Thesis, University of Wolverhampton, 2011.

[15] P. Sahare, P. Gaikwad, S. Narule, N. Thakre, P. Chandekar, “RFID Technology Based Attendance Management System,” International Journal Of Engineering and Computer Science, 6:3, 2017, https://doi.org/10.18535/ijecs/v6i3.10.

[16] S. Kim, Y. Yoon, “Multimedia collaborative adaptation middleware for personalization E-learning,” in 2009 IEEE International Symposium on Collaborative Technologies and Systems (CTS2009), 558–564, 2009, https://doi.org/10.1109/CTS.2009.5067527.

[17] Universiti Tenaga Nasional (UNITEN), 2020 SMART UNIVERCITY, https://www.uniten.edu.my/research/smart-univercity/(accessed: 2021)

[18] University of Malaya (UM), 2020 SMART CAMPUS @ UM, https://ptm.um.edu.my/smart-campus-um (accessed: 2021)

[19] X. Wei, “Preminary Study of management Information Planning in Digital Campus Construction,” Procedia Engineering, 15, 505–509, 2011, https://doi.org/10.1016/j.proeng.2011.08.096.

[20] Z. Cheng, S. Sun, M. Kansen, T. Huang, A. H. Tsuruga, “A personalized ubiquitous education support environment by comparing learning instructional requirement with learner’s behavior,” in Proceedings 2005 International Conference on Advanced Information Networking and Applications (AINA), 567–573, 2015, https://doi.org/10.1109/AINA.2005.46.

[21] Z. Zhou, S. Zhong, M. Zhou, X. Quan, Y. Sun, “Notice of Retraction: Primary and secondary school-based on management of Digital Campus,” in 2011 2nd International Conference on Artificial Intelligence, Management Science and Electronic Commerce (AIMSEC), 4702–4705, 2011, doi: 10.1109/AIMSEC.2011.6010515.

[22] K. Abas, K. Obraczka, K, L. Miller, “Solar-powered, wireless smart camera network: An IoT solution for outdoor video monitoring”, Computer Communications, 2018, https://doi.org/10.1016/j.comcom.2018.01.007.

[23] N. Gligorić, A. Uzelac, S. Krco, “Smart classroom: Real-time feedback on lecture quality”. 2012 IEEE International Conference on Pervasive Computing and Communications Workshops, PERCOM Workshops 2012, https://doi.org/10.1109/PerComW.2012.6197517

[24] Adhav, Deepak & Pagar, Rahul & Tawade, Ravi. (2019). Smart Laboratory. International Journal of Trend in Scientific Research and Development. Volume-3. 504-509. 10.31142/ijtsrd22840.

[25] Aluri, Diamond Celestine. (2020). Smart Lock Systems: An Overview. International Journal of Computer Applications. 177. 40-43. 10.5120/ijca2020919882.

[26] Alghamdi, Abdullah & Thanoon, Mohammed & Alsulami, Anwar. (2019). Toward a Smart Campus Using IoT: Framework for Safety and Security System on a University Campus. Advances in Science, Technology and Engineering Systems Journal. 4. 10.25046/aj040512.

[27] G. Ikrissi, Mazri, Tomader. (2020). A STUDY OF SMART CAMPUS ENVIRONMENT AND ITS SECURITY ATTACKS. ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. XLIV-4/W3-2020. 255-261. 10.5194/isprs-archives-XLIV-4-W3-2020-255-2020.

[28] Joshi, Ankur & Kale, Saket & Chandel, Satish & Pal, Dinesh. (2015). Likert Scale: Explored and Explained. British Journal of Applied Science & Technology. 7. 396-403. 10.9734/BJAST/2015/14975.

[29] Wilson, Charlie & Hargreaves, Tom & Hauxwell-Baldwin, Richard. (2014). Smart homes and their users: A systematic analysis and key challenges. Personal and Ubiquitous Computing. 19. 463-476. 10.1007/s00779-014-0813-0.

