

## USAGE OF INTERNET OF THINGS (IOT) TECHNOLOGY IN THE HIGHER EDUCATION SECTOR

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### Abstract

Internet of Things (IoT) is a potential field of the future. It improves modern human life in many sectors. It helps establish smart cities, smart environment, security, intelligence, industrial control, automation, agriculture, health, education, and especially in the higher education sector. This technology is used to improve the comforts of people. It signifies a grand opening in the education field. It can collect the data, improve the learning knowledge, and support providing a better learning process environment. Its usage in the different areas is growing fast, especially in smart cities and higher education institutions. Therefore, it is very productive to use this technology in a better way. This article explains a brief introduction to the IoT and how they benefit from this higher education technology. In this paper, the concepts of smart campus, smart classrooms, and intelligent labs are discussed. The authors explain how it is beneficial for the students, teachers, and universities for higher education processes and faster learning. A comparison of conventional and IoT supported institutions are also explained in the paper. Moreover, it is explained that how it is better than traditional classes are studies. Different challenges are involved in implementing it in the universities, which are also highlighted in this paper. A framework for implementing these services is in progress, which is a part of our future work.

Keywords: Connected devices, Education, E-learning, Higher education, Internet of Things, Smart classrooms.

## 1. Introduction

IoT is comparatively a new technology, which rooted itself in different sectors, especially in education systems. It is expected to make more changes in this area after the extensive use of this technology. A lot of IoT devices can be used to interact with the board, like digital highlighters. Text can be transfer digitally to the cellphones with the help of a digital scanner. Students can communicate with their teachers, peers, and experts from the whole world by sitting in classrooms with these network devices [1]. The authors focus on the services of IoT in the Learning Management System (LMS). It enhances the framework of LMS, which is introduced by the authors [2]. This framework explains many current services provided in the LMS with some new features, which are possible due to IoT devices enhancing the model. Veeramanickam and Mohanapriya [3] introduced a new model, "ICampus," in the universities for e-Learning purposes. In this model, the concept of "Smart Classrooms" and "Smart Labs" is presented. All the data related to the classrooms is collected and upload for use in the future. Moreover, by using "Smart Notes Sharing," a person connected to this network can share classroom notes/data using these smart devices, which can provide you real-time data to E-Learning applications.

Selinger et al. [4] discussed the Internet of Everything (IoE) concept as a network of data, people, things, and processes. IoE is not focusing on IoT, which is a composition of objects of material things. It provides power processing to millions of devices that are related to objects and people as well. Charmonman et al. [5] claimed that IoT can provide a reason to learn more with the help of this modern technology. Instructors can teach their students according to their experience and provide materials to their learners in real-time. Learners can learn more according to their level and capabilities. The authors conducted experiments that provide evidence about the improvements in student's education-related issues.

An agent-based architecture is introduced for the knowledge in a standard collaborative environment presented by Mershad and Wakim [2]. Objects of the solving problems run continuously and can regulate their behavior according to changes in the atmosphere. It controls their actions and internal state and keeps the path and knowledge while focusing on their goals. It takes proactive initiatives to fulfill its requirements. Smart agents are installed in an IoT system to create a Multi-Agent System (MAS) for better student learning by endorsing a real-time collaboration among teachers/ students.

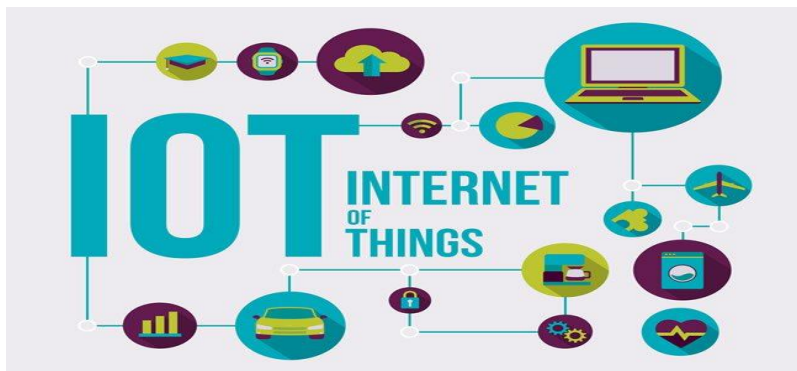
IoT allows interacting with the physical universe for communication and learning uses. These physical spaces use in the classrooms to monitor the teaching activities. It can contact the associated data recorder to contribute to the e-learning area [6]. In this way, a simple old classroom can transform into a smart class that can synchronize with the e-learning applications. A study conducted to discover IoT's environment in the higher education sector. The study aims to maximize its benefits and decrease hazards in connecting with devices. The article studies the comparison of the results of IoT in higher education institutions [7].

