

REVIEW PAPER

Significance of Internet of Things in Higher Educational System with Cloud Environment–A Review

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ABSTRACT

The rapid advancement of digital technology has transformed the sector of higher Education with the Internet of Things (IoT). IoT refers to interconnected devices and sensor that collect exchange and analyze data in real time. It offers enhanced opportunities for automation in educational system. The significance of IoT in higher education is analyzing its major applications, benefits and challenges. IoT enables smart classrooms improve teaching effectiveness through interactive tools, automated attendance, adoptive learning systems and real time performance monitoring. University deploy surveys Smart campus infrastructure including intelligent lighting, security, and energy management systems and this helps educational cost & reduce its cost. IoT Support research and Laboratory activities, enables data–driven decision-making and collaboration with other institutions. IoT provides personalized learning support, and improves engagement through technology. But there are also disadvantages of applying IoT in higher Education, Such as high implementation cost, concern about data privacy, cybersecurity risks and the need for digital readiness among teachers and students. The review emphasizes that these challenges can be overcome through proper policy framework, skill development, robust cybersecurity measures, can be taken for better accessed. IoT plays crucial role in modern higher education, enabling smart academic environment that fosters innovation and improves learning outcomes.

Keywords: Education Technology, Smart Education, Digital Education, IoT, Emerging Technology

The Internet of Things refers to the network of interconnected physical objects attached with sensors Software and communication technologies that enables them to collect exchange and analyse data over the Internet. It extends traditional Internet capabilities by allowing objects such as devices classrooms

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laboratories and campus infrastructure to communicate autonomously. There are many technologies such as Radio Frequency Identification (RFID), Wireless Sensor Network, GPS, Infrared Sensor Camera and Smart variable devices from core components of IoT system. And they collect real time data and monitoring automation and intelligent decision making across various domains including education^[13]. Recently Internet of Things IoT expresses as a prominent area of research in both academic and industries. IoT technology depends on traditional Internet technology. IoT can connect with any object to the Internet for information sharing interaction based on protocol utilizing technologies such as radio frequency identification, infrared sensors, GPS, lasers scanners etc. This system can identify tracking monitoring and management of objects. The impact of technology transform and reshaping how technology and learning can take place more effective student centric by using technology development of smart education system combine with cloud computing and IoT. The IoT plays a key role in collecting, transmitting and managing data. Educational institutes are using IoT to process data and promote sustainability^{[5],[9]}.

Review of Literature

A number of research articles and studies have been evaluated related to the concept of IoT implementation in Higher Education. This article investigates the following literatures—

Al-Taai, S.H.H. *et al.* (2023)^[4] in this paper the authors mentioned that the IoT encompasses all the devices and tools we use daily that can connect to the Internet and are controlled via applications on smartphones, computers, and other devices. This is a contemporary, worldwide technology rooted in the Internet, aimed at delivering an information technology infrastructure. The Internet of Things offers several significant advantages and is vital for organizations looking to lower expenses and launch products through marketing and promotion with greater convenience. It is an effective means of overcoming certain issues and bolstering the relationship between student and teacher. It is cost-effective, saves considerable time and data, and liberates individuals from the constraints of time and location. Some of the key traits of the Internet of Things include: Interaction, heterogeneity, dynamic changes, intelligence, sensing capabilities, massive capacity, and communication, among others.

Bashir, B. *et al.* (2025)^[5] in this paper the authors stated that the integration of the Internet of Things (IoT) into education is transforming teaching and learning approaches. It enables tailored educational experiences, increases student involvement, and improves the effectiveness of administrative procedures. This paper details the numerous benefits of IoT, including better resource distribution, enhanced campus safety, and the development of interactive learning environments. However, to fully realize its advantages, challenges such as limited finances, security weaknesses, and unreliable internet access must be addressed. It is crucial to make strategic investments in infrastructure, training, and awareness to help mentors and students fully leverage IoT technologies. As educational institutions adapt to technological advancements, collaboration among all stakeholders will be essential to fully harness the advantages of IoT, thus preparing students for success in a more digital and interconnected world.

