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Present and the Future Role of the Internet of Things in Higher Education Institutions

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Abstract

Change is never changing, and accepting the differences can bring immense changes in our lives. The Internet of Things (IoT) is the key to changes in this cyber world, and embedding it has been bringing wonders into the community. By and large, the IoT has become an impacting phenomenon in every walk of life, and education is not an exception. This research study aims to trace the evolution of the IoT in the field of education in Higher Education Institutions (HEIs) and highlight the achievements and promising hopes of the IoT technology for higher education for the upliftment of humankind. The study spells out the parts played by the high-speed Internet, smart devices, advanced software applications, communication technologies, and competent soft tools in establishing smart educational institutions for the enrichment of learning experience anywhere, anytime, and at any chosen pace in the current scenario and lists the highly expected future potentials.

Keywords: IoT, Higher Education, 5G-technology, RFID, Smart Campus, Virtual Learning

1. Introduction

The world of computing is evolving fast, and the Internet of Things (IoT) is one of the innovations making headlines due to its complex infrastructure of interconnected activities. The IoT concept incorporates numerous areas of life, such as businesses, healthcare, cities, agriculture, transportation, and education. This technology is envisioned to transform operations in diverse institutions. As such, the complete development of technology in the education sector promises to embed change within their systems to develop and produce classy and secure learning environments (Majeed & Ali, 2018; Alfiras et al., 2020, Alakrash & Razak, 2021). Besides, the Internet of Things usage in higher education enables knowledge dissemination using physical object controllers and sensors without human interaction or intervention. As well, IoT has created a modern environment and approach for education. The technology is expected to bring a significant shift in learning by providing quantifiable and flexible education systems (Shaikh et al., 2019). Therefore, an overview of IoT in learning institutions evidences the existence of numerous emerging trends in higher education that portends massive transformations and simplification of learning in the future of education.

1.2 Genesis

The Internet of Things is a technological phenomenon that determines the future of digitalisation. The first-ever appliance operated by the Internet was a Coke machine at Carnegie Melon University. In the early 1980s, the programmers could track and check on the storage of the vending machine by connecting to the machine through the Internet, so that they can decide to make the trip down to the machine from the upper floors (Ning & Hu, 2012).

Though the concept "Internet of Things" was initiated in the 1980s with this vending machine, the original term was labelled by Kevin Auston, the Executive Director of Auto-ID Labs in MIT in 1991 (Ning & Hu, 2012). In the same year, under the title, "Ubiquitous Computing," Mark Weiser emphasised how to bring in the smart environment using the application of mobile phone technology with an advanced multimedia system (Ali, Ali, & Badawy, 2015).

The emergence of the concept of the IoT in the field of education can be traced back to 1999. Auto-ID Center of Massachusetts Institute of Technology (MIT) was the first educational institute to propose the IoT concept in 1999. However, the business field took the IoT to the next level before the education sector could adopt it. In 2003-2004, the IoT based projects, namely Cooltown, Internet0, and the Disappearing Computer initiative, gained space on the book titles for the first time (Ali, Ali & Badawy, 2015). RFID was gaining popularity in leaps and bounds as it was employed by the Defence Department of the United States (Ali, Ali & Badawy, 2015). In 2005, with its first report by International Telecommunication Union, the IoT made a prominent establishment (Ali, Ali & Badawy, 2015). In 2008, the corporates, to name a few, Cisco, Intel, SAP and many other companies, initiated the IPSO Alliance to promote and market the IoT concept. The credit of giving birth to the IoT goes to Cisco Cisco Internet Business Solutions Group (IBSG) in 2008-2009 (Postscapes, 2014). In a nutshell, IoT can be defined as "a set of smart things/objects such as home devices, mobile, laptop, etc., addressed by a unique addressing scheme and connected to the Internet through a unified framework this framework may be cloud computing" (Ali, Ali & Badawy, 2015).

Following this, in Europe, the *Internet of Things-An action plan for Europe* (Ning & Hu, 2012) incorporated IoT research and education, which further inspired Japan, Korea, and Singapore to launch IoT research programs. In China, the Minister of Education (MOE) proclaimed a list of novel undergraduate majors, including IoT, as a mainstream (2010). Gui (2010) examined the need for an effective curriculum for IoT as a major that the colleges can refer whereas Hu (2010) proposed a curricular system for the IoT engineering stream, Chen and Shi (2011) for the IoT construction major and Xie and Huang (2011) for the IoT professional personnel training. Zhang and Yu (2011) listed the expected qualifications of the IoT qualified personnel by highlighting the objectives of IoT personnel.

