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Attributes of SMART Education in SMART Cities

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A B S T R A C T

Recent years have seen a surge in research on smart communities and sustainable developments. As the phrase "smart university" draws professionals and researchers from a variety of fields, and because technology continues to infiltrate every area of life, it is inevitable that the Smart university will exist and implement the futuristic vision of smart cities. To begin achieving this goal, it is critical to establish a common understanding of what a smart university is. There is still no consensus on what a Smart university should look like or on the primary components that comprise a Smart institution. Thus, the purpose of this study is to use a set of extensive criteria to ascertain what constitutes a Smart university and to assess these criteria in light of stakeholders' perceptions. The primary criteria are established via a literature study, and four case studies on the American University of Sharjah, Dubai's Hamdan Bin Mohammed Smart University, Mohamed bin Zayed University of Artificial Intelligence, and Abu Dhabi Polytechnic are performed to evaluate the prescribed criteria. This exploratory study analyzes using both qualitative and quantitative techniques, taking into account the perspectives of students, teachers, and information technology service providers. Ultimately, after defining and evaluating the criteria that support the Smart university model, a series of suggestions is made to guide the use of Smart universities in higher education contexts. This study paves the way for future research to acquire a more in-depth understanding of the kind of choices required to convert a conventional university into a Smart university.

1. INTRODUCTION

The higher education environment is at a crossroads due to an unprecedented digital change. Higher education is experiencing complicated upheaval as a result of a shifting student population that is digital native and expects a more seamless experience that promotes good results [1][2]. This is where a smart university, also known as a smart campus, may help to change people's lives [3]. Innovative institutions understand the value of real change via the use of technology that allows smooth, touchless, and seamless experiences powered by a digitalized community [4].

Students are users and customers who have the ability to choose. With social consciousness, today's students make decisions based on reason, value, and experience. As a result, institutions must reconsider their objectives and rethink how they will proceed in the face of technological advances that other industries have already adopted [5][6]. Universities and colleges must adopt intuitive engagement that promotes good results based on creative approaches that use emerging technology to improve the customer experience [7]. Faculty and personnel anticipate a digital environment that enables them to concentrate on meaningful initiatives that serve a real purpose and advance the university's goal. Both of these changes may necessitate institutions being digitally linked [2][8][9].

Smart banking, digital commerce, smart digital

workspaces, and smart venues such as hospitals and venues may all be used to benchmark best practices for higher education institutions. By utilizing the most sophisticated and next-generation capabilities available, these smart spaces provide a simple and stable environment [10][11][12]. More significantly, they are always modernizing and adjusting their procedures to suit their constituents' demands [13]. Universities should use information systems and analytics-based data to improve the well-being of the societies in which they are anchored in order to remain viable and relevant [14][15].

Scholars increasingly realize that higher education institutions are hubs of productivity and that by using smart-university methods, they may enhance the experience of students, professors, administrators, scholars, practitioners, and regions [16]-[20]. The remainder of the paper is structured as follows. The associated technologies in the smart university are evaluated in the Literature Review Section; the research methodology is portrayed in Section 3; the results and section are investigated in Section 4; the recommendations for the smart university are discussed in Section 5, and the paper is concluded in the last section.

2. LITERATURE REVIEW

The literature addresses many qualities that are seen as key enablers of a Smart University. These needs include apps that provide seamless and connected workspaces that are supported by the IoT systems, cloud computing, and big data processing. This section will explore and offer a framework for these requirements.

2.1. Smartcard Implementation

A smart card can be thought of as a little computer fitted with a microcontroller chip for data storage and processing. The smart card enables secure, convenient, and fast accessibility to Smart University facilities [21]-[25]. The scientists of [3] used King Fahd School of Petroleum and Minerals as an example of how a smart card could be utilized on campus to handle a photo ID and a digital billing, as well as to enhance library borrowing privileges, entertainment, health clinic services, e-learning, and regulated access to educational institutions [4][26][27]. Furthermore, Figure 1 highlights many other applications mentioned in the literature [28].

As such, the correct and comprehensive implementation of smartcards allows a smart university to manage and track a large variety of transactions at the student level, and may also be implemented for faculty and staff [29]-[34]. Having access to this level of information is highly beneficial to the smart university in making intelligent decisions and building a useful database.

2.2. Intelligent Classrooms and Laboratories

A smart classroom can be conceived of as a piece of technology that seamlessly combines various technologies with traditional classroom settings [35]-[39]. The smart class concept is based on contemporary technologies including 3G, 4G, and Internet of Things (IoT) systems and utilizes voice recognition, machine learning, and other innovations to create a connected and integrated environment [5][40][41][42]. Furthermore, as illustrated in Fig 1, the literature discusses many applications for smart classroom criteria [43].

It is expected that future laboratories will be equipped with smart labware that may interact with learners proactively via the usage of an IoT-enabled laboratory environment and AI-enabled lab equipment [6][44][45][46]. For example, labware may offer real-time data on students and laboratory operations, as well as aid students in performing labs tasks [47]-[52]. Thus, learners may get a user-friendly experience with human communication through audio, video, and augmented reality, allowing them to concentrate completely on lab activities and obtaining the best possible lab experience [53]-[58]. Furthermore, virtual and remote laboratories will be an economical and efficient method of promoting experience-based learning in subjects with restricted equipment and time limitations [7][59][60]. Innovative laboratory services have the potential to significantly increase laboratory productivity while avoiding potential safety issues [8][61][62].

Therefore, a smart class may be considered key criteria within the context of the Smart University since it enhances the level of learning by making it more participative, cooperative, time effective, user-friendly, and ecologically friendly [63][64].

2.3. Intelligent Energy Management

A criterion for energy management is defined as a framework for planning and optimizing power

consumption via the utilization of local renewable energy sources and battery banks [65]-[70]. The energy management system is linked to data storage and exchange facilities that may be used as network infrastructure for predicting energy use and production [71]-[73]. The proposed approach aims to reduce energy consumption in future Smart Infrastructure by optimizing electric loads while preserving the same level of user comfort [74]-[79]. Figure 1 abridges the uses of the Energy Management System (EMS) infrastructure that may aid in the monitoring of facilities at Smart Institutions [80]-[84].

Energy management is a key component of facility management, which means it must be addressed while transforming a traditional university into a Smart University [10][85]-[90]. The literature supports the idea of smart energy control as a way to optimize resource use at a reduced cost while also being more resilient, monitored, and regulated for efficient management.