[30] A. Hossain Masud, X. Huang, ―An E-learning System Architecture based on Cloud Computing‖, World Academy of Science, Engineering and Technology, Vol: 62, 2012.

[31] B. Li, S.C. Kong, G. Chen. (2015). Development and validation of the smart classroom inventory. *Smart Learning Environments*. https://doi.org/10.1186/s40561-015-0012-0

[32] G. Carutasu, M. Pirnau. (2017). FACILITIES AND CHANGES IN THE EDUCATIONAL PROCESS WHEN USING OFFICE365. *Journal of Information Systems & Operations Management*.

[33] S. Song, X. Zhong, H. Li, J. Du, F. Nie. (2014). Smart classroom: From conceptualization to construction. *Proceedings - 2014 International Conference on Intelligent Environments, IE 2014*. https://doi.org/10.1109/IE.2014.56

[34] E. K. F. Chan, M. A. Othman, M. A. Abdul Razak. (2017). IoT based smart classroom system. *2018 International Conference on Advances in Computing, Communications and Informatics (ICACCI)*.

[35] Z. Wang, Smart spaces: Creating new instructional space with smart classroom technology. 2008. *New Library World*. https://doi.org/10.1108/03074800810857603

[36] Yau, Gupta, Karim, S. Wang. (2003). Smart classroom: Enhancing collaborative learning using pervasive computing technology. *II American Society …*. https://doi.org/10.1.1.1.7561

[37] A. Atabekov, (2016). Internet of things-based smart classroom environment. *Proceedings of the 31st Annual ACM Symposium on Applied Computing, SAC '16*. https://doi.org/10.1145/2851613.2852011

[38] A. Zhamanov, Z. Sakhiyeva, R. Suliyev, Z. Kaldykulova. (2018). IoT smart campus review and implementation of IoT applications into education process of university. *2017 13th International Conference on Electronics, Computer and Computation, ICECCO 2017*. https://doi.org/10.1109/ICECCO.2017.8333334

[39] V. Chichernea, D. Smedescu. (2016). CAMPUS INFORMATION SYSTEMS FOR ENHANCING QUALITY AND PERFORMANCE IN A SMART CITY HIGH EDUCATION ENVIRONMENT. *The International Scientific Conference ELearning and Software for Education*. https://doi.org/http://dx.doi.org/10.12753/2066-026X-16-007

[40] L. Chamba-Eras, J. Aguilar. (2017). Augmented Reality in a Smart Classroom - Case Study: SaCI. *Revista Iberoamericana de Tecnologias Del Aprendizaje*. https://doi.org/10.1109/RITA.2017.2776419

[41] K. Zhu (2016). Virtual reality and augmented reality for education. *SIGGRAPH ASIA 2016 Symposium on Education: Talks, SA '16* https://doi.org/10.1145/2993363.3006041

[42] E. De Angelis, A.L.C. Ciribini, L.C. Tagliabue, M. Paneroni. (2015). The Brescia Smart Campus Demonstrator. Renovation toward a zero Energy Classroom Building. *Procedia Engineering*. https://doi.org/10.1016/j.proeng.2015.08.508

[43] C. Le Thanh Man, M. Kayashima. (2011). Virtual machine placement algorithm for virtualized desktop infrastructure. *CCIS2011 - Proceedings: 2011 IEEE International Conference on Cloud Computing and Intelligence Systems*. https://doi.org/10.1109/CCIS.2011.6045085

[44] B. Hirsch, J.W.P. Ng. (2011). Education Beyond the Cloud: Anytime-anywhere learning in a smart campus environment. *6th International Conference on Internet Technology and Secured Transactions*, 718–723. Retrieved from http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6148426&isnumber=614834

[45] J. Murphy, R. Lee, E. Swinger. (2011). Student Perceptions and Adoption of University Smart Card Systems. *International Journal of Technology and Human Interaction*. https://doi.org/10.4018/jthi.2011070101

