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SMART UNIVERSITIES: A TECHNOLOGICAL FRAMEWORK

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ABSTRACT: Higher education is an essential platform for generating high-quality educators. The education sector is entering a new global dimension with the advent of Web 2.0 and IoT technology. Smart campuses are a universal digital link via cloud computing, big data, network platforms, and security services. This study mainly focuses on the conceptual framework of a smart campus and its usage efficiently and effectively. The technologies involving in this conceptual study listed as automatic attendance systems, Virtual reality (VR), Augmented reality (AR), Wireless sensor networks, body sensor networks, smart door locking system, cloud computing, wireless sensor networks, and smart library. The attendance issue, pedagogical issue, and infrastructure issues are the critical issues of any educational sector. When the proposed technology is developed with mentioned technology as a full pack, all education sectors will be given their best throughputs.

KEYWORDS: Smart Campus, Internet of things, Augmented Reality, cloud computing, smart library, virtual reality

1. INTRODUCTION:

Higher education is an essential platform for generating high-quality educators. It is also a critical contributor to the national literacy rate [1] and political, social, and economic discrepancies. Globally, the higher education sector provides significant contributions to the fields of business [2], [3], healthcare [4]–[6], tourism [7], [8], marketing, leadership, and management [9]–[13]. Higher education contributes human resources to almost all sectors.

Higher education practically starts at the university level. It contributes to national development via various fields. Students are provided with the best training that would shape them into valuable outputs for society. This is why the nature of education, the rate of learning and understanding, technological infrastructures, the flexibility of teaching-learning activities, and learner-teacher collaborations in universities are crucial. Today, students and teachers are facing difficulties in pedagogical management. The quality of education in universities and the education system is hindered by several issues, including exorbitant costs, low attendance, inflexible schedules, multi-course challenges, examination-based education, assignment issues, depression, and technical issues. These problems are indicated to be solvable with the application of smart campuses integrated with IoT technology.

The education sector is entering a new global dimension with the advent of Web 2.0 [14]–[20] and IoT technology [21]–[28]. The smart campus is a universal digital link via the usage of cloud computing [29], IoT, and Web 2.0, which results in comprehensive and effective pedagogical activities [30]–[34]. Synchronized components of a smart campus include sensors [35], [36], big data [37], [38], cloud computing [39]–[41], network platforms [42], and security services [43].

There are pros and cons with IoT-integrated smart campuses. The pros would include improved student education programs, more respite time, significant reduction of human errors, more flexible pedagogical practices, and hybrid learning capabilities. Meanwhile, the cons would include poor technological knowledge and high system implementation costs.

This study aims to seek the best technologies which provide the best services to the student and educational system via a conceptual framework

2. LITERATURE REVIEW

According to S.C. Mukhopadhyay and T. Islam [45], smart campuses allow for live sessions to be conducted outside of campus via the Internet of Things (IoT). A. Abdullah, M. Thanoon, and A. Alsulami [46] asserted that Campus and stakeholder security could be guaranteed with the usage of sensors and drone cameras, but such technology also brings about financial, technical and political challenges. A. Zhamanov, Z. Sakhiyeva, R.

Suliyev, and Z. Kaldykulova [47] added that smart campuses can control room temperature in empty rooms. RFID can be used to monitor teachers and students while the administration has direct access to student feedback via mobile applications.

M. Rao, R. Swathi, M. Sneha, S. Kotian, and N. Rao [48] suggested that the usage of IoT which is a form of Artificial Intelligence in smart campuses can lead to energy savings. Additionally, WIFI sensors are a better alternative than Bluetooth, whilst Zigbee supports smart devices. D. M. S. P. K. Dawndasekare and A. Jayakody [49] proposed several concepts for the implementation of IoT in university campuses including energy management and eco-system monitoring, campus security and classroom access control, health monitoring for students, improvement of teaching & learning via RFID, and NFC. T. M. Fernández-Caramés and P. Fraga-Lamas [50] suggested the usage of IoT and cloud computing on campus grounds as a form of campus monitoring; it not only assures good communications, but also efficient energy usage so as to maximize IoT battery life via blockchain thus delivering accountable, transparent, secure, and efficient data management and processes.

S. Ambilkar, S. Hegonde, R. Therade, and S. Lingamwar [52] recommended a contactless data collection system i.e. NFC using web and mobile applications.