Nevertheless, the higher educational institutes realised that they would be lagging behind if the concept of IoT was not embedded in their academic system. From administration to teaching until research, every university employs cloud computing to manage the database and keep track of every iota of the educational processes with respect to every bonafide individual associated with the university. The current status of the IoT in the HE institutes and the possible future action plans are listed in this article to benefit the research community as well as to track the progress of the same in the future to predict further. We need to wait for what 5G would contribute to us.

2. Overview of Current IoT in HEIs

The IoT encourages the development of cheaper and smaller wireless systems that can be integrated into various devices that consume less power. It comprises three components that allow interconnections, which are hardware, middleware, and presentation. According to Aldowah et al. (2017), the hardware consists of embedded communication gadgets, actuators, and sensors; middleware includes on-demand computing and storage tools for analysing data, while the presentation aspect entails interpretation and visualisation tools, which can be accessed using various devices and different platforms for various applications. Various communication technologies can be used in IoT implementation, such as Near Field Communication (NFC), Bluetooth variants, ZigBee, and Wi-Fi. Other formats that can be used include Radio Frequency Identification (RFID), which allows wireless communication through microchips and can incorporate Wireless Sensor Capabilities (WSN) that can be used with books or wearable devices (Aldowah et al., 2017).

IoT is currently one of the trends determining technology developments (Abd-Ali, Radhi, & Rasool, 2020). It is connected with Ambient Intelligence, which includes smart environments that respond to people's presence; Augmented Reality, where virtual reality and physical users

are fused; Wireless Sensor Networks, where environmental or physical conditions are monitored using distributed sensors; Cloud Robotics, where robot capabilities are augmented through cloud computing; Ubiquitous Computing, which connects real world and virtual world through web services; Web mashups, where real-world devices can be mixed to create applications; Semantic Web, where machine understands the human knowledge; and Web-Squared used to integrate sensing and web technologies (Dregvaite & Damasevicius, 2014).

2.2 Smart Campuses

The term "smart" has been used in different fields to indicate the digitisation of campuses by incorporating smart technologies. Some scholars have stated that the term "smart campus" is adopted from the term "smart cities" through the application of the latter's principles to the operations of the universities' campuses (Gupta, & Kar, 2015). The use of such smart technologies in campuses has already started, aiming to digitise campuses, provide services in a timely manner, reduce effort, and reduce operating costs, which are burdens in the traditional campuses (Galego, Giovannella, & Mealha, 2016; Majeed, & Ali, 2018). The idea behind smart campuses is to overcome the issues and challenges of the traditional campuses so that the university can provide better services for students and staff, especially that the smart campuses help universities' leaders to have better decisions to improve the university. Some universities have already started investing in IoT. Birmingham City University, for example, invested £260 million to transform its campus into a smart campus, and they could save £140 thousand of energy cost savings, and reduces 40% of CO2 emissions (Abuarqoub et al., 2017). Also, the University of Glasgow is investing £800 million to transform the campus into a smart campus (Abuarqoub et al., 2017), with the purpose of cost-saving and increasing efficiency of human interaction.

One of the applications of the smart campus is to save cost and energy by installing IoT services to monitor environmental conditions such as temperature, humidity, pressure, natural lighting, auto switch for lights, and controlled ventilation (Hipwell, 2014; Abuarqoub et al., 2017; Subbarao, Srinivas, & Pavithr, 2019). IoT services can also control the services in buildings, such as switching off the light in empty places and adjusting the temperature in buildings and classrooms during the day (Alghamdi, & Shetty, 2016). Such services reduce costs and efforts and contribute to environmental sustainability since the sensors on the campus can control energy consumption.

Another application of IoT in Campuses is security since sensors might automatically detect the faces of the people going in and out of the campus and those who are visiting non-authorised areas inside the university (Abuarqoub et al., 2017). Such face-recognition merit of IoT might also be used for marking the attendance of lecturers, staff, and students (Alghamdi, & Shetty, 2016), which solves one of the issues that has passed different solutions, but none of them seems to be efficient like using IoT in the campuses. IoT technology might also increase the security of asset track record, valuable things, student record, the security of paper exam, and original certificate, which helps to solve a major concern for the documents of the graduates at the university.

The study of Widya Sari et al. (2017) added that smart parking is essential in the smart campus through a parking system that enables campus visitors to find empty parking for staff, academicians, and students. They added that IoT supports the integration of smart rooms because IoT systems give information about the vacant classrooms to be used by lecturers, students, or management.