The term "Living Lab" use in the EU for the first time. Research conduct to join different concepts, including IoT, i-campus, smart box, and Pervasive-interactive-Programming (PiP). This study aims to teach necessary programming skills to beginners by using IoT and PiP technology. An evaluation study conducted to ass its performance shows that PiP helps students and staff improve programming skills [8]. Another study was introduced for the lab development kit through sensors with

Zigbee and Rasberry Pi/ Arduino boards, maintaining wireless communication. A module design technique leads to course labware. This Raspberry Pi-based Lab Kit response was positive by the student, pointing towards a new field [9].

This research article provides an overview of IoT in the higher education sector and also explores the possible impact of IoT in this sector with some future challenges. The remainder of the paper is organized as follows. Section 1 discusses all the introductions. IoT work in the field of the higher education sector explains in Section 2. In Section 3, different challenges involved in IoT are present. Section 4 consists of the conclusion the future work.

Kevin Ashton was the man who uses the term "Internet of Things" (IoT) for the first time in 1999. The researchers define IoT as an Internet of People, Internet of Anything, Internet of Everything, Internet of Marks, Internet of Data, and internet of Services [10]. IoT is a worldwide network that joins things and provides resources to the internet to communicate with the environment [11]. IoT is a system of interrelated computing devices, mechanical and digital machines that provide unique identifiers. It can transfer the data over the network automatically without human or computer interaction. Sensors play vital roles in the implementation of IoT technology. Nowadays, billions of IoT units with IP Connectivity install in the world. IoT technologies improve human life in different sectors like smart cities, smart homes, elder care, medical/health care, transportation, industrial applications, agriculture, energy management, environment management, living labs, military use, and education sectors. Figure 1 shows its uses in different phases of lives. Our focus in this paper is how IoT can be useful for the education sector and especially in the higher education sector in learning for the next generation.



**Fig. 1. Usage of IoT technology in different ways.**

The IoT is a modern technology for researchers to develop small and more affordable wireless systems, which use less energy and easily integrate with other devices [12]. IoT has three essential components: Hardware, made of sensors, actors, and actuators; Middleware: has storage and computing abilities for data analysis; and Presentation: is a visualization and interpretation tool that can be retrieved on many platforms and also designed for different applications as well. Various technologies for low-power communication to IoT devices like ZigBee, Bluetooth, NFC, and Wi-Fi introduce, but Wi-Fi is more famous for wireless technology. IoT also enhances the different other formats like Radio Frequency Identification (RFID) used in business, industry, and personal technology systems [10].

Internet of Things (IoT) can manage things efficiently and economically. Smart buildings are an essential part of smart universities. It can save time, maintenance, environmental protection, adequate parking, and improve energy management. The University of Brescia established its smart campus with smart facilities in the classrooms, labs, and buildings [13]. Universities having IoT-supported infrastructure are better than the conventional universities, which have no smart devices, and universities educational institutions are better than the universities, which have no such setup. Table 1 shows the detailed comparison of the facilities with and without IoT in the universities.