According to A. Alghamdi and S. Shetty [53], IoT is applicable for smart buildings, smart grid, and learning settings due to its cost-effectiveness, efficiency, and superior quality. The usage of IoT in terms of campus access control, voting, and parking still require further examination. Meanwhile, S. N. Kane, A. Mishra, and A. K. Dutta [54] suggested the adoption of PIR, RFID and cameras in developing smart rooms, smart parking, and smart education.

Z. Y. Dong, Y. Zhang, C. Yip, S. Swift, and K. Beswick [55] highlighted the significance of IoT, cloud computing, and Augmented Reality (AR) in developing smart campuses and subsequently smart cities. The authors also suggested a Human-centered Learning-oriented Smart Campus (HLSC) which delivers essential services, personalized services, and additional services.

S. Fortes et al. [56] provided an improvement solution to current smart campus systems with the integration of a green island which is equipped with vegetation, efficient energy, innovative technology, comfort as well as innovation plans including foster research and interdisciplinary smart campus projects.

According to S. Syidada, E. Wahyuningtyas, and F. H. S. Pratama [57], the internal and external IT infrastructures in smart campuses are assessable using the McFarlan Strategy, Grid Analysis, and IT trend analysis. B. Sánchez-Torres, J. A. Rodríguez-Rodríguez, D. W. Rico-Bautista, and C. D. Guerrero [58] highlighted the security issues related to IoT which can be minimized via encryption. C. D. G. B. Sánchez-Torres, J. A. Rodríguez-Rodríguez, and D. W.Rico-Bautista [59] agreed on the effectiveness of encryption in securing information transfer via radio frequency. Future solutions to smart campus security will include the usage of AWS-ECC508 chips on top of IoT-enabling web development frameworks.

X. Zhou [60] suggested a smart campus model that integrates smart city concepts, smart microgrid, community-based services, comprehensive view of the smart campus, dissemination of smart campuses, and achievement of long-term success for better campus management using RFID, Actuators, Sensors, Cloud computing, Augmented reality, and web services.

R. Jurva, M. Matinmikko-Blue, V. Niemelä, and S. Nenonen [61] recommended an architecture that can be developed by employing real 5G, IoT, MEC, and cloud computing. An NFC-based all-in-one card can add more value to smart campuses for making payments [62] consistent with the assertion of G. Guo [63] regarding the IoT and RFID-driven Programmable Logic Controller (PLC) which can take over almost all the functions of a campus card including Student ID, Library ID, Staff ID, medical certificates and others.

A smart campus design based on the Building Information Modeling (BIM) was proposed by T. Bi [64]; its development employs the usage of Autodesk Revit software and 3D Geographic Information System (3DGIS) which leads to the development of a Skyline-driven database.

Meanwhile, an android application for academic communication was developed by Sagar R et al. [65]; the system is indicated to be highly effective for recording maintenance and storage data, and is highly efficient as a time management mechanism. Teaching and learning in a smart environment can be accomplished in less amount of time as compared to traditional methods.

According to Nuzzaci and Vecchia [66], learning in a smart environment improves the quality of knowledge and education. Therefore, smart campuses provide the right way forward in conducting pedagogical activities today.

Judita KASPERIŪNIENĖ and Sigitas DAUKILAS [67] examined the usage of smart technology at a vocational training center involving 25 randomly selected vocational teachers via focus group interviews. The findings show that the teachers employ technological tools to communicate with their students. Today, smart technology exists almost everywhere as a way to simplify educational activities. A smart campus would be highly beneficial for those involved in conducting pedagogical activities. According to H. El Mrabet [68], younger teachers are more open to embracing new technologies as opposed to older teachers. Hwang [69] identified a number of

factors that drive students and teachers to adopt a smart learning environment including adaptiveness, teaching/learning interface, and context-awareness.

Nathan Nachandiya et al. [70] developed a conceptual model for the creation of a smart campus [60], [71] classroom based on Big data [72], mobile computing [73], cloud computing [74], and network infrastructure. There are six layers to this model namely: Network Layer, Cloud computing layer, Big Data layer, Smart Application layer, Smart Device layer, and Awareness layer. In terms of Smart Device layer, students and teachers can use personal computers, mobile phones, and other devices. The Application layer offers applications that are specific to the smart classes. The Smart Device layer can install these applications into the smart devices. The Cloud layer delivers highly secure database functionalities whereby assignments can be uploaded unto the cloud layer and downloaded to the students' devices. The Network layer transfers all data from the device to the cloud using the network protocol. The Big Data layer analyses the massive volume of data, and stores only important data in the Cloud layer. This allows the students and teachers to engage in pedagogical activities in a smart digital environment effectively. A number of studies argued that smart campuses and classrooms must be incorporated into the physical and digital environments [75]–[77] to form an integrated learning method. Therefore, the digital space is complete with the physical space focusing on providing the best pedagogical services for students and teachers.