Pervez, S., Rehman, S. & Alandjani, G. (2018)^[14] in their paper the authors stated that as the Internet of Things (IoT) becomes more popular, small gadgets are becoming widely embraced, particularly among students who use wearable devices with small sensors to connect to learning systems. IoT sensors are built into contemporary interactive devices, allowing them to connect to users' devices and offer limited data downloads depending on the type of accounts being used. The Internet of Things allows devices to connect to the Internet and is transforming many aspects of our daily lives. With the aid of the Internet,

the online learning system has established a firm presence in our schools, and e-learning has become a standard practice in contemporary education systems. However, there are many applications of the IoT in education, and the effects of this disruption are vast. It benefits the system and community in multiple ways, much like the rise of mobile technology.

Saeed, M.K. *et al.* (2021)^[16] in their work the authors mentioned that the Internet of Things (IoT) represents a promising area for the future. It enhances various aspects of contemporary human life. It aids in the establishment of smart cities, smart environments, security, intelligence, industrial control, automation, agriculture, health care, education, and particularly in higher education. This technology serves to enhance the comforts of individuals. It represents a major launch in the education sector. It can gather the data, enhance the learning knowledge, and assist in offering a better environment for the learning process. Its application in various domains is rapidly increasing, particularly within smart cities and higher education institutions.

Objectives of the work

This paper titled “*Significance of Internet of Things in Higher Educational System – A Review*” has some basic objectives like as follows —

- ☐ To be informed about the fundamentals of Internet of Things.
- ☐ To understand what smart education means.
- ☐ To gain knowledge benefits of Internet of Things in Higher Education
- ☐ To learn about the applications of IoT.
- ☐ To gain knowledge about impact of IoT in Higher Education.
- ☐ Challenges of IoT implementation in higher education

Methodology of the work

The paper entitled “*Significance of Internet of Things in Higher Educational System – A Review*” is both conceptual and theoretical. The current work is of a descriptive nature. It depends completely on data from secondary sources. The data and information used for analysis come from different sources, including printed articles, journals, government publications, reports, and several official websites of the Government.

Evolution of IoT and Smart Education in Higher Education

This helps us evolve from the traditional and old classroom based digital learning to the Smart education system which help with IoT. Previously the education system mainly depends upon the information and communication system and tools such as projector, and computer labs basic learning system. But increase in use of E learning platform and Massive Open Online Courses, education more flexible accessible to all the students. With the help of many devices such as sensor smart devices and real time data analytics RT helps to respond dynamically to every student behaviour, environmental condition, and institutional requirements. And there are many features of smart enabled classrooms such as adjusting

light temperature and multimedia resources with the help of IoT which will the active learning and students' concentration and participation in higher education^[14]. Education 4.0 also helps to advance the digital learning system and helps to build digital skill an industrial experience to student which fills the gap between the theoretical learning and practical application by providing students hands on classes and experimentations which builds the problem-solving skills and technical skills of the students. And with the help of cloud computing and big data analytics, IoT offers good decision making and all the huge quantities of data were produced by the universities and schools related to the performance and resource are managed by cloud servers which helps to upgrade the found and technological element of next generation higher education system^[10].

The intensified and versatile expansion of proliferating in online education tools has an accelerated and personalized change by ensuring learning in transition making instruction that make adaptable, widely available, inclusive and tailored to the individual and the massive Open online Courses has an intensified this paradigm shift, fostering an educational landscape that is increasingly accessible. Internet of Things elevates the educational platforms by upgrades pedagogical tools, real-time data flow between users and environments that has a seamless information sharing, intelligent e-learning systems, smart classrooms and connected learning systems, responsive, or interoperable communication. Here the smart education represents to the integration of the Internet of Things to help to modernize the learning environments of students and help to gain the interest of this. The ITS or intelligent Tutoring Systems refers those platforms where adapt content helps to study the students' needs via these IoT data. The responsive environments emphasizes that the surroundings, via sensors and highlights the ability to represents the physical merging of learning tools with the logical data. In context-aware learning examines the ability to use, environment-specific data. And the CPS (cyber-physical Systems) in education that adjust to learner needs and real-time data-driven instruction, and responsive, adaptive learning e-learning systems^[11].