Other studies have highlighted the centralisation and communication advantages of using IoT (Phougat, Wakurdekar, Pruthi, & Sinha, 2017; Subbarao, Srinivas, & Pavithr, 2019). That is, centralisation refers to interconnection among departments so that all the activities in every department can be managed through IoT services. In terms of communication, using smart campus through the adoption of IoT helps to implement effective communication with students and parents, especially in terms of registration, fees, holidays, examination time table, events, and results. These activities can be managed better and easier with the adoption of IoT.

2.3 Smart University

The term "smart university" refers to utilising smart technologies, especially IoT, to improve the students' academic performance (Takpor, & Atayero, 2015; Aldowah, Rehman, Ghazal, & Umar, 2017). The current status of education shows that technology has the potential to improve students' learning. There are many ways to improve learning through IoT as it supports cooperation among students; develops active learning; increase communication between teacher and student; facilitates discussions; and supports different ways of learning (Banica, Burtescu, & Enescu, 2017). However, creating smart universities is challenging due to the requirements of advanced data fusion and optimisation and the need for real-time and high-speed communication. Accordingly, smart universities need to ensure that the pedagogical methods and computer teams support IoT implementation (Liu, 2017; Wang, 2017; Rico-Bautista, Medina-Cárdenas, & Guerrero, 2019). Figure 1 shows the basic elements of a smart university (Maciá, Berná, Sánchez, Lozano, & Fuster, 2017).

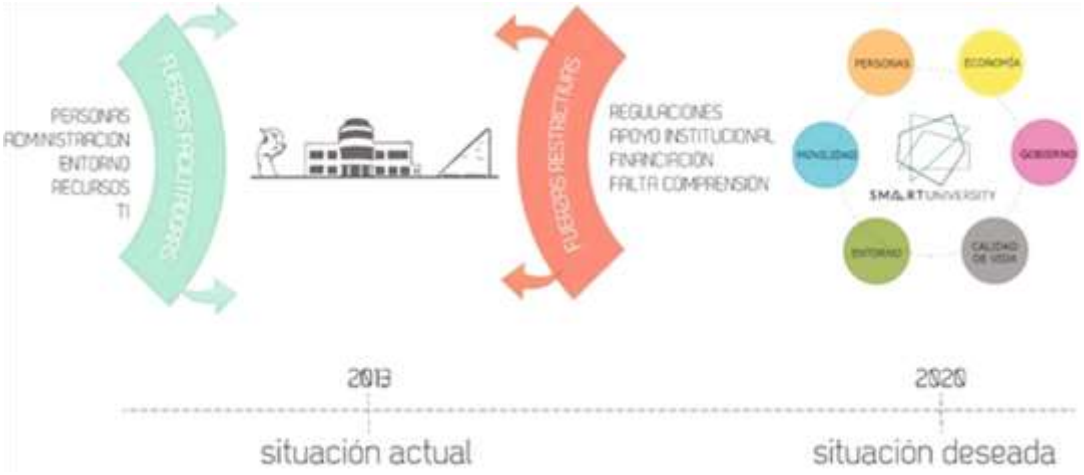

Figure 1. Components of a smart university (Maciá, et al., 2017)

One of the advantages of IoT is having e-classrooms (Subbarao, Srinivas, & Pavithr, 2019). These e-classrooms make education smarter through the centralised sharing of knowledge, enabling the students to get better by reading and understanding the courses innovatively. The innovative research-oriented technology plays a main role in this regard to improve the students' learning skills and academic performance. Subbarao, Srinivas, & Pavithr, (2019) added that smart classrooms of IoT are connected with multimedia devices to make learning easier, and the students can study from any place if they are absent and cannot attend the classroom. Students who might not be able to attend the classes for any urgent reason such as the outbreak of COVID-19, can attend the classes remotely, and they can study lessons even from home effectively (Alfiras et al., 20210).

The process of learning in an intelligent environment has four stages: the learning process, the assessment, the interaction, and the analysis of learning and results. These stages can be performed better by adopting an IoT intelligent system, which can suffice the students' aspiration and mental abilities of students to provide a better learning environment (Lazaroiu, G. C., Dumbrava, V., Costoiu, M., Teliceanu, M., & Roscia, M. 2015; Alghamdi, A., & Shetty, 2016). According to Subbarao, Srinivas, & Pavithr (2019), an advantage of IoT in universities in the Learning Management Systems (LMS), which provide practical learning activities. These activities include content, communication between lecturers and students, collaboration among students, assessment by lectures, and assessment by the students at home, and course design. These steps show that IoT can make learning more effective for university students.