[46] A.M Nair, J.P. George. (2019). Cashless campus - An interoperable electronic fare management standard for college campuses. *AIP Conference Proceedings*. https://doi.org/10.1063/1.5092939

[47] A. Paterson. (2009). Smart and smarter: Exeter university library and the implementation of a campus-wide card. *New Review of Information Networking, 3*(1), 13–22. https://doi.org/10.1080/13614579709516892

[48] Y. Khamayseh, W. Mardini, S. Aljawarneh, M.B. Yassein. (2014). Integration of Wireless Technologies in Smart University Campus Environment. *International Journal of Information and Communication Technology Education*. https://doi.org/10.4018/ijicte.2015010104

[49] H. El. Mrabet, A.A. Moussa (2017). Research and design of smart management system in classroom. *Proceedings of the Mediterranean Symposium on Smart City Application, SCAMS '17*. https://doi.org/10.1145/3175628.3175645

[50] Y.K. Hooi, K. Shafee Kalid, & S. Tachmammedov. (2018). MULTI-FACTOR ATTENDANCE AUTHENTICATION SYSTEM. *International Journal of Software Engineering and Computer Systems*. https://doi.org/10.15282/ijsecs.4.2.2018.5.0049

[51] KUMARI, NEETU (Department of Commerce, U. C., Jammu, U. of, Udhampur, 182101, I., KHANNA, JHANVI (Department of Commerce, U. C., Jammu, U. of, & Udhampur, 182101, I. (2017). CASHLESS PAYMENT: A BEHAVIOURIAL CHANGE TO ECONOMIC GROWTH. *Вестник Росздравнадзора*.

[52] X.P. Wang. (2011). Application of IOT Technologies in Campus Security System. *Advanced Materials Research*. https://doi.org/10.4028/www.scientific.net/amr.268-270.1884

[53] H. Xu, J. Tay, A. Malik, S. Afzal, D.S Ebert. (2015). Safety in view: A public safety visual analytics tool based on CCTV camera angles of view. *2015 IEEE International Symposium on Technologies for Homeland Security, HST 2015*. https://doi.org/10.1109/THS.2015.7225333

[54] C. Patel, D. Shah, A. Patel. (2013). Automatic Number Plate Recognition System (ANPR): A Survey. *International Journal of Computer Applications*. https://doi.org/10.5120/11871-7665

[55] M.Y. Aalsalem, W.Z. Khan. (2017). CampusSense - A smart vehicle parking monitoring and management system using ANPR cameras and android phones. *International Conference on Advanced Communication Technology, ICACT*. https://doi.org/10.23919/ICACT.2017.7890230

[56] H. Im, B. Hong, S. Jeon, J. Hong. (2016). Bigdata analytics on CCTV images for collecting traffic information. *2016 International Conference on Big Data and Smart Computing, BigComp 2016*. https://doi.org/10.1109/BIGCOMP.2016.7425985

[57] A.D, A. V. N. P. (2016). Smart CCTV Camera Surveillance System. *International Journal of Science and Research (IJSR)*.

[58] C. Held, J. Krumm, P. Markel, R.P. Schenke. (2012). Intelligent video surveillance. *Computer*. https://doi.org/10.1109/MC.2012.97

[59] A. Nurhopipah, A. Harjoko. (2018). Motion Detection and Face Recognition for CCTV Surveillance System. *IJCCS (Indonesian Journal of Computing and Cybernetics Systems)*. https://doi.org/10.22146/ijccs.18198

[60] A. Rego, A. Canovas, J.M. Jimenez, J. Lloret. (2018). An Intelligent System for Video Surveillance in IoT Environments. *IEEE Access*. https://doi.org/10.1109/ACCESS.2018.28420