By deploying IoT-enabled devices such that smart boards, utilizing interconnected devices that utilizing, adopting and incorporating the things and interconnected things like technologies, connected infrastructure that allows to monitor and assess student behaviour, environmental conditions and infrastructure in real time. These infrastructure requirements help to adjust to individual student's needs and the classroom situations, and the learner requirements, institutional demands and facilitating dynamic, data-driven adaptation to institutional and individual needs. And generally, the rise of IoT in intelligent learning that a critical advancement toward a next generation of this higher educational Ecosystems helps to get digital transformation of education through interconnected devices and the sensor-based and smart pedagogical systems. The smart campus ecosystems refer automated, interconnected, intelligent and data-driven campuses. And the personalized learning that represents adaptive education, student-centric, individualized learning pathways and tailored instructional design. And there is another efficiency system that is operational efficiency that refers data-driven, optimized, streamlined administration and there is another ecosystem of continuous innovation that follows the disruptive technological growth, sustainable evolution and ongoing pedagogical growth. This also coupled with the real-time data that allows institutions to adapt the instantaneously to individual learner needs and the operational demands and the classroom conditions also have immediate educational intelligence, live data analytics capabilities and context-aware, instantaneous data processing and dynamic-actionable and real-time insights^[8].

Internet of Things and Architecture platform

The Internet of Things (IoT) is related with electronic devices and sensors to communicate via internet, offering solutions to enhance various aspects of day-to-day life. It is more effective to provide IoT solution which can reduce the resources for implementation. IoT architecture classify into 3 category such as (a) client side (IoT device layer) (b) server-side management (IoT gateway layer) (c) a connecting pathway between clients and servers (IoT platform layer). This study is a qualitative research article focuses on the education. The object of study is to answer the following Question. How IoT affects on education in higher education? The essential features of IoT are function, scalable, and adaptable etc. IoT maintain 4 steps as platform.

☐ Sensing layer (Data collection)

At this stage physical objects are equipped with sensors and capture data.

☐ Network layer (Data communication)

After the data is digitized then it is transmitted through internet for further analysis and processing.

☐ Data processing layer (Initial analysis)

In this stage works between sensing and application layer.

☐ Application layer (Smart processing and application)

Data gathering → Data transmission → Process information → Application and management

Benefits of Internet of Things in Higher Education

In higher education, IoT offers numerous benefits that helps both academic and administrative functions. One of the major benefits of IoT is personalized learning where different students of different ability are learning behaviour and performance data are analysed in real time to deliver adaptive and customized educational content. This improves the efficiency and supports students. Here other benefits of IoT in higher education are practice-based learning, activity-based learning, skill-oriented learning, industry-oriented or real-world related learning. By this IoT student can achieve their practical skill, skill-based learning, skill increase, and they get chance to examine the digital environment for practicing their skills up and simulated the environment means replicates the real-world scenario for their safe examination^{[6],[15]}. Not only all of these, but students can also gain their knowledge through the direct experience and can learn within context of application. And they can solve the real-world problems and can focus on hands-on training like direct, physical, or simulated engagement with the tools. And also, another thing they can connect theoretical understanding or theoretical comprehension that's like contextualized learning that means growing the knowledge in a relevant and practical context and the applied knowledge that refers academic knowledge that only limited into books and only theory-based and another is bridge theory and practice that connecting the real-world tools.

It also improves students' engagement and interaction through modern digital smart classroom with sensors interactive displays and wearable devices these are all technologies with real time feedback, collaborative learning and immersive educational experiences.