2.4. Adaptive Learning

Adaptable education or ubiquitous learning may be defined in a Smart University as an educational method that is built on a computerized mechanism that helps in tailoring the teaching process or learning environment to an individual's needs [91]-[95]. Additionally, it helps learners in identifying themselves within the framework of a Smart University and offers context-sensitive personalized learning and evaluation [11][96][97]. Additionally, [12][98] emphasizes the need to incorporate an Artificial Intelligence (AI) concept into the infrastructure of a traditional institution in order to transform it into a smart campus. As shown in Figure 1, the research focuses on a range of adaptive learning applications [99][100].

As technology progresses and the university transforms into a digitally augmented campus, active learning becomes a crucial requirement for incorporation in the framework of a Smart University, as it enables customization, bolstering students' weaknesses, enhanced visibility of class achievement, precise testing, aiding students, making recommendations, and elective e-learning.

2.5. Smart Transportation

Another valuable addition to the criteria for establishing a Smart University is smart transportation and mobility [101][102]. By optimizing logistics, providing push notifications and live alerts, and additional smart services, the smart university can provide a better experience in all matters related to transportation [103]-[105]. Fig. 1 exemplifies some of the uses stated in the literature.

2.6. Cybersecurity

The privacy and safety standards contribute to enhanced protection by utilizing the perception of Root Cause Analysis (RCA), a methodical approach for detecting the "root cause" of an issue and preventing its recurrence [106-[111]. Additionally, Heinemann recommends that a Smart Campus use recognized data networking crisis monitoring to enable the fast reaction to IoT-related catastrophes [112]-[115]. The figure highlights some of the approaches that have been explored in the literature.

Safety and security are essential components of every institution's functioning and management [116]-[120]. As a consequence, it becomes essential to include these criteria within Smart University's purview.

2.7. Data Analytics Centres and Big Data

As a key component of any institution, a data center for optimizing and analytics is an essential factor to meet inside the Smart University design [121]-[126]. These criteria aid in continuous development, data lakes, data sharing, and data classification [17], [18]. The application of optimizing and analytical data tools in the literature is summarized in Figure 1.

2.8. Smart Amenities

Services for Intelligent Amenities Stakeholders benefit from active university life, functioning facilities, and easy access to sports fields, student centers, libraries, and restaurants [127]-[132]. As illustrated in Figure 1, the literature discusses many applications for smart facility solutions. Smart facilities services, as a critical component of facility management, must be incorporated into the Smart University system[15][14][13][133].

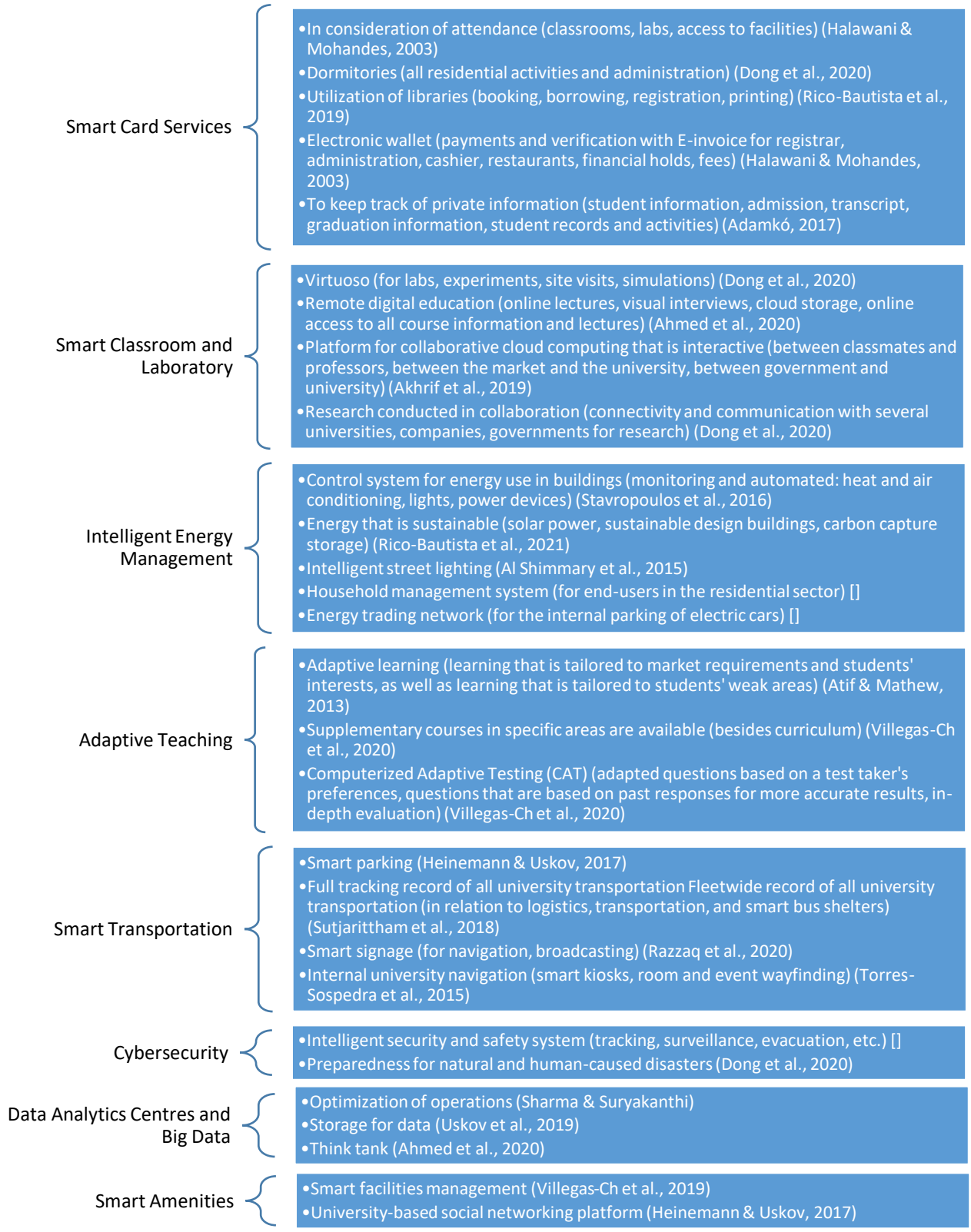

Figure 1- The proposed holistic framework for smart universities.

Additionally, Figure 1 summarizes the section by highlighting the underlying criteria derived from the literature. As illustrated in Figure 1, a cohesive structure for a Smart University is presented,

consisting of eight primary criteria and 25 uses built on top of the Internet of Things (IoT) and a cloud technology platform [15][16][134][135]. The purpose of this research is to utilize a comprehensive set of criteria to define what constitutes a Smart University and to analyse these criteria in light of stakeholders' perceptions of executing Smart University applications while also highlighting substantial enabling factors and challenges associated with instituting a Smart University through the use of the following case studies [136]-[140].