[61] V.C. Banu, I.M. Costea, F.C. Nemtanu, I, Bădescu. (2017). Intelligent video surveillance system. *2017 IEEE 23rd International Symposium for Design and Technology in Electronic Packaging, SIITME 2017 - Proceedings*. https://doi.org/10.1109/SIITME.2017.8259891

[62] S.N. Jyothi, K.V. Vardhan. (2016). Design and implementation of real time security surveillance system using IoT. *Proceedings of the International Conference on Communication and Electronics Systems, ICCES 2016*. https://doi.org/10.1109/CESYS.2016.7890003

[63] A. Costin. (2016). Security of CCTV and Video Surveillance Systems: Threats, Vulnerabilities, Attacks, and Mitigations. *TrustED '16- Proceedings of the 6th International Workshop on Trustworthy Embedded Devices*. https://doi.org/10.1145/2995289.2995290

[64] H. Pinggui, C. Xiuqing. (2017). Design and Implementation of Campus Security System Based on Internet of Things. *Proceedings - 2017 International Conference on Robots and Intelligent System, ICRIS 2017*. https://doi.org/10.1109/ICRIS.2017.28

[65] Barbu, T., Biale, N., Coordinator, A., Technology, A., Program, L., Braje, W., … Wei, H. (2010). FaceIt will Enhance & Compliment your CCTV Surveillance System ! FaceIt Surveillance can Automatically …. *ReVision*. https://doi.org/10.1007/978-3-319-00566-9_25

[66] N.A. Abdullah, M.J. Saidi, N.H.A. Rahman, C.C. Wen, I.R.A. Hamid. (2017). Face recognition for criminal identification: An implementation of principal component analysis for face recognition. *AIP Conference Proceedings*. https://doi.org/10.1063/1.5005335

[67] Ravesteyn, P., Plessius, H., & Mens, J. (2014). Smart Green Campus: How IT can Support Sustainability in Higher Education. *Proceedings of the 10th European Conference on Management Leadership and Governance (Ecmlg 2014)*.

[68] J. Pan, R. Jain, S. Paul, T. Vu, A. Saifullah, M. Sha. (2015). An Internet of Things Framework for Smart Energy in Buildings: Designs, Prototype, and Experiments. *IEEE Internet of Things Journal*. https://doi.org/10.1109/JIOT.2015.2413397

[69] R. Hussin, V. Kunjuraman. (2015). Exploring strategies for sustainable 'ecocampus': The experience of University Malaysia Sabah. *Malaysian Journal of SOciety and Space*.

[70] S. Hipwell. (2014). Developing smart campuses-A working model. *Proceedings of 2014 International Conference on Intelligent Green Building and Smart Grid, IGBSG 2014*. https://doi.org/10.1109/IGBSG.2014.6835169

[71] O. Bates, A. Friday. (2017). Beyond Data in the Smart City: Repurposing Existing Campus IoT. *IEEE Pervasive Computing*. https://doi.org/10.1109/MPRV.2017.30

[72] Toward a Green Campus with the Internet of Things - the Application of Lab Management. (2013). *Lecture Notes in Engineering and Computer Science*.

[73] W. Zhang, Y. Wen, Y. W. Wong, K.C. Toh, C.H. Chen. (2016). Towards Joint Optimization over ICT and Cooling Systems in Data Centre: A Survey. *IEEE Communications Surveys and Tutorials*. https://doi.org/10.1109/COMST.2016.2545109

[74] T.G. Stavropoulos, G. Koutitas, D. Vrakas, E. Kontopoulos, I. Vlahavas. (2016). A smart university platform for building energy monitoring and savings. *Journal of Ambient Intelligence and Smart Environments*, *8*(3). https://doi.org/10.3233/AIS-160375

[75] A. Barbato, C. Bolchini, A. Geronazzo, E. Quintarelli, A. Palamarciuc, A. Pitì, … G. Verticale. (2016). Energy optimization and management of demand response interactions in a smart campus. *Energies*, *9*(6). https://doi.org/10.3390/en9060398