**Table 1. Comparison of facilities in conventional and IoT supported universities [14].**

Facility Name	Conventional Universities	IoT Supported Universities
<b>Campus</b>	The campus is unsafe and difficult to control.	Intelligent, safe, and easily controllable
<b>Learning</b>	Lecturers are recourse of information	Distinguish learning, and students can learn remotely
<b>Building</b>	Difficult to manage the resources	Smart and easy to manage the buildings
<b>Attendance</b>	Attendance is manual, which takes time and effort	It uses a different attendance system automatically.
<b>Students tracking</b>	It is tough to follow students on campus	It is effortless to track students on campus
<b>Parking</b>	Difficult to find a parking space for the faculty and students	It is easy to find a parking lot for the university community.
<b>Energy</b>	It is challenging to manage energy consumption in the conventional setup.	Easy to manage energy consumption
<b>Security</b>	Security of the institutions are difficult to manage	With the help of different smart devices, a campus can be safer
<b>Governance</b>	Governance is not easy.	Governance is more comfortable and manageable

The future of the universities not connected with just adopting the available technology on the campus. It is all about using modern technology smartly by adapting to the institutions' current and future needs. It can make the learning process easy for the students and the teachers to perform their teaching skills more efficiently with technology. A smart university can be developed by using its strategic plan, which is called a framework. Universities are assigning their budgets to spend their resources for the implementation of digital transformation. This strategic plan of the university should meet the mission and vision of the institution. These smart campus services are similar to smart city facilities with some additional needs of the universities.

## 2. IoT in the Education Sector

The environment of the universities can entirely change by using IoT based smart facilities in the institutions. It can improve the overall facilities by applying IoT technologies. A digital campus is establishing, along with smart classrooms, smart laboratories, and smart buildings. Different applications can develop to manage these devices and systems. Here is the brief of such systems:

A digital campus system is a vital podium for the students to get all sorts of information [15]. New technologies are changing the campus administration areas as well. Advancement in technology is increasing the demand for higher educational institutions to digitize all contents and events. Their focus is to adopt such methods, which allow academic and research related members to work efficiently in a digital environment [16]. An established physical campus integrating with technology can provide a digital university base, which provides appropriate settings and services for training, learning, and research work. It provides supports and inspires the ultimate learning [17]. A digital campus for the universities must possess the technology supporting the teaching, education, and cooperative research. All the digital universities have some intimidations; however, only a few have the vision to make the strategy and implement it with the state of the art of technology [18].

Implementing the digital campus can decrease the university's operational cost and security improvements and provide more tools to the academics, students, staff, and scholars. A digital campus consists of two parts. First, it uses the existing IT Services Delivery Platform to offer network connectivity and security while using these applications and other necessary services on the campus. Secondly, different IoT applications supported by digital campus support university professionals, allowing teaching and learning activities to improve the students' experience. As per Cisco's "Digitizing Higher Education To enhance experiences and improve outcomes," IoT network applications are different from other conventional applications because they support sensors and their data instead of users and their data. IoT application for a modern digital campus can consist of five key types: Building Control and Management, Security and Access Control; Video and Information Systems; Location and Attendance Systems; and Energy Monitoring and Control.

IoT supported smart universities emphasizes the applications which enhance the structure and provide academic services. It is applied to the units within and outside the educational domain due to the financial and economic perspectives. Now a day, smart universities and smart campuses have become the buzz word [19]. Different services for socialization, sharing of events information, and hangout provide on the campus. These services are classified into different domains like academic, social, and practical lives [20]. An application developed by the University of Twente (UT), Netherland, to find the existing problems, a request can be submitted for the maintenance, repair work, and monitor its progress.

Moreover, Birmingham City University, UK linked the intelligence into the university to improve the business processes with the low energy consumptions. Saint Lous University, USA debates on the smart campus while focusing on improving different smart campus aspects but does not develop any general model [21]. A smart campus network can work using the 4G/5G network technology to implement an online teaching system. Different localization algorithms can use to find the students' location, arrival time, data transmission, and other necessary information [22].

A wireless network plays a vital role in the digital campus, designed to fulfill all the modern university requirements. Different objects of the university, like doors, projectors, printers, classrooms, conference halls, laboratories, parking areas, buildings, can convert into smart objects by using sensors, RFID, NFC, and

QR tags with the help of IoT technologies [23]. In this way, a digital campus, all the spaces like classrooms, halls, labs, sports venues, restaurants, and hostels can be an area to train students anytime and anywhere. It will lead the universities into global learning and training centers [24]. A smart campus system can be a set of numerous smart application areas, as shown in Fig. 2.