Bart Valks et al. [78] measured real-time space usage by universities in their survey. Sensors are used for the purposes of computerizing lighting, heating, and ventilation based on the number of occupants in the university. The sensors are utilized for calculating the number of classroom occupants based on the changes in temperature and lighting. Space usage management in some other universities depends on the usage of Bluetooth, wearable sensors, and Wi-Fi for monitoring people.

Yao CHEN [79] proposed a modular framework model for developing smart campuses. The model utilizes IoT technology, mobile internet, big data, cloud computing, and other new technologies including intelligent decision-making, knowledge management, artificial intelligence, and virtual reality. The modular framework for the smart campus entails a comprehensive design of each technical structure which includes the communication module, environmental module, data module, and service module.

Yang Liu and Liang-Shan Shao [80] related the smart campus to the Internet which forms its basis, with the usage of a service framework and the development of teaching, research, organization, and campus life for the purposes of teaching, learning, and living. Smart campus development entails the improvement of the students' learning and living conditions and the creation of a comprehensive, astute, innovative and open data administration.

Yacine Atif, Sujith Mathew [81] defined the smart campus as a universal learning model. Their study backs learner-oriented methodologies and improved campus-wide collaborations cooperation so as to identify learning needs and outcomes. The authors also proposed the augmentation of book images using 3D virtual imagery via mobile devices so as to improve the instructional value of book contents (e.g. viewing a 3D molecule in a book by pointing to the molecule on the mobile screen).

Smart Library and Smart Campus are linked to the Web 4.0 technology as proposed by Hubert C. Y. Chan, Linus Chan [82]. The evolution of Webs 1.0, 2.0, 3.0 and 4.0 can also lead to the development of the 4.0 library system. According to the authors, Library 4.0 need to incorporate software-based approaches and technological environment developments including maker space, Google Glass, context-aware technology, content digitalization, big data, cloud computing, and augmented reality. The authors had expanded the concept to cover the entire campus. According to them, Library 4.0 will enable the integration and capitalization of IoT, RFID, and GPS technology in the education system. This will lead to strengthening learning capacity, improving happiness, and developing competitiveness in universities. The authors also proposed the usage of other intelligent systems including RFID Applications, Smart Bookshelf, 24-hour Self-Service Library, Smart Locker, Robot (Stocktake), Book Drop and Sorting Unit, Room & Equipment Booking System, Self-Check-In/Out Station, Book Sterilizer, Intelligent Monitoring System, Real-Time Location System, Recommender System, Face Recognition System and AI Greeting Robot.

A conceptual framework for a smart university was proposed by D W Rico-Bautista [83], who examined how IT technologies and other factors can improve the community in universities. Their proposal entails an IT organization unit that adapts all "smart" technologies into the university environment, including teaching, research, and management

3. METHODOLOGY:

Education is the backbone of any country to obtain the growth of the country. The education system provides the best asset to society. The campus environment of any country must be very efficient and effective to produce the best asset. This study mainly focuses on the conceptual framework of a smart campus and its usage efficiently and effectively. The technologies involving in these conceptual studies listed as automatic attendance

system, Virtual reality (VR), Augmented reality (AR), Wireless sensor networks, body sensor networks, Internet of things (IoT), building lighting/heating/cooling/power systems, Virtual laboratories, e-learning, smart learning materials, security surveillance, and Smart door locking/access. A frequent problem of any campus these days includes the attendance issue, pedagogical issues, and infrastructure issues. This study entirely dealing with the full stack conceptual framework for obtaining solutions for all those issues.