Another benefits of IoT in higher education systems that helps to improve analytical thinking and cognitive skills, reasoning and logical skills, applied problem-solving skills, technical capability and analytical skills, technical competence how to build the ability to handle real-world tasks, enhance the ability to use specialized tool, focused on the tangible skills and competency-based education and help to increase the analysing evaluating and creating solutions and critical thinking development. The continuous innovation of IoT help to change the systems based on immediate feedback and data-driven instructions that give live-analytics and guide teaching use to increase the proactive learning that constantly refine the processes of new added data and here is another benefit that helps to adaptive learning by using IoT technologies to change the path of learning real-time and another is tailored instruction that refers to customise pedagogy for specific of student situations. IoT also help to increase the resource utilization in the institutions. Smart ecosystem helps to track the usage of different things like the classrooms that connected with it, laboratories, library and the requirements. These administrators can optimize the allocate resources, streamline operations, resource utilization and maximize orchestration. They have a strategic planning, proactive preparation and predict resource of this requirement that automates resource help to enhance the demand planning and efficiency. In administer section, IoT enhance operational efficiency by automating attendance system optimizing energy consumption and it also improves the resource utilization RT supports data driven decision making which allows institution to predict all the student's behaviour and performance and improve their overall institutional effectiveness. Overall, Internet of Things supports the higher education systems to increase smarter, optimized, student-friendly, streamlined-learner friendly, time saving and student-friendly, operationally effective, well-organized, better and much easier for students and learner effective. And these smart ecosystems create a learner friendly environment. Students can easily growth by this Internet of Things and IoT has a huge scope in future of students^[6] Fig. 1 describe about Benefits of Internet of Things in Higher Education.

1. Applications of IoT in Higher Education

IoT has been applied in various areas of Higher Education. Now we can discuss the applications of IoT in Higher Education.

(a) Quality of Teaching and learning

IoT can help to improve the quality of teaching and learning according to students' performance. It can provided smart learning experience as per requirement of students. Modern tools and technique are introduced in classroom teaching. A smart classroom has can measure the level of understanding student's interest by monitoring their behaviours using cameras and microphones. Wearable technology in the education teaching learning process can enhance process of teaching. Smart Classroom also has learning models such as adaptive learning models which provide content to the student as per preferences and performances for if a student is not that brilliant and studious and he or she is suffering from a topic there will be more precise guidance to him for that topic so this level of customization helps the gain more interest in studying. From faculty members Perspective they can also track during the classes and they can also change their teaching attitude and strategies accordingly. With the integration of the learning management system LMS this allows synchronization coarse material assignment and assessment and helps to improve instructional efficiency and active participation^[12].