3. RESEARCH METHOD AND DATA COLLECTION

The objective of qualitative and quantitative research is to get a better understanding of experiences. Interviews were conducted with experts and practitioners at four distinct universities: University of Richmond (R), the American University of Sharjah (A), Mohamed bin Zayed University of Artificial Intelligence (Z), and Abu Dhabi Polytechnic (P). The research used semi-structured interviews to ascertain stakeholders' opinions of the critical nature of trust in smart-university applications. The survey was sent to students four local institutions and received a total of 196 answers. The data were examined using thematic and quantitative analysis, which is a technique for determining the relative significance of each criterion to the greatest possible value.

The survey (appendix 1) included three multiple-choice questions (1,3,7), one rating based question (4) where students were tasked with evaluating the degree of agreement between the given phrases on a 7-point scale (1 being the lowest degree of agreement and 7 being the highest), and three descriptive questions (2,5,6). Specific expressions question 4 addressed various aspects and characteristics of the ideal smart university, including smart cards, smart classrooms, energy management, adaptive learning, smart transportation, security, data centers, and social.

3.1. Qualitative (Interviewees, Case Studies)

The profile of the interviewees is shown in Table 1. Four interviewees were selected due to their positions in Academia and are considered experts in matters relating to Higher Education Institutions. The interviewees were selected from University of Richmond (R), the American University of Sharjah (A), Mohamed bin Zayed University of Artificial Intelligence (Z), and Abu Dhabi Polytechnic (P).

Table 1- List of Interviewees in each university and their academic position

Interviewee	Position
P1 (R)	Associate Professor of Leadership Studies
P2 (A)	Laboratory Instructor
P3 (Z)	Principle Engineer with a Master of Science in Electrical Engineering
P4 (P)	Dean of Petroleum Engineering

4 .ANALYSIS AND DISCUSSION

4.1. Qualitative Evaluation

Participants were asked about their opinions of the identified Smart University metrics and usage, and if these are adequate to convert a traditional university into a Smart University, to verify the research results from the literature and gain a complete understanding of professionals' perceptions of the difficulties and enablers of a Smart University [141]-[146]. What additional apps or criteria would they want to see implemented on their university, and their views of the barriers and facilitators to establishing a Smart University [147]-[152].

The answers showed that all academics questioned at the aforementioned institutions felt that the Smart University apps and criteria stated in this study were adequate to convert a conventional university into a Smart University [153]-[160]. P1, P2, and P3 said that the aforementioned criteria and capabilities are sufficient to designate a university as a Smart University as a first step, but different applications are required to go the extra mile [161]-[167]. Additionally they agreed that the investigated criteria and applications are strikingly similar to those deployed globally and are proceeding effectively toward a smart conversion [168]-[172].

Concerning the respondents' views of other apps that they would want to have implemented on their university, and what more criteria they would prefer to add to those already determined by the research, the following flowing answers were given:

All respondents highlighted the importance of smart buildings designed with sensor gates that open or close automatically and classrooms designed with remote-controlled systems, in

addition to smart structure equipment that helps educators and learners improve their teaching and learning adventures by making them feel satisfied both indoors and outdoors [173]-[176].

All respondents also asserted a need for smart communication facilities that incorporate video and similar connectivity devices to facilitate synecious communication between learners and educators due to constrained office hours, that could help alleviate the busy nature of social interaction between teachers and students outside the educational setting;

According to interviewees P2 and P3, a Smart University must also include smart implementations that inform students whether an educator is occupied or accessible in the office without knocking on the door and that these applications assist professors in notifying learners of their accessibility and occupancy without interfering with their work time [177]-[180].

When respondents were questioned about the barriers and facilitators to fostering a Smart University, the accompanying answers were discerned:

P2, P3, and P4 all expressed similar worries about the "initial costs" of implementing the Smart University apps, but they also alluded to the long-term advantages that might help offset these costs.

All respondents agreed that the Smart University requirements and applications described need "training" for all participants, particularly students and teachers, but getting all members on board might be difficult [181].

According to interviewees P3 and P4, cultural obstacles are one of the obstacles in a conventional environment, and therefore adopting Smart University apps may encounter some early friction.

All respondents agreed that these obstacles could be overcome with appropriate planning, execution, and supervision of implementation. P1 and P3 emphasized that training and teaching students and academics on Smart University learning may assist in the closing of the knowledge gap. As a result of these answers, the primary obstacles observed were as follows:

- Reluctance to alter established modes of delivery;
- Expenses associated with the intelligent application and assured returns on investments;
- Protocols for privacy; and data security.
- Inadequate instances;
- Support for information technology and competent end-users;
- Reliability and business continuity are ensured via the use of a failover solution.

While the primary drivers of a Smart University have been identified as:

- Change management, determination, and a real vision for smart transformation are required.
- Increasing understanding of technology and the possibilities of Smart Universities;
- Professors and students are rewarded for implementing Smart University apps.
- Ensure that all university stakeholders get enough training and motivation;
- Industrial businesses and academic institutions should work closely together to enhance their smart application and ongoing support further.

These obstacles and facilitators aid this research in determining educators' views and comprehension of the idea of a Smart University, as well as the most effective methods for promoting the current criteria for the stakeholders' mutual benefit. According to P1, P2, and P3, using database systems for study and work has become an inevitable trend in the growth of schools and universities. Teachers and employees may query and count the necessary expertise in the database system, which includes a significant quantity of data information and content. When building a smart university, data can offer strong support for all facets of education, and everything can be digitized to the maximum extent feasible. Only in this manner can the full value of big data's application and forecasting function be represented [19].

In terms of functionality, educators must work in a laboratory environment and provide the most realistic atmosphere possible. Practice is the distinction between what a student thinks they know and what they demonstrate they really understand, both from the student's and

employer's viewpoints. Without virtual labs, it is akin to one learning about driving a car without physically driving one; the effect is vastly different. Online training, live lectures, and curriculum materials are comparable to learning to drive in detail. To begin, classroom training in vehicle operation and knowledge of the traffic rules included on the driver's test are needed. Students then utilize learned concepts to concretize them in virtual labs. The hands-on experience reinforces concepts and aids students in acquiring the necessary skills for safe vehicle operation. Similarly, virtual labs assist in reinforcing curricular content.

All interviewees responded that augmented reality technology might also be integrated into lab equipment, such as AR eyewear that show experiment steps, identify related instruments, and provide textual user instructions. The AR state in the laboratory enables students to find and concentrate on tasks more rapidly and with less body control, thus increasing learning efficiency during laboratory work.