An important advantage of IoT adoption at the university is the improvement of distance learning. Distance learning is increasing because many people are tied with their jobs, and they cannot attend classes at the university (Kiryakova, Yordanova, & Angelova, 2017). Also, some students might need to study courses that are available in a foreign university or a university located in a distanced place. An

important aspect of distance learning is the flexibility of time and courses because students can customise courses according to their needs and according to their free time, which helps students to work to earn a livelihood and continue their education (Zheng, Guan, Li, & Deze, 2016).

The IoT-based smart library system is an additional value for university students. Smart libraries can automatically authenticate users, reply to their inquiries, provide them with the required publications, issue and return books, and assist them in their research for references (Vaidya, Snehal Kulthe, Khaire, & Kela, 2017; Kaladhar, & Rao, 2018). Smart library systems can be designed to serve the universities as in (Brian, Arockiam, & Malarchelvi, 2014), who proposed an IoT based smart library system that enables students to fetch a book from its place using a triangulation Wi-Fi-based local positioning system and Near Field Communication (NFC) tags.

Another advantage of IoT is smart laboratories that help students to benefit better from the available resources. IoT based smart labs help can be managed virtually through the voice of the students (Knight, Kanza, Cruickshank, Brocklesby, & Frey, 2020). This saves time since IoT systems can guide students to the sources in the lab. Also, the IoT-based smart labs can control the lab air conditioners and track the students' usage of the lab computers, which might be auto-switched off when students do not use them. Such auto management in smart labs saves the time of students in finding a place to work, and it guides them to utilise the existing resources. Also, air conditioners and electricity powers are controlled by IoT systems to save energy, and it supports environmental sustainability.

To sum up this section, the integration of IoT in HEIs has not reached its full adoption, and this is attributed to the challenges posed by the requirements of smart campuses. That is, adopting IoT in universities might need thousands of sensors and other devices that are a burden at least in requiring manual configuration (Rico-Bautista, Medina-Cárdenas, & Guerrero, 2019). Also, the adoption of IoT in campuses requires various devices that need to work in a single system, which is a challenge, in addition to the challenge of analysing the huge volume of data to change them to information that the university can utilise to improve its performances (Atzori, Iera, & Morabito, 2017, Alakrash et al., 2021). However, the orientation of universities towards smart campuses might provide better solutions, and the requirements in the future might not be the same as it is in the current time. In other words, scientists and scholars are still in the wave of innovation and creativity of smart campuses, and their efforts are surely going to provide easier ways to implement IoT in campuses instead of the huge requirements in the current time.

3. Future of IoT in HEIs

IoT aims to replace how institutions work by increasing the students' learning capacity at all levels. More progress is required to influence the IoT applications, systems, services, and devices' outcomes. Imperatively, IoT is rapidly developing and becoming an indisputably developing topic of interest and concerns among diverse stakeholders in education worldwide. Many signs show that technology will change various divisions and education establishments, specifically higher learning institutions. Today, institutions are deploying advanced IoT models, which would cater to the IoT service industry in the future, taking into account the Trust, Identity, Privacy, Protection, Safety, and Security in IoT scope (Aldowah et al., 2017). IoT should fully emulate learning in institutions and various justification components and the purpose within the higher education scope (Banica et al., 2017).

A recent IoT communication infrastructure has visualised the future where day-to-day activities will be based on intra-communication of microcontrollers and transceivers via numerous protocols. The technology would allow communication between various users, making it the hub of the e-learning structure (Abd-Ali, Radhi, Rasool, 2020). Various devices, including cameras, smart-watches, digital displays, and audio recorders, could be interconnected and would be able to transform and exchange information. The interconnectivity concept would provide learners and teachers dynamic services through gathered and generated IoT devices' data. The technological revolution has enabled universal interaction between objects, people, and environments (Majeed & Ali, 2018).

3.2 Use of Actuators and Sensors

The embedded actuators and sensors collect and transmit data to respective applications for processing. Hence, IoT has been acknowledged as a crucial component of industrial and business change in the contemporary world. This realisation has helped to change physical surroundings into smarter environments through various interconnections. Almost every life aspect has changed concerning efficiency, economy, sustainability, and accuracy. Industries, including energy management, weather forecast, smart homes, airport traffic control, education, environmental monitoring, healthcare, and traffic management systems, have already incorporated IoT. Therefore, players in the education sector are trying to streamline the processes to promote sustainability in learning institutions (Majeed & Ali, 2018).