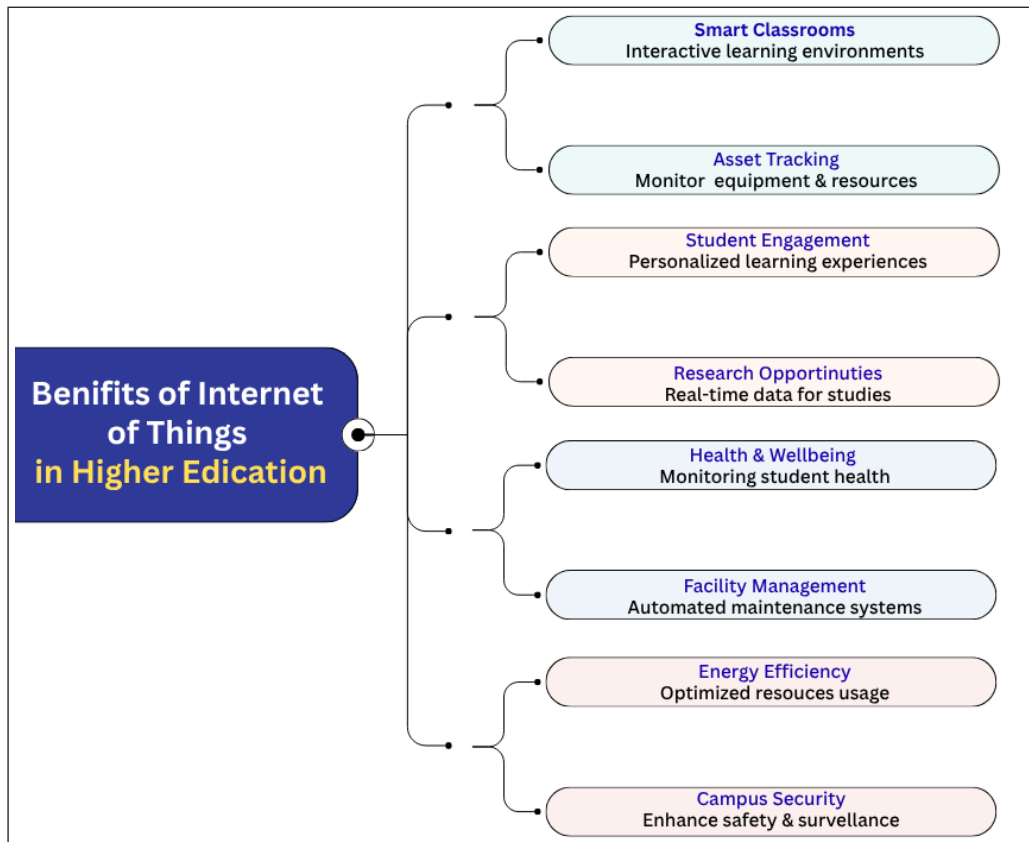


Fig. 1: Benefits of Internet of Things in Higher Education

(b) Campus Management System

Internet of Things has been applied in campus management like energy management and Eco-system monitoring to provide energy control in campus. Companies can effectively balance power generation and distribution to provide more effective operations by using IoT. This system also provides energy consumption report automatically to improve financial flows and control waste management. Classroom in school and colleges are also nowadays enhanced with IoT in higher education and this classroom integrates many things such as sensor camera microphones and smartboards and wearable device to make it more interactive and for the students and this also helps collect data from the student sites such as attendance engagement and learning patterns and classroom condition in real time. RFID tags are also used in smart classroom which helps to manage the attendance of the students and many sensors also used in educational institutions such as biometric sensor and facial recognition which helps to trace a by their activities and collect data from them by their facial expressions and eye movement and then provide some insights from them^[7].

(c) Eco-System Sensor Supervision

Device operators use IoT system to predict many factors from grid report to present condition of eco-system. By using this type of system universities can create a green campus environment by minimizing carbon dioxide emissions, monitoring and control energy, power supply for teaching and learning process. By installation sensors in classrooms, study rooms and library for measuring temperature, humidity, carbon dioxide, etc. It is also allowing an analysis of indoor comfort level and air quality in environment.

(d) Campus Safety and Security management

To provide safety and security in universities area and managing students access to classroom, hostel, laboratories and other places in within area of universities are some of challenges which could be managed by new technologies. RFID (Radio-frequency Identification) and NFC (Near Field Communication) are the two-sensor technology for implementing IoT which can be used for improve university security system. This system can be managing monitoring student attendance by using RFID tags in student ID cards. Students can track their current location in the campus by using geofencing technology. Emergency response by geofenced alerts directly to students through their smartphone based on their real-time location. AI enabled CCTV cameras can identify suspicious or unauthorised person to restricted at the campus.

(e) Student's health care monitoring

The IoT plays an important role in health care sector by monitoring patients and preventing disease. This system can keep the record of different students' health information such as their medical history, blood pressure, blood group record, EEG report etc. The wear wearable device can monitor physiological signals over the time framework and Fig. 2 is showing one of them.