**Fig. 2. Main areas of a digital campus.**

An intelligent digital campus may consist of the following things:

- IoT supported Smart E-learning
- Smart IoT-based Classroom
- IoT supported Smart Labs
- IoT supported Sensors for Notes Sharing
- IoT Sensors used for Mobiles Devices
- IoT supported Hotspot for Campus
- Smart Parking and lighting
- Smart Inventory
- Smart Students Tracking
- Datacenters

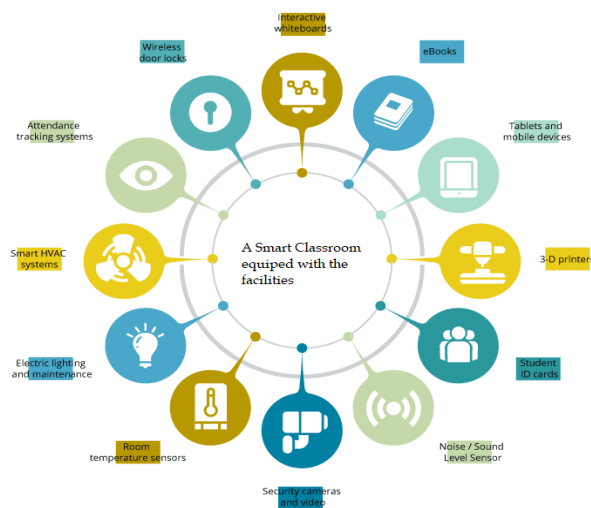
### **2.1. IoT based classrooms**

IoT-based smart classrooms mean providing an intelligent environment equipped with the latest IoT technology or smart things. These smart nodes stuff can be a camera, a microphone, or any sensors, which can use to evaluate student's contentment regarding their learning. These smart things provide easiness, comfort in teaching, management of the class, and overall teaching environment. A teacher uses a classroom management application approach to control his classroom. The teacher's sound level can be controlled according to the environment to deliver lectures efficiently. A smart classroom allows teachers to what students want to study and how which is beneficial for both students and teachers. This advancement in education technology is assisted faculties in designing modern classrooms. Taking attendance in the class is a time-consuming job that can manage with IoT technology. RFID tags card is attached to the student ID cards. A Classroom Roll Caller System (SCRCS) is set up in every classroom to easily read students' identity cards. This record is available online for the academic office as well.

Moreover, a web-based attendance system by using NFC technology can use in Android smartphones. The students just tap the card to this NFC supported android smartphone for attendance, and it saves it on the server spontaneously. Student's feedback related to lecture quality is quite essential. An IoT supported smart classroom provides a real-time opinion from the student using sensing students' reactions and monitoring technology. Figure 3 shows some devices used in a smart classroom.

The usage of IoT devices in the education sector is a hot development across the world. It provides an innovative approach to education and classroom controlling. Many tools are used; some of the commonly IoT devices used in the classes are:

- Interactive Whiteboards
- Tablets and Mobile devices
- eBooks
- 3-D Printers
- Student ID Cards
- Attendance Tracking Systems
- Security Cameras and Video
- Wireless door locks
- Room Temperature Sensors
- Electric Lighting and Maintenance



**Fig. 3. A smart classroom.**

## 2.2. IoT based labs

An IoT-supported lab consists of lab equipment with new IoT technology and mobile applications. Interactive tests and simulations perform remotely, connecting with different apparatuses like a microscope, oscilloscope, and chemical reactor

with these IoT devices. It allows students to access these devices and remotely control them using a Learning Management System (LMS). A student having a valid user and password can log in to the system to perform any specific experiment. He/she will select the required lab and type of test, which has to perform. The students can also use the IoT module to collect the prerequisite data for the experiment, if required, and save it for further use. Grade distribution and assessment methods are defined by using IoT. Once the student completes all its attempts or the time mentioned for this lab experiment is finished, LMS integrating with IoT supported sensor modules can automatically evaluate them. A student can save necessary readings on the LMS, which can reflect in his/ her profile. It reduces the considerable burden on the faculty.