3.3 Use of Smart Objects and Wearable Devices

Various universities have incorporated the use of wearable devices and smart objects in classrooms. Essentially, massive data amounts are being produced reasonably using actuators, chips, and sensors through these gadgets, which extensively depends on IoT. The IoT impact in learning institutions is focused on this research, which looks at the education model concerning education and the IoT practical aspect in learning and teaching improvements, attendance monitoring systems, classroom management methods, institutions' security, and students' healthcare management. Today, many devices collect data about us without even our knowledge using things controlled by sensors, made for information gathering, worn on our bodies, or installed into objects. Such things communicate and share data via the cloud or the IoT. Considering its rapid developments, it is important to consider its qualities and prepare for its inevitable impact on education. The way it is incorporated in institutions will determine how people would move into a world of expanding interconnectedness (Majeed & Ali, 2018).

3.4 Use of RFID and NFC Technologies

Access to learning institution facilities such as classrooms, libraries, and laboratories could be managed using current technologies to make them safe and secure for students. For instance, to improve security, RFID, or NFC technologies could be used to ease access control. NFC can help create classroom control, where students' attendance information is collected using connected sensors, which can be displayed in a school's application. Besides, RFID tags could help monitor students' locations within the institution. Such IoT technologies can help transform an institution into a smart one (Majeed & Ali, 2018).

3.5 Use of Gadgets for Virtual Learning

IoT can improve the learning experience by offering actionable and immediate discernments of student performance. Today, most university students have moved to laptops and tablets and away from textbooks as their primary modes of taking notes and making recordings in the classroom environment. Accordingly, this advancement in the classroom setup gives students the flexibility of learning on their own in an environment similar to that of a classroom. Imperatively, virtual learning allows students to follow all proceedings in class from the comfort of their hostels. This has contributed to an increase in satisfaction and progression rates, and it has enabled instructors to have persistent assessments and one-on-one instructions (Abd-Ali, Radhi, Rasool, 2020). It is worth noting that virtual learners have adequate time to consult with their tutors on a diversity of issues and concepts learned in class. Therefore, by incorporating IoT in their teaching activities, instructors can also gather information about students' performance, which can help them determine the kind of attention needed by every student. The availability of this information could assist them in changing methods and plans for classes in the future, given that the one-on-one interactions could help them assess the learners' levels of comprehension and ability to grasp and apply concepts learned in class. Device connectivity provides for dynamic classrooms, and logging attendance and interventions will be streamlined by supporting the use of wearable devices that can show and acquire students' ECG patterns. Besides, devices can also encourage students to study by giving warm-up exercises and activities, and the student's cognitive activities can be monitored using EEG sensors (Aldowah et al., 2017).

3.6 Computer-Supported Collaborative Learning

IoT provides for Computer-Supported Collaborative Learning (CSCL), an environment that allows students to build knowledge, share experiences, and interact actively. A CSCL that incorporates face-to-face interactions provides a highly motivating learning environment, which helps promote student collaboration and change the classroom dynamics to achieve good results (Yassin et al., 2019). The learning environment's dimension has also been improved by the addition of educational robotics to form a Mobile Robotic Supported Collaborative Learning (MRSCL). While still upholding the fundamental technological assistance, collaboration, and face-to-face interactions, Educational Robotics enables the inclusion of real-world capabilities (Plauska & Damasevicius, 2014). This transforms the virtual environment associated with eLearning into a real environment, which gives students a shared resolution space where world immersion and exploration are enabled through mobility. Besides, with independent navigation and flexibility, the robot can interact with a group of students and the physical world. MCSCL presents an environment that encourages constructivism for new knowledge in a more instinctive manner as directed by the instructor (Dregvaite & Damasevicius, 2014).

3.7 5G Technology

New technology is improving IoT and changing people's ways of life, which is considered the next cellular communications generation. This technology is known as 5G. It is an improvement of the current network technologies with regard to reliability, the density of devices, and bandwidth (Park, Jabagi, & Kietzmann, 2020). The technology is being incorporated in various educational scenarios, such as the advanced instructive applications and services in music subjects. Music is a good example to test such a solution because of the low-latency requirements and tight multimedia connections. 5G can allow synchronous interactive sessions that enable instructors to interrelate with students with full access to visual materials. As a result, 5G can bring about ground-breaking eLearning virtual and augmented settings and improve current initiatives (Baratè et al., 2019).

4. Conclusion

In retrospect, the Internet of Things (IoT) is an important technological innovation for application in the education sector. Learning institutions can leverage IoT to provide solutions to various challenges, including building smarter plans, monitoring vital resources, designing safer learning facilities, and developing access to information. Such systems can bring substantial value to education by motivating and engaging staff and students and improving the learning speed. Moreover, IoT can improve the interactions between learners and instructors, consequently improving the learning outcomes. Therefore, given that technological developments are increasingly dynamic, there is a need for further studies to focus on the effective application of IoT in the higher education sector.

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