[76] A. Gambarotta, M. Morini, M. Rossi, M. Stonfer. (2017). A Library for the Simulation of Smart Energy Systems: The Case of the Campus of the University of Parma. *Energy Procedia*. https://doi.org/10.1016/j.egypro.2017.03.514

[77] D. Van Merode, G. Tabunshchyk, K. Patrakhalko, G. Yuriy. (2016). Flexible technologies for smart campus. *Proceedings of 2016 13th International Conference on Remote Engineering and Virtual Instrumentation, REV 2016*. https://doi.org/10.1109/REV.2016.7444441

[78] Y. Wang, B. Saez, J. Szczechowicz, J. Ruisi, T. Kraft, S. Toscano, … K. Nicolas. (2018). A smart campus internet of things framework. *2017 IEEE 8th Annual Ubiquitous Computing, Electronics and Mobile Communication Conference, UEMCON 2017*. https://doi.org/10.1109/UEMCON.2017.8249106

[79] M. Jain, N. Kaushik, K. Jayavel. (2017). Building automation and energy control using IoT - Smart campus. *Proceedings of the 2017 2nd International Conference on Computing and Communications Technologies, ICCCT 2017*. https://doi.org/10.1109/ICCCT2.2017.7972303

[80] T. Narendrakumar, A.S. Pillai. (2018). Smart connected campus. *2017 International Conference on Intelligent Computing, Instrumentation and Control Technologies, ICICICT 2017*. https://doi.org/10.1109/ICICICT1.2017.8342808

[81] S. Vivek Sathe, P. Manna, A. Developer. (2017). Hyper-Convergence: Revolutionizing The Data Center. *International Journal of Advanced Scientific Technologies in Engineering and Management Sciences*.

[82] P.P. Ray. (2018). A survey on Internet of Things architectures. *Journal of King Saud University - Computer and Information Sciences*, *30*(3), 291–319. https://doi.org/10.1016/J.JKSUCI.2016.10.003

[83] A. Sivanathan, D. Sherratt, H.H. Gharakheili, A. Radford, C. Wijenayake, A. Vishwanath, V. Sivaraman. (2017). Characterizing and classifying IoT traffic in smart cities and campuses. *2017 IEEE Conference on Computer Communications Workshops, INFOCOM WKSHPS 2017*. https://doi.org/10.1109/INFCOMW.2017.8116438

[84] R. Nocerino, A. Colorni, F. Lia, A. Luè. (2016). E-bikes and E-scooters for Smart Logistics: Environmental and Economic Sustainability in Pro-E-bike Italian Pilots. In *Transportation Research Procedia* (Vol. 14, pp. 2362–2371). Elsevier B.V. https://doi.org/10.1016/j.trpro.2016.05.267

[85] T. Jones, L. Harms, E. Heinen. (2016). Motives, perceptions and experiences of electric bicycle owners and implications for health, wellbeing and mobility. *Journal of Transport Geography*, *53*, 41–49. https://doi.org/https://doi.org/10.1016/j.jtrangeo.2016.04.006

[86] R.S. Raja Abdul Aziz, A. Roza, B.M. Adji, M.R. Karim. (2011). Preference of University Students towards Cycling in Campus. Proceedings of Eastern Asia Society for Transportation Studies, 8, 1-10. Doi: doi.org/10.11175/eastpro.2011.0.239.0

[87] Ayob, Noorul & Hussin, Ab & Dahlan, Halina. (2009). Three Layers Design Guideline for Mobile Application. 427 - 431. 10.1109/ICIME.2009.99.

[88] Z. Chen, F. Xia, R. Cheng, J. Kang, C. Li. (2012) Oncampus: A mobile personal assistant for college students. In: ICCE, p 22

[89] C. Heinemann, V.L. Uskov (2018). Smart university: Literature review and creative analysis. In *Smart Innovation, Systems and Technologies* (Vol. 70). https://doi.org/10.1007/978-3-319-59454-5_2

[90] F.A. Yu. (2012). MOBILE/SMART PHONE USE IN HIGHER EDUCATION. *Proceedings of the 2012 Southwest Decision Sciences Institute*.