### **3. Critical Challenges of IoT in the Higher Education Sector**

IoT facilitates the education sector and makes the classroom environment smart. The exceptional development of global computing, IoT technology like cloud computing, big data, and analytics supports enlightening the values of training and quality of research. It also changes the IoT society and encourages a new digital philosophy. There is an immense increase in the online classes and degree programs day by day. It makes the digital momentum higher in educational bodies, especially in higher education institutions. For successful integration of IoT devices in the campus, educational institutions may face numerous challenges, which discuss below:

- Most of the universities are using a hybrid cloud to host IoT applications as their enterprise architecture. The Millennials generation, which is studying in universities, is using a tablet or mobile technology. It opens new methods to upsurge the enterprise architecture effectiveness, instructional technology, research, and educational environment. Cloud provides us with seamless connections and IT services. Enterprise architecture used in universities depends upon hybrid cloud setups with computing podiums on private clouds. There is a significant demand for content because of the substantial growth of audio and video instructions; therefore, it needs to reduce latency time in the institutions' enterprise architecture.
- The use of e-learning management systems like Blackboard and Moodle generates a considerable amount of data in audios and videos. IoT-based classrooms and labs furnished with the latest equipment used for lecture recording and web streaming allow students to access this data when requested. IoT must deliver extra agile and firm services level agreements to handle this data during online courses.
- IoT offers exceptional opportunities to deliver digital courses while maintaining the quality of instructions. This digital instruction highlights students' different ethics, academic honesty, plagiarism, and data fraud in scientific societies. Therefore, IoT-based informative applications, various tools, and technologies for the teachers and scientific communities develop to improve research work and address these ethical issues in higher education institutions.
- The use of different IoT based applications is increase with the integration of mobile learning applications for the student's evaluation. These typical applications can support students to learn resources, cope with assignments,



and working on projects. Teachers use some other apps to demonstrate technical concepts, simulations, and others.

- The successful implementation of IoT technologies in the higher education sector involved different security and privacy challenges. Although some work is done in IoT infrastructure and its security still, no strategy is defined to identify business risks related to data breaches. Therefore, the higher education sector needs to develop some standards to secure these IoT supported applications, collaborative methods for the safety, security, and privacy of valuable data.
- The overall cost of IT technologies is increasing every year because of content and application stacks increase. Most of the institutions have no strategy for sharing the cost of overall IoT infrastructure. They have budget constraints as well. Therefore, the higher education sector must emerge with new finance, IT infrastructure, and services.
- It is noticed that sometimes there are devices and applications, which are incompatible with building an IoT set up in educational institutions. IT equipment and teaching methods must support the IoT technology on the campus. Therefore, high risk and some other barriers are involved while going for IoT options.
- Data integrity, accuracy, and authenticity are another challenge in successfully implementing IoT in the higher education sector. Educators need to work with government agencies to ensure the development of IoT in this sector. There is a lack of robust policy in the adaption of technology in classrooms. Therefore, an effective integration into the program is required.
- A high-speed wireless network is required to provide adequate bandwidth for the audio, and video streaming of the lessons is required continuously.

#### 4. Conclusion and Future Work

Modern technology, especially IoT in the higher education sector, has opened many doors for innovative ideas to better the educational environment. Ample research is conducted to design digital campuses, smart classrooms, and smart laboratories while facilitating the students and teachers in recent years. Many new devices and applications introduce related to IoT, which will enhance over time. The study aims to find out more potential areas of it to get more benefit from it. It is observed that different challenges are involved in implementing it in the education sector. Therefore, it needs more study and attention to handle these problems. It requires a comprehensive framework and methodologies to address these challenges.

Critical future challenges are listed in the paper, which needs to address as future work. Therefore, a detailed framework for the next generation of smart campuses and universities will be designed.

#### References

1. Ralhan, B.D. (2017). How IoT is transforming the education sector. Inc42, Retrieved August, 1, 2017.
2. Mershad, K.; and Wakim, P. (2018). A learning management system enhanced with internet of things applications. *Journal of Education and Learning*, 7(3), 23-40.