4.2. Quantitative Evaluation

As mentioned above, three multiple-choice questions (1,3,7) and a rating-based question (4) where students were tasked with evaluating the degree of agreement between the given phrases on a scale of 1 to 7 (1 being the lowest degree of agreement and 7 being the highest degree of agreement) were included in the survey. Figure two demonstrates the level of awareness among university experts and professors regarding the concept of smart universities.

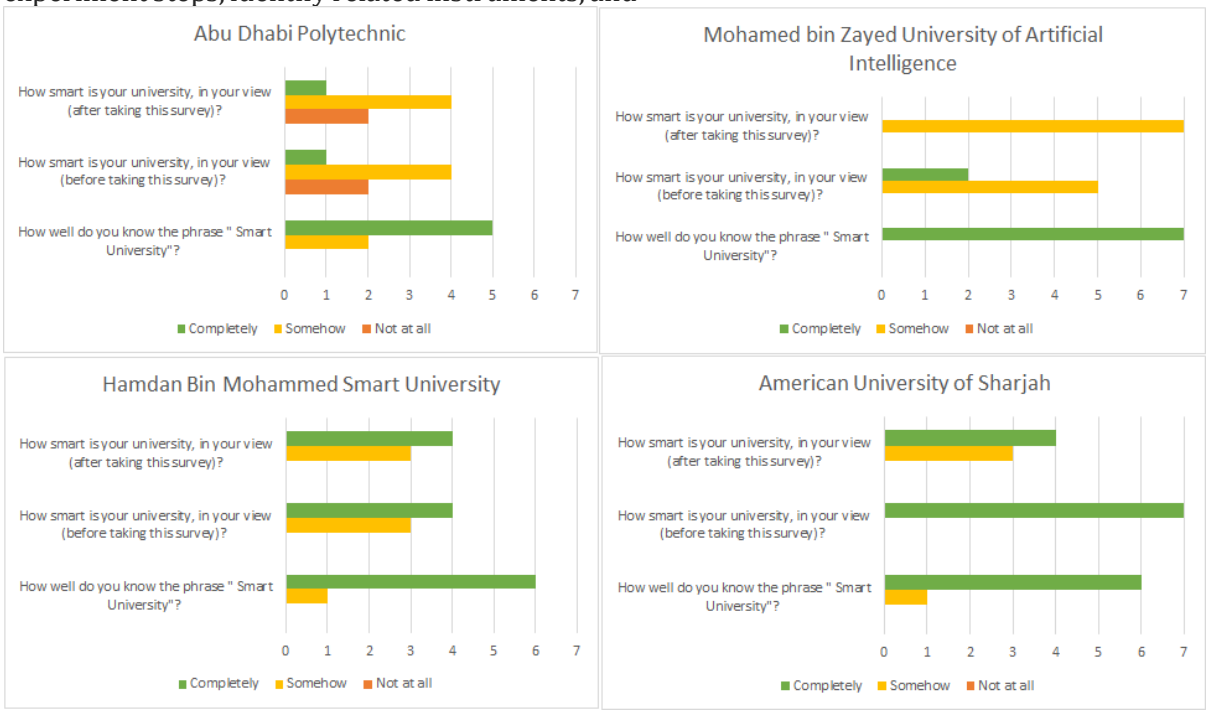

Figure 2- Level of awareness among university experts and professors regarding the concept of smart universities

It can be seen that respondents in all four universities are somewhat aware of smart university requirements. In both Hamdan Bin Mohammed Smart University (HBMSU) and American University of Sharjah (AUS) universities, almost 60% of the respondent believe that their university is fully smart. It must be noted that the level of confidence in the smartness of the university respondents in AUS has decreased by about 40% after participating in the survey, which indicates a lack of proper knowledge regarding the issue. Responses from Mohamed bin Zayed University of Artificial Intelligence (MBZUAI) portrayed a similar challenge. In the end, it should be pointed out that Abu Dhabi Polytechnic and MBZUAI cannot be considered smart universities based on the responses which are in accordance with their official website content [20], [21]. HBMSU and AUS could be considered smart universities based on the responses, which are in

accordance with their official website content [22], [23].

Furthermore, participant responses to the rating-based question (4) where students were tasked with evaluating the degree of agreement between the given phrases on a scale of 1 to 7 (1 being the lowest degree of agreement and 7 being the highest degree of agreement) are demonstrated. The primary purpose of a conventional bar chart is to evaluate numeric quantities between classified variable levels. Each grade of the category variable is represented by a single bar, with the length of each bar representing the numeric value. A stacked bar chart does the same thing but also has a secondary purpose. A stacked bar chart is employed because it is necessary to decompose each main bar according to the ranges of a second category variable. Each bar now contains a number of sub-bars, one for each grade of a secondary category variable [24].