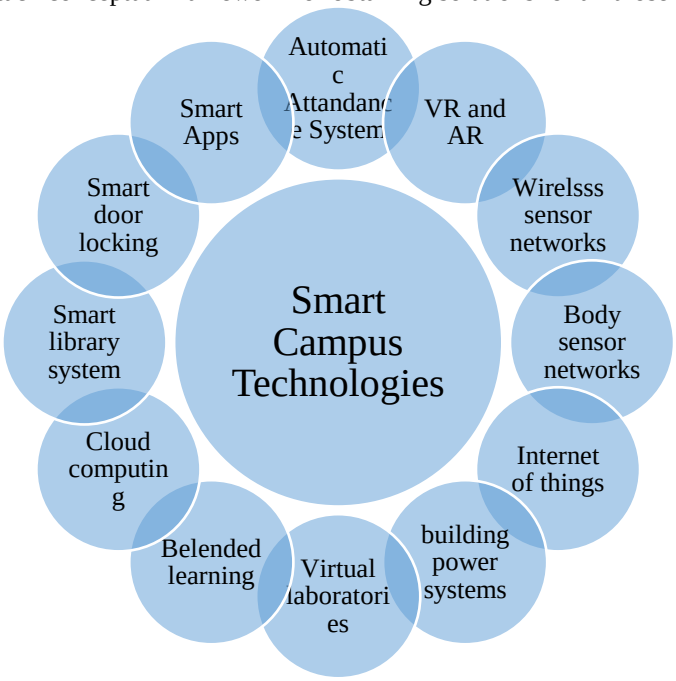

Figure 1: Smart Campus technologies

4. RESULTS AND DISCUSSION

Automatic smart attendance system

Generally, most educational institutions having a problem with attendance. When the number of students increases, the problem even increases parallelly. The major attendance issues in the traditional system are time-consuming, fraud signatures, and less secure. However, this needs to be replaced with the proper technology. This study focuses on the RFID-based two-factor automatic attendance system. The RFID tag system is used for the first verifications. The biometric or machine learning technique is used for a second verification. When both are okay with the database, then the attendance will be stored automatically without any interventions.

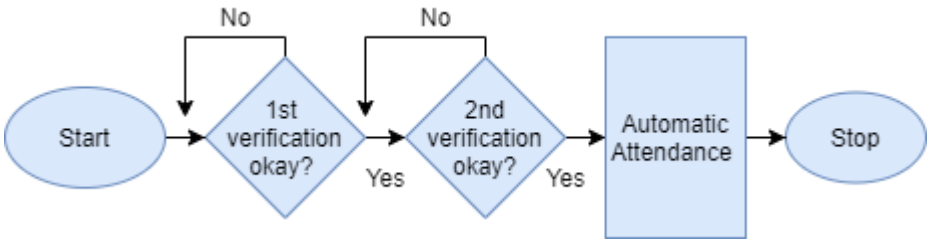

Figure 2: Flowchart for the attendance system

Smart door locking/ access system

When the two-step verification of the attendance system is completed without failure, then the door needs to be open the allowing the student inside the classroom. The microcontroller system is used for this process. A dc motor connected with the door will process based on the verification process. If verification fails, the student or teacher can not be entered the classroom. The RFID tag can be embedded with the student, and the lecturer id card will help to access the door lock of the smart campus.

Table 1:Door lock devices and functions

Device	Function	Image
Arduino microcontroller	Regulator of the system	
RFID tag	First verification	
DC motors	Access the door	

Body Sensor Networks (BSN)

A wearable device placed in the student and lecturer's body part continuously monitor the pulse, heart rate, and necessary aspects. It stores and updates the changes of the critical parameter of human body conditions. This highly helpful to monitor the health condition of the students and lecturers in the education sectors. When an emergency, the body sensor network will pass the necessary information to the responsible parties via wireless sensor networks. The wireless nodes and the access pointer will do these services without fail.

Wireless sensor network (WSN)

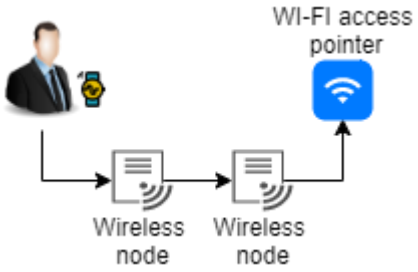

Figure 3: Body sensor network

With the help of a wireless node, the human body's changes will pass to the cloud environment for further progress. Generally, WSN used to passes the environment changes at a distance. In the case of the smart university, the body changes of the human observed by the BSN, and It will pass to cloud storage by WSN and internet technologies. A base station or pole acts as an aggregator to collect and send all signals from sensors to the cloud.