[91] B. Aditya. (2014). Smart parking. *Happiest Customers Minds*. https://doi.org/10.13140/RG.2.2.18187.28966

[92] N.M. Suki. (2013). Students' dependence on smart phones: The influence of social needs, social influences and convenience. *Campus-Wide Information Systems*. https://doi.org/10.1108/10650741311306309

[93] T.L. Chou, L.J. ChanLin. (2012). Augmented Reality Smartphone Environment Orientation Application: A Case Study of the Fu-Jen University Mobile Campus Touring System. *Procedia - Social and Behavioral Sciences*. https://doi.org/10.1016/j.sbspro.2012.05.132

[94] S. Bhattacharya, M.B. Panbu. (2013). Design and Development of Mobile Campus, an Android based Mobile Application for University Campus Tour Guide. *International Journal of Innovative Technology and Exploring Engineering (IJITEE)*.

[95] T. Arsan. (2016). Smart Systems: From design to implementation of embedded Smart Systems. *13th HONET-ICT International Symposium on Smart MicroGrids for Sustainable Energy Sources Enabled by Photonics and IoT Sensors, HONET-ICT 2016*. https://doi.org/10.1109/HONET.2016.7753420

[96] X. Dong, X. Kong, F. Zhang, Z. Chen, J. Kang. (2016). OnCampus: a mobile platform towards a smart campus. *SpringerPlus*. https://doi.org/10.1186/s40064-016-2608-4

[97] L. Zheng, C. Song, N. Cao, Z. Li, W. Zhou, J. Chen, L. Meng. (2018). A New Mutual Authentication Protocol in Mobile RFID for Smart Campus. *IEEE Access*. https://doi.org/10.1109/ACCESS.2018.2875973

[98] G. Durak, E.E. Ozkeskin, M. Ataizi. (2016). QR codes in education and communication. *Turkish Online Journal of Distance Education*. https://doi.org/10.17718/tojde.89156

[99] N.M.N. Mohammad, M.N. Mamat, P.M. Isa. (2013). M-learning in Malaysia: Challenges and Strategies. *Procedia - Social and Behavioral Sciences*. https://doi.org/10.1016/j.sbspro.2012.11.343

[100] S. Goyal, S. Yadav, M. Mathuria. (2016). Exploring concept of QR code and its benefits in digital education system. *2016 International Conference on Advances in Computing, Communications and Informatics, ICACCI 2016*. https://doi.org/10.1109/ICACCI.2016.7732198

[101] S.N. Abdul Rabu, H. Hussin, B. Bervell. (2019). QR code utilization in a large classroom: Higher education students' initial perceptions. *Education and Information Technologies*. https://doi.org/10.1007/s10639-018-9779-2

[102] H. Susono, T. Shimomura. (2006). Using mobile phones and QR codes for formative class assessment. *Current Developments in Technology-Assisted Education*.

[103] A.M. Abdullah, R. Aziz. (2014). Evaluating the use of quick response (QR) code at Sulaimani University Libraries. *International Journal of Advanced Research in Computer Science and Software Engineering*.

[104] N. N. A. Aziz, Y.M. Mustafah, A.W. Azman, N.A. Zainuddin, M.A. Rashidan. (2015). Features selection for multi-camera tracking. *Proceedings - 5th International Conference on Computer and Communication Engineering: Emerging Technologies via Comp-Unication Convergence, ICCCE 2014*. https://doi.org/10.1109/ICCCE.2014.76

[105] P. Fussey, (2014). Emmeline Taylor, Surveillance Schools: Security, Discipline and Control in Contemporary Education . *Journal of Applied Security Research*. https://doi.org/10.1080/19361610.2014.942832