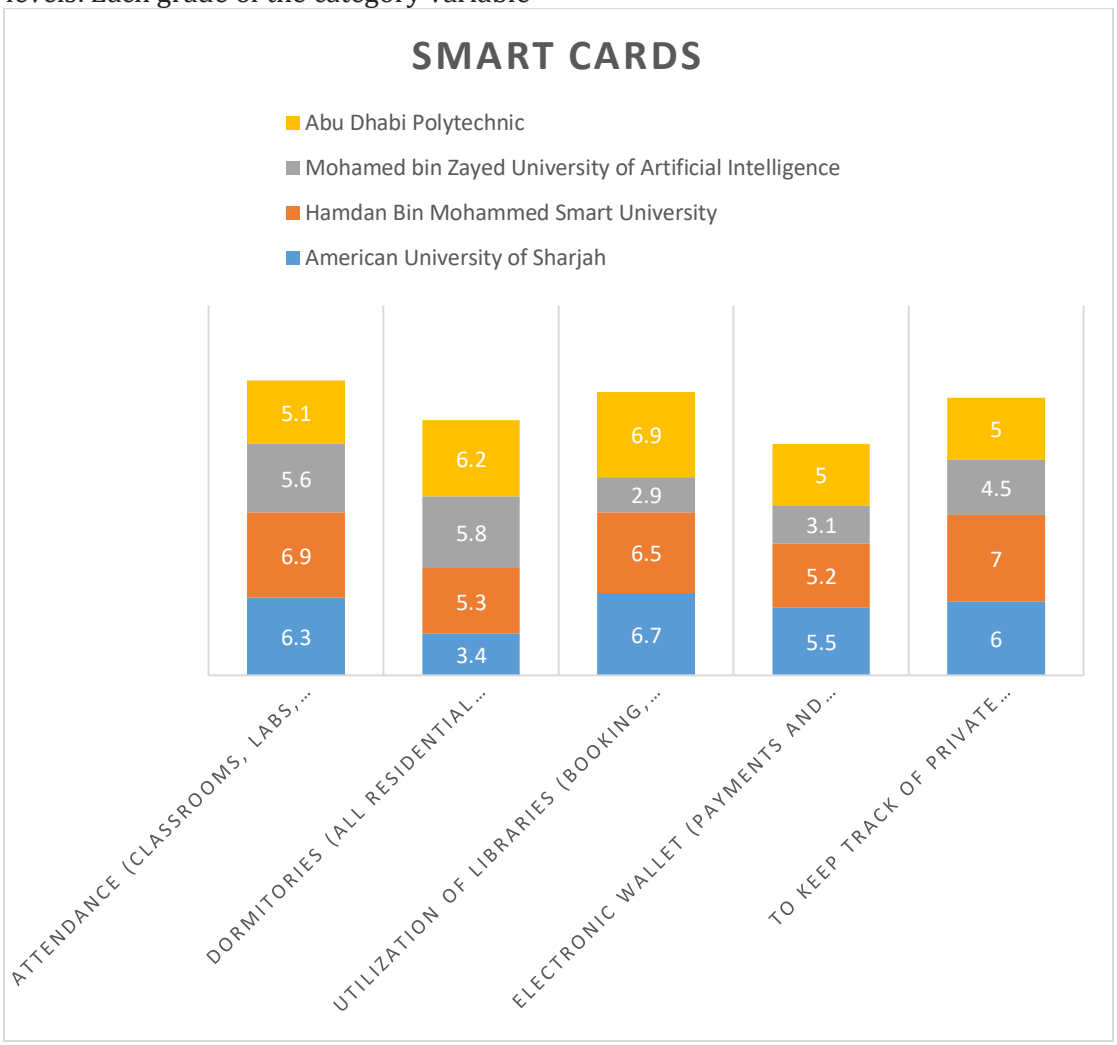

Figure 3- Smart Cards ranking according to the survey.

Figure 3 illustrates the mean value assigned to the E-card criteria and its significance across various facilities inside the university campus. The findings revealed that the usage of E-cards to facilitate attendance evaluation and record students' attendances in various courses and laboratories received the highest ratings amongst the participants, followed by its usage for library activities and maintaining track of private information.

These findings, however, suggest that students are more concerned with the usage of E-cards to simplify and speed up services and procedures than physical mobility and ease of access.

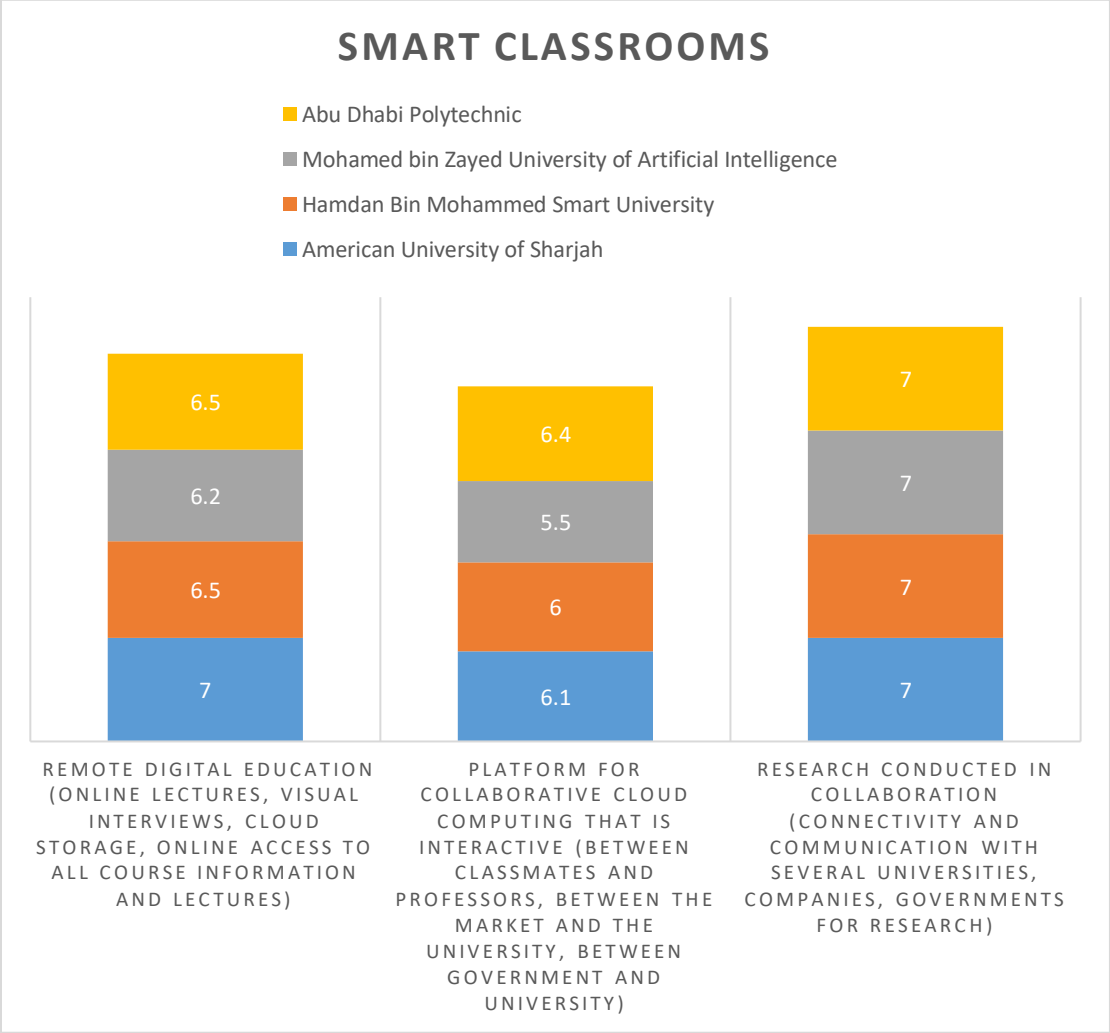

Figure 4- Smart Classrooms' ranking according to the survey.

According to students views, Figure 4 illustrates the importance of smart classroom uses for a Smart Campus. The result indicates that the dynamic, collaborative research system is the most significant application in comparison to other applications.