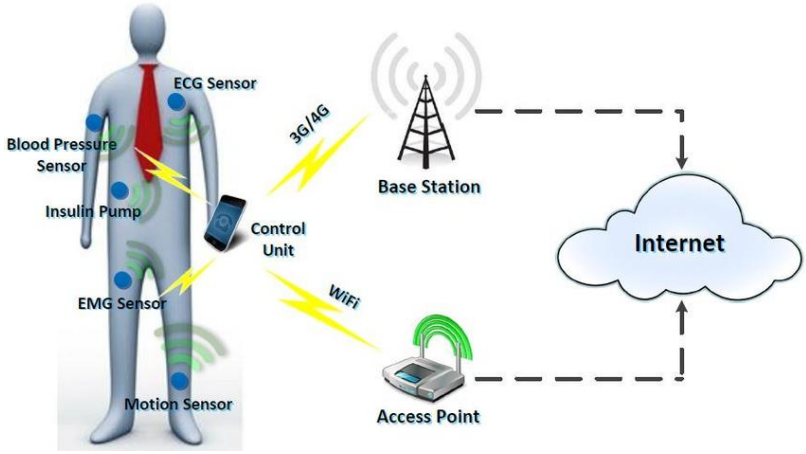

Figure 4: BSN and WSN

Cloud computing

Cloud computing generally provides several services and opportunities in a cloud environment. Third parties own the cloud storage, and people would use it on a hire basis. Cloud technologies provide standardized services than another conventional systems. Machine learning techniques even applicable to the cloud environment. Based on the smart campus data, a machine learning model can be trained and achieved the necessary actions. In a smart system, emergency service needs can be monitoring by train and validate the data of students and lecturers from BSN. Also, the automatic attendance system's second verification can be done by machine learning models.

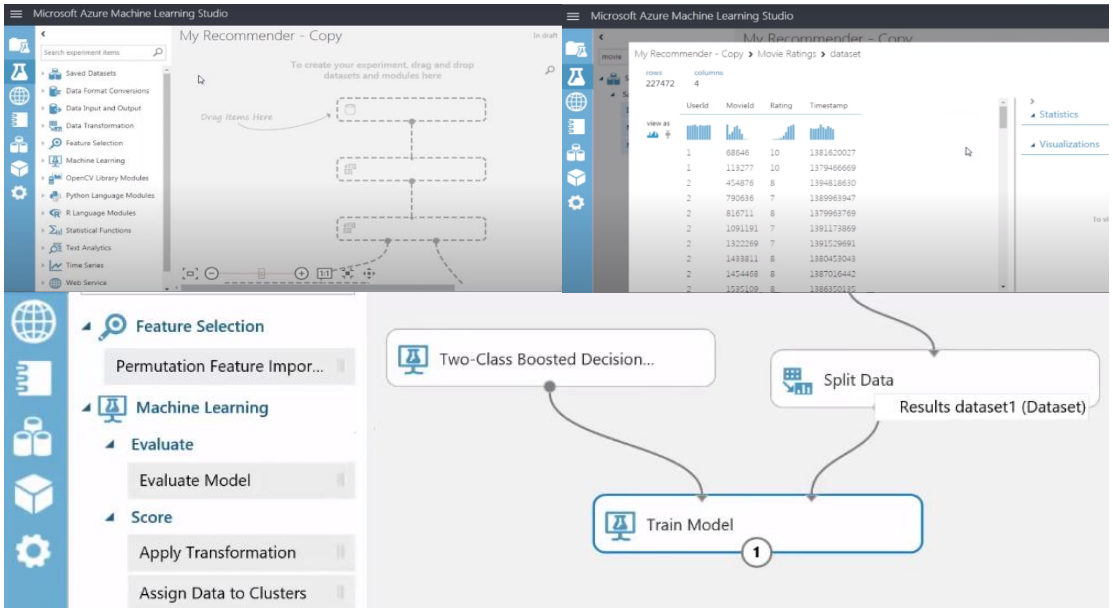

Figure 5: Cloud storage and machine learning envirnoment

Smart Library system

In the case of the conventional library system, most things are done by human efforts. However, managing large university libraries is not easy as thinking. When the number of students and books increases, the complexity also increasing. So the best option for this issue is a smart library system with smart technologies. The proposed library system with smart university consists of the following aspects as below.