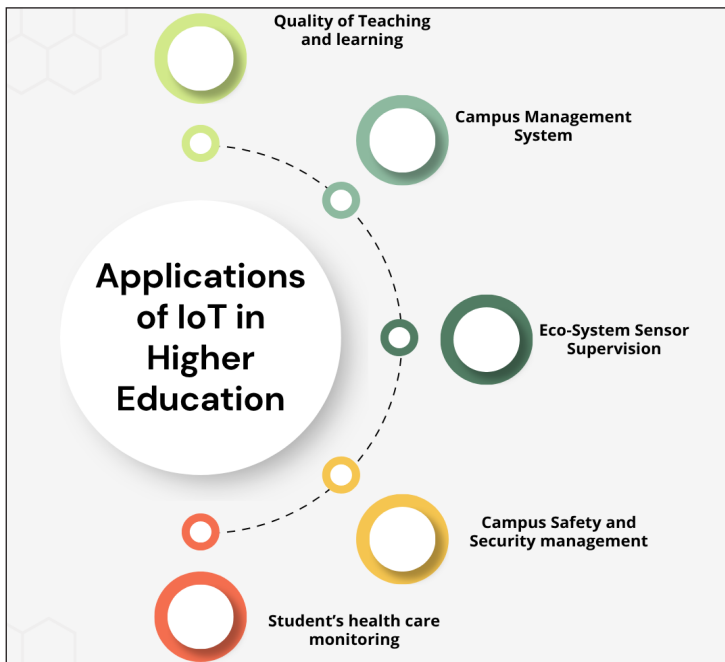


Fig. 2: Applications of IoT in Higher Education

2. Role of IoT in Academic Administration and Institutional Management

IoT not only helps in academic teaching and learning process but it also helps academic administration and institutional management which have many complex process in it such as admission scheduling asset management and faculty management facility maintenance which can maintained and optimized through IoT based automation. With the help of IoT, many things can be analysed such as classroom occupancy faculty availability course require to generate optimized timetables asset manage laboratory equipment library resource and infrastructure usage reducing loss increasing the maintenance planning. RFID or NFC, these are all smart identification systems are also used to improve academic facilities such as building hostels and laboratories while improving the security of the institution. IoT also helps in facility management educational institutions such as energy consumption water usage and environmental condition across campus facilities which are controlled by smart sensors and some automated system also helps in adjusting lighting heating and cooling based on real time occupancy leading to cost saving sustainability. IoT also helps in communication between student and faculty members and the administrations regarding the academic schedule emergencies and any updates which can be delivered instantly with the help of IoT devices which allows institution to focus more on academic Excellence and students development^[18].

(a) Integration with IoT sensors and mobile devices

IoT has changed classroom by using sensors and mobile devices. It has created student engagement and collaboration in teaching learning process. The IoT refers to a system of connected with various electronics hardware, software and network components designed for exchanging and collecting data. Application part of IoT such as follows finance, travel, education and communication system. Higher Education institutions are adopting IoT technologies to improve both academic functions and administrative official efficiency. By utilizing IoT tools institution handle big data more effectively, optimize processes. IoT is reshaping education through the integration of smart teaching tools. IoT enhances operational efficiency, enriches learning material, modern classroom shift towards e-learning and digital resources. IoT provide more interactive content.

3. Impact of IoT on Higher Education

Higher education is adopting IoT technologies to improve both academic and administrative efficiency. By using IoT tools such as RFID and cloud computing, institution is now able to applications of Big Data more effectively, optimize processes. IoT is reshaping education through smart tools. IoT access to educational technology and resources fostering learning environment that prepare students for updated technology. By using the IoT learning resources, classroom management shift towards e-learning, use digital resources. Students acquire more interactive learning through IoT. Despite some advantages of IoT in the education sector, different challenges are facing such as budget constraints, safety and security concern, limited internet support for IoT devices^[16].

It has a good impact on socioeconomic implication such as smart education system also contributes workforce to the modern industries with the students who are digitally and analytically skilled. And graduates those who are trained in IoT enable enrolments are better prepared for technology driven careers and Fig. 3 shows the Impact of Higher Education.