3. Veeramanickam, M.R.M.; and Mohanapriya, M. (2016). Iot enabled futures smart campus with effective e-learning: I-campus. *GSTF journal of Engineering Technology (JET)*, 3(4), 8-87.
4. Selinger, M.; Sepulveda, A.; and Buchan, J. (2013). Education and the internet of everything. Cisco Consulting Services and Cisco EMEAR Education Team.
5. Charmonman, S.; Mongkhonvanit, P.; Dieu, V.; and Linden, N. (2015). Applications of internet of things in e-learning. *International Journal of the Computer, the Internet and Management*, 23(3), 1-4.
6. Dlodlo, N.; Foko, T.E.; Mvelase, P.; and Mathaba, S. (2012). The state of affairs in internet of things research. *The Electronic Journal Information Systems Evaluation*, 15(3), 244-258.
7. Yu, Y.; Wang, J.; and Zhou, G. (2010). The exploration in the education of professionals in applied internet of things engineering. *4th International Conference on Distance Learning and Education*. San Juan, USA, 74-77.
8. Chin, J.; and Callaghan, V. (2013). Educational living labs: A novel internet-of-things based approach to teaching and research. *9th International Conference on Intelligent Environments*. Athens, Greece, 92-99.
9. Temkar, R.; Gupte, M.; and Kalgaonkar, S. (2016). Internet of things for smart classrooms. *International Research Journal of Engineering and Technology*, 3(7), 203-207.
10. Gubbi, J.; Buyya, R.; Marusic, S.; and Palaniswami, M. (2013). Internet of things (IoT): A vision, architectural elements, and future directions. *Future Generation Computer Systems*, 29(7), 1645-1660.
11. Gowrishankar, S.; Madhu, N.; and Basavaraju, T.G. (2015). Role of BLE in proximity based automation of IoT: A practical approach. *IEEE Recent Advances in Intelligent Computational Systems (RAICS)*. Trivandrum, India, 400-405.
12. Jing, Q.; Vasilakos, A.V.; Wan, J.; Lu, J.; and Qiu, D. (2014). Security of the internet of things: Perspectives and challenges. *Wireless Networks*, 20(8), 2481-2501.
13. Abuarqoub, A.; Abusaimh, H.; Hammoudeh, M.; Uliyan, D.; Abu-Hashem, M.A.; Murad, S.; Al-Jarrah, M.; and Al-Fayez, F. (2017). A survey on internet of things enabled smart campus applications. *In Proceedings of the International Conference on Future Networks and Distributed Systems*. Cambridge, United Kingdom, 1-7.
14. Ahmed, V.; Alnaaj, K.A.; and Saboor, S. (2020). An investigation into stakeholders' perception of smart campus criteria: The American university of Sharjah as a case study. *Sustainability*, 12(12), 5187.
15. Tegta, O.; Khurana, R.; and Kaur, R. (2016). *Placement question bank: Android informer*. Bachelor Degree. Department of Computer Science and Engineering and Information Technology, Jaypee University of Information Technology Wanknaghat.
16. Sherson, G.W. (1999). *Education and the digital campus*. MSc. Thesis, Universal College of Learning. Retrieved October, 5, 2020, from <https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.106.7081&rep=rep1&type=pdf>.

17. Verga, P.L. (2020). SPIRE Baia Mare. State of the Art. Innovation Landscape Report. Bioflux: Cluj-Napoca.
18. Dong, Z.Y.; Zhang, Y.; Yip, C.; Swift, S.; and Beswick, K. (2020). Smart campus: definition, framework, technologies, and services. *IET Smart Cities*, 2(1), 43-54.
19. Min-Allah, N.; and Alrashed, S. (2020). Smart campus-A sketch. *Sustainable Cities and Society*, 102231.
20. Saint Louis University, welcome to SLU, Alexa. Retrived from <https://www.slu.edu/>.
21. Xu, X.; Li, D.; Sun, M.; Yang, S.; Yu, S.; Manogaran, G.; Mastorakis, G.; and Mavromoustakis, C. X. (2019). Research on key technologies of smart campus teaching platform based on 5G network. *IEEE Access*, 7, 20664-20675.
22. Porter, A.; and Sherwin, M. (2013). *The digital campus the online future for higher education*. Precedent, UK.
23. Cață, M. (2015). Smart university, a new concept in the internet of things. *14th RoEduNet International Conference-Networking in Education and Research (RoEduNet NER)*. Craiova, Romania, 195-197.
24. Tianbo, Z. (2012). The internet of things promoting higher education revolution. *Fourth International Conference on Multimedia Information Networking and Security*. Nanjing, China, 790-793.