1. Self-check-in/ check out the facility
2. Speed functionalities
3. High security

4. Smart alerts
5. Stock managements
6. Book dropbox
7. Location finding services
8. Tracking books

The library system fully copes with the RFID system. Each student who enters the library needs to use their RFID tag for pre-verifications. Once they are authorized, they can be allowed to enter the library. If the students want to search for a book, they can use the specific android applications developed for that purpose. The app will show the map for the book. Each book tracks embedded with an RFID reader end of the corner—also, each book embedded with RFID tag. When the students want to take a book, they can place the book tag in the RFID reader. An ethernet shield used with the microcontroller passes the book information to the central server and cloud server.
Additionally, WSN is used for passing the data to the cloud and library servers. Each track contains a microcontroller that holds the camera module, which provides surveillance services 24 x 7 hours. Also, an SMS alert system delivers the SMS to remind the students about the deadline of brought books from the library.

AR and VR technologies

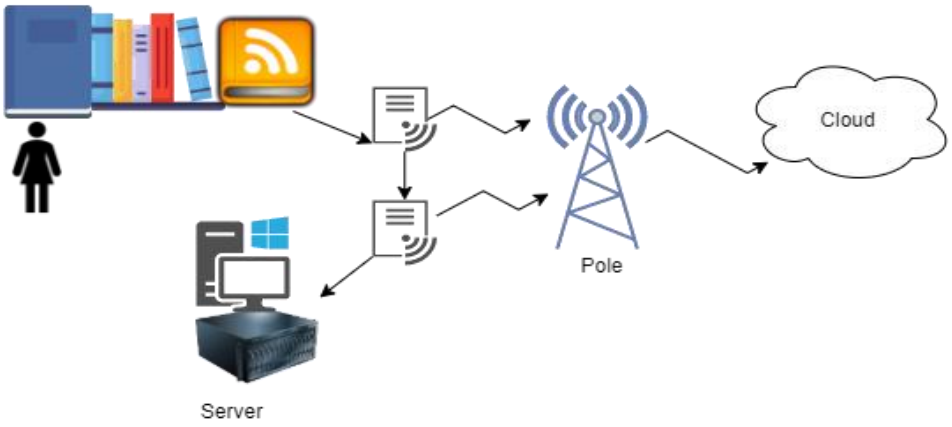

Figure 6: Book Check-in process of the smart library

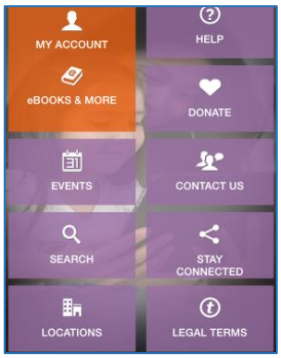

Figure 7: Android app interface

Virtual reality provides an experience that is different from reality. In comparison, Augmented reality is an enhanced version of the real world achieved through digital images, sounds, or other sensory elements delivered via technology. The campus education, not 100 percentage dealing with theoretical, and it has several practical aspects. The practical subject must teach understandably to achieve higher output. However, that is an arduous task.

Nevertheless, there are many challenges faced by campuses in dealing with this issue. However, introducing VR and AR on the campus avoiding these issues very simply. The very best examples are biological education using VR and flight cocktail with VR and AR simulations.

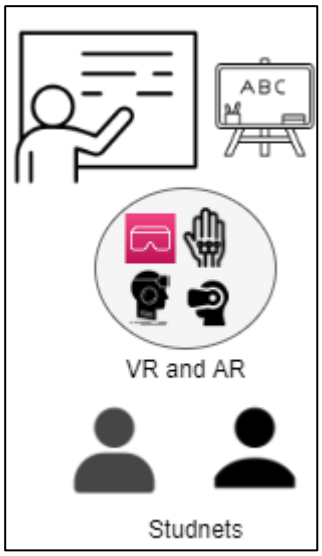

Figure 8: VR and AR
teching methods

5. Conclusion

The Smart Campus is an emerging concept that is becoming increasingly pertinent for higher education institutes not only for the aspect of learning but also for administration, building maintenance, energy serving, campus access, payment, parking, prevention of environmental pollution, and others for campuses worldwide which will ultimately result in time and cost savings in the long run. This study entirely dealt with the technological solutions of a smart campus. Seven technologies were proposed with functionalities throughout this study. The attendance issue, pedagogical issue, and infrastructure issues are the critical issues of any educational sector. When the proposed technology is developed with mentioned technology as a full pack, all education sectors will be given their best throughputs

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