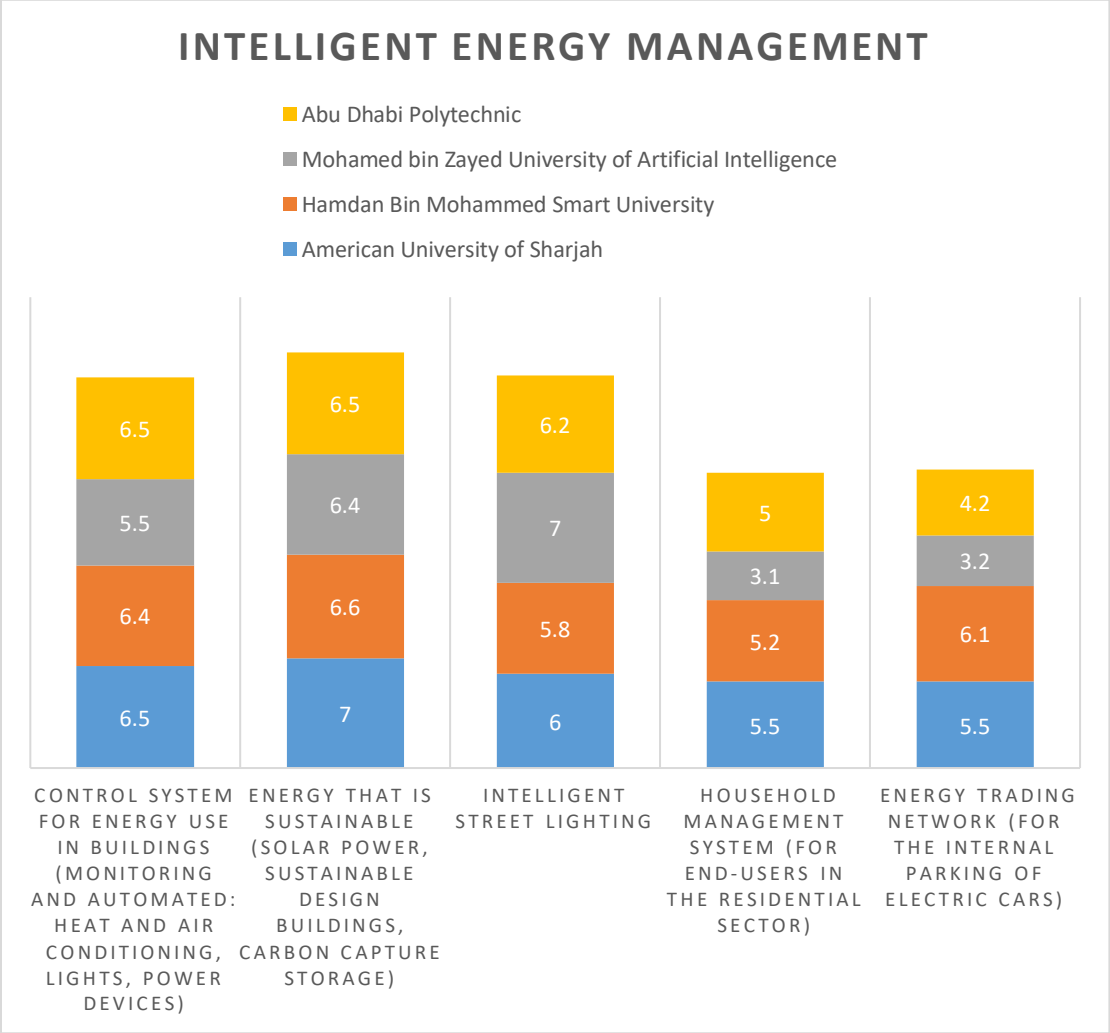

Figure 5- Energy Management ranking according to the survey.

Students views of the significance of energy management apps for a Smart Campus are shown in Figure 5. The findings indicate that students ranked sustainable energy as the most critical application, followed by energy management systems for buildings, smart streetlights, home control systems, and energy trading structures. Thus, these findings suggest that students recognize the value of a sustainable climate and prefer it over energy efficiency.

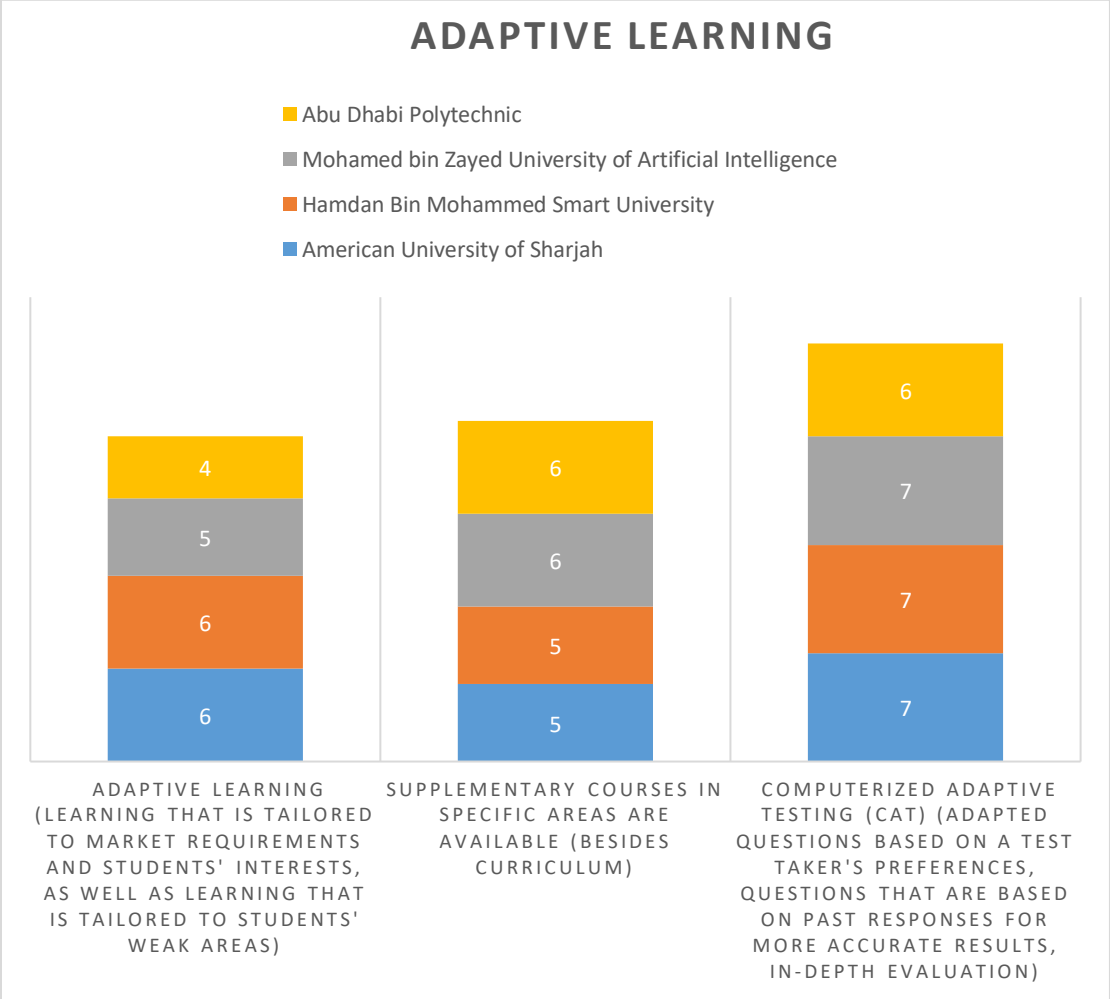

Figure 6- Adaptive learning ranking according to the survey.