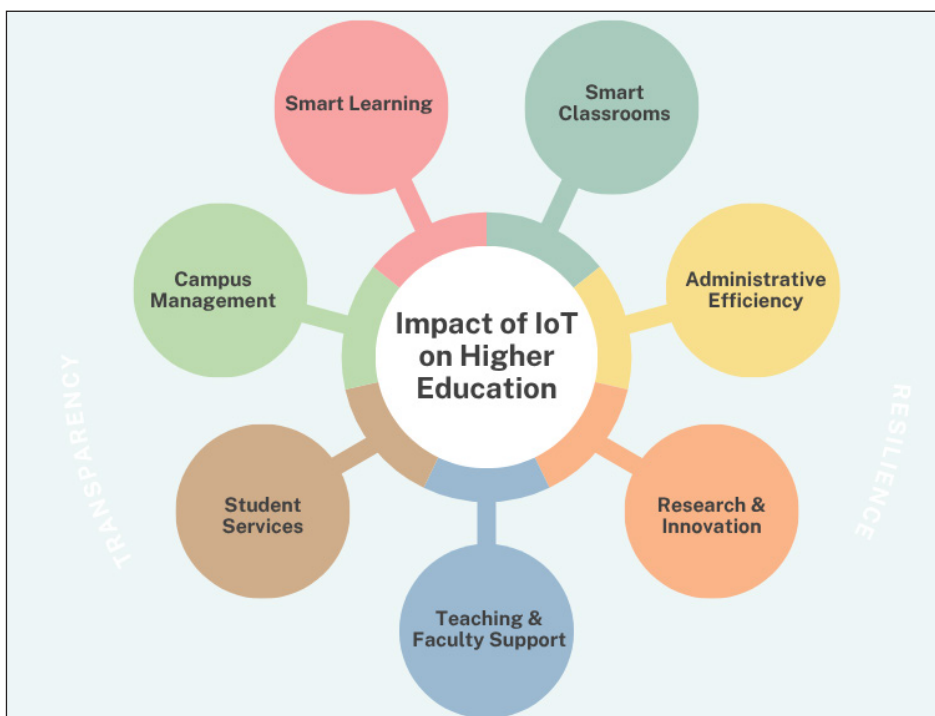


Fig. 3: Impact of IoT on Higher Education

4. IoT in Research Innovation and Laboratory Automation

IoT has a huge role in transforming research and innovation within higher educational institutions. Smart laboratories are installed in higher education institutions with IoT sensors that enabled real time monitoring of experiments data collection and equipment performance. Students can access laboratory data and can also control experimental and collaborate with peers across institutions. And laboratory automation with the help of IoT reduces humanitarian and improved research accuracy. IoT sensors continuously monitor temperature pressure humidity and chemical concentration ensuring experimental consistency. Cloud Base platforms are used to store and analyse data that is collecting fascinating advanced analytics reproducibility. Interdisciplinary research Collaborator in computer science and engineering healthcare environmental science and management disciplines where universities can establish new innovation hubs and Research Centre where student's faculty on real Audi applications fostering creativity and industry engagement. Students prepare themselves with the help of IoT enabled research for Industry 4.0 by exposing them to advanced technologies and data driven. This helps to enhance employability and bridge the gap between academic research and industrial application^[8].

5. Impact of IoT on student engagement and learning outcomes

The impact is very real as it influences the engagement of students and the learning outcomes also increases because of this previously old and traditional teaching methods fail to address individual learning and the engagement level of the student and their attention to the education However IoT overcomes this limitation by enabling continuous monitoring and personalized feedbacks. Many new devices such as

smart watches and other wearable device and smart learning tools track students' activity attendance physiological indicators such as trace level and this raw data helps instructor to identify student who may require more academic and emotional support. Real time analytics allow early intervention reducing dropout rates and improving the performance of the students^[16].

Internet of Things also elevates the active participation, learner collaboration, active engagement, peer interaction, learner participation, group-based learning, interactive, participatory, collaborative learning practices. IoT helps to collaborative learning and student engagement in smart practices and peer interaction to learn the participation that helps to participate and collab learning practices. It also collaborates in studies by enabling many group activities, lab activities and sharing digital resource in groups. This helps students to be the main character education, actively participate in all the learning activities which also improve their understanding critical thinking and long-term knowledge retention. And as a result, learning becomes more efficient inclusive and outcome oriented.

6. Challenges of IoT implementation in higher education

There are not only advantages of IoT implementation, many challenges are also there such as data privacy and security as IoT system continuously collect all the sensitive and personal and academic data of student and faculty and any unauthorized access and data breaches and surveillances concerns raise ethical and legal issues that an institution must face and it should address it through strong cyber security framework and data protection policies.