Figure 6 depicts students perceptions of the three apps in terms of their relevance to the Smart Campus in terms of student enrollment. The findings indicate that students ranked Computerized Adaptive Testing (CAT) as the essential adaptive learning application, followed by supplemental courses.

Likewise, Figure 7 illustrates the average score assigned to the smart commuting criteria and their implementations in relation to their significance on the university site. The image demonstrates that participants identified all four criteria as critical applications, including smart parking, on-campus navigation, fleet monitoring for all campus vehicles, and intelligent signage. This shows that, although participants seemed to support all of these uses, they did not express a clear preference for one over the other.

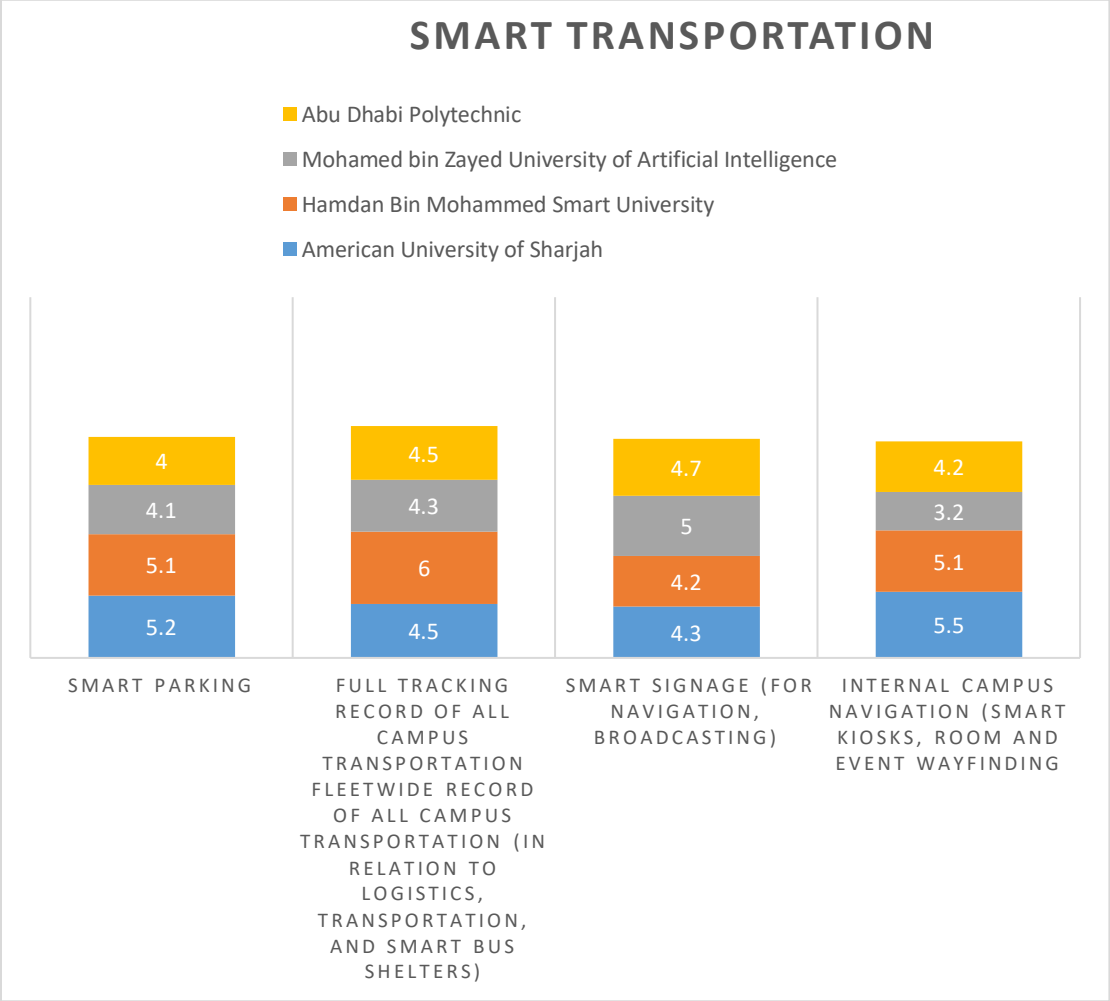

Figure 7- Smart Transportation Smart Cards' ranking according to the survey.

Lastly, Figure 8 depicts the students views after being asked to assess apps based on three distinct criteria: security and safety, data center optimization and analytics, and smart facility services. The findings indicate that students deemed data center optimization to be the most critical criterion and application, followed by smart safety and security process monitoring.

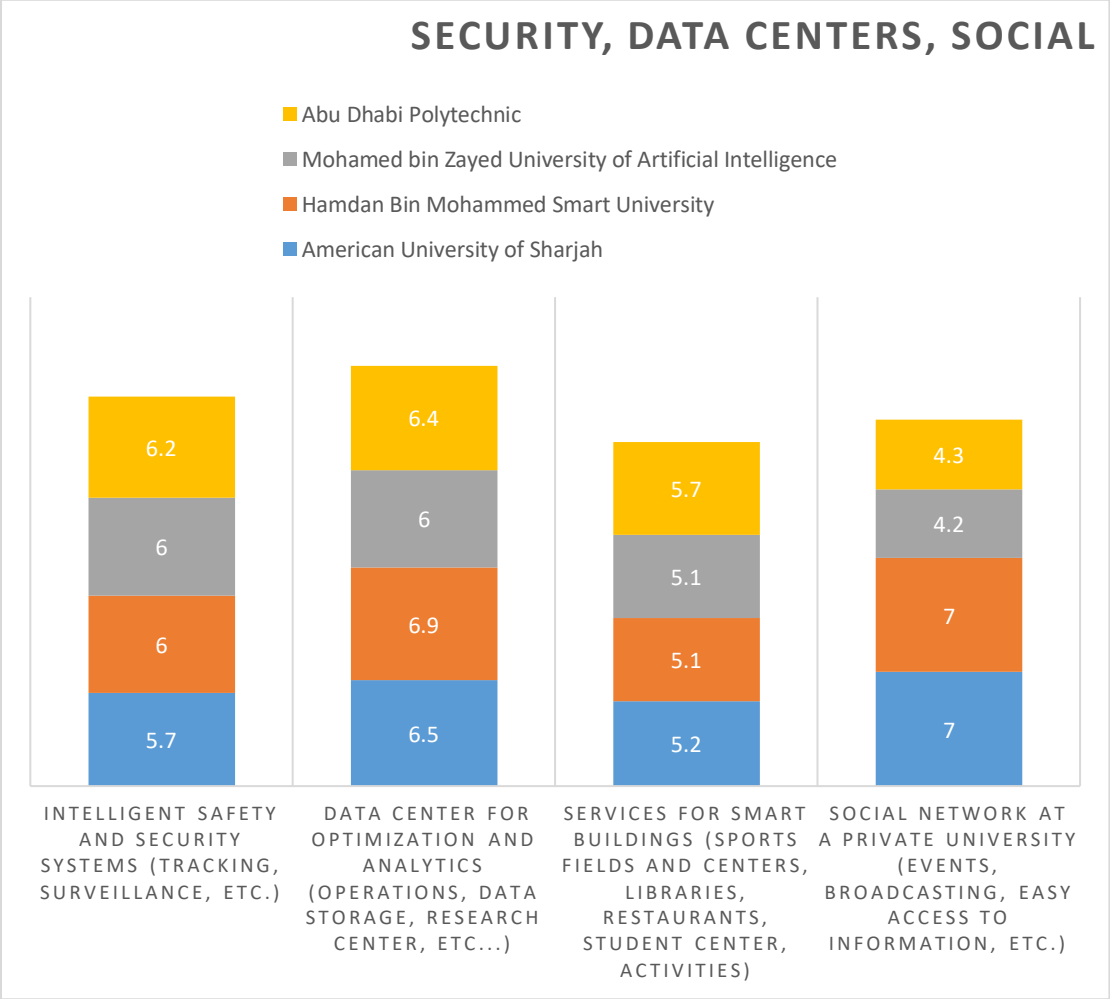

Figure 8- Security, Data Centers, Social rankings according to the survey.

Thus, from the viewpoint of students, the most critical applications are smart card technologies, smart class usage, energy management operating systems, adaptive learning systems, and intelligent security and safety apps. Additionally, it can be observed that the average rating for all of the above-mentioned criteria is higher for HBMSU and AUS (previously assumed smart universities) than for ADPC and MBZUAI, indicating a greater understanding of the issue's significance in universities that have exhibited smart characteristics. This demonstrates and confirms that all of the specified criteria and applications are critical characteristics of a Smart Campus, as shown earlier in the literature study.

- ***Study Limitations***

The study's methodology has a disadvantage in that it is academic in nature. While the students in this study represent genuine, potential users of a smart university system, future work may use bigger samples to adjust for demographic factors such as age, gender, and computer proficiency. Another limitation of the design is the dependence on a field survey rather than an experiment. The study was further disadvantaged by having responses recorded over digital means which do not allow the interviewers and survey takers to express vocal opinions due to the limitations of the scope.

- ***Future Studies***

In general, university professors' and educators' views are essential for validating smart applications since they will be the ones immediately interacting with these features and enhancements in educational institutions. To adhere to and integrate the concept of a Smart University, however, the following actions must be taken:

- Evaluation of graduate quality in the job sector and making a comparison between graduates of smart universities against

conventional universities.

- Additional, more technical study on each of the proposed framework's specified criteria;
- Guidelines for implementing each of the intelligent systems included inside the Smart Campus paradigm;
- Conducting cost-benefit assessments on each of the suggested Smart Campus criteria;
- Engaging industry experts to assist in developing a complete knowledge of all obstacles and constraints;
- Additional study into predictive analytics that assists in determining which smart technology to fund or not fund, depending on the campus stakeholders' budget, vision, and existing preferences.
- Other research is necessary to ascertain the impact of additional trust-related variables, such as the students' background, usage time, and technical competence.

5. CONCLUSION AND RECOMMENDATIONS

This research aims to bring forward the most desirable aspects and variables of smart universities. Through the literature review, various authors and journals were reviewed to discover this set of variables. All articles showed that the lack of consensus had limited the potential of universities in their development from conventional to smart structures. By combining and expanding on the work reviewed in the literature review, this paper sets the framework for academics and institutions to create a universal standard that all universities can follow in their journey to become smart universities.

The second objective is to explore and examine the perceived worth of the Smart University paradigm from the perspective of its critical stakeholders. As the primary customer of universities, students are considered one category of these stakeholders that need to be accommodated and targeted for marketing. As the primary services providers, instructors are further key stakeholders that can evaluate the added value derived from smart factors resulting in smart universities. Finally, the general market and society are considered stakeholders as they view students as products provided by universities. They demand that the students are of an excellent caliber, which provides the incentive to universities to create excellent students upon graduation. Through the experience of instructors and students alike, this study finds that the smart university is much better equipped to produce high-quality graduates compared to its conventional counterparts. Through adaptive learning, the term "no student is left behind" receives new meaning. It allows the smart university to create individually tailored programs and assessments that suit the requirements of every student. This objective is highly impractical to achieve in conventional universities.

Furthermore, with the automated transactions facilitated by smart amenities, smart cards, and data analytics centers, the administration can better cater to the needs of students, faculty, and staff, which incentivizes them to perform better always. The use of smart classrooms and smart laboratory technology further enhances the student experience. It allows instructors to monitor student activity better due to the assistance of technology and reporting software in a method that greatly outclasses the degree of observation available to conventional instruction.

This realization offers stakeholders interested in developing a Smart Campus inside educational institutions insight into the diverse views of end-users on Smart Campus apps and their derived advantages. This research creates opportunities for future research that will examine stakeholders' interests in developing Smart Universities and will identify the essential criteria that hold significance to specific beneficiaries and the added importance that these requirements and their usages can provide in terms of expense versus value. Thus, it is within the scope of this study's future research to expand on existing results to create decision support systems that will assist decision-makers and financiers in making good investment choices about the value and associated costs of Smart University applications. As a result of this research, a route for incorporating smart technologies into future Smart University expansion plans is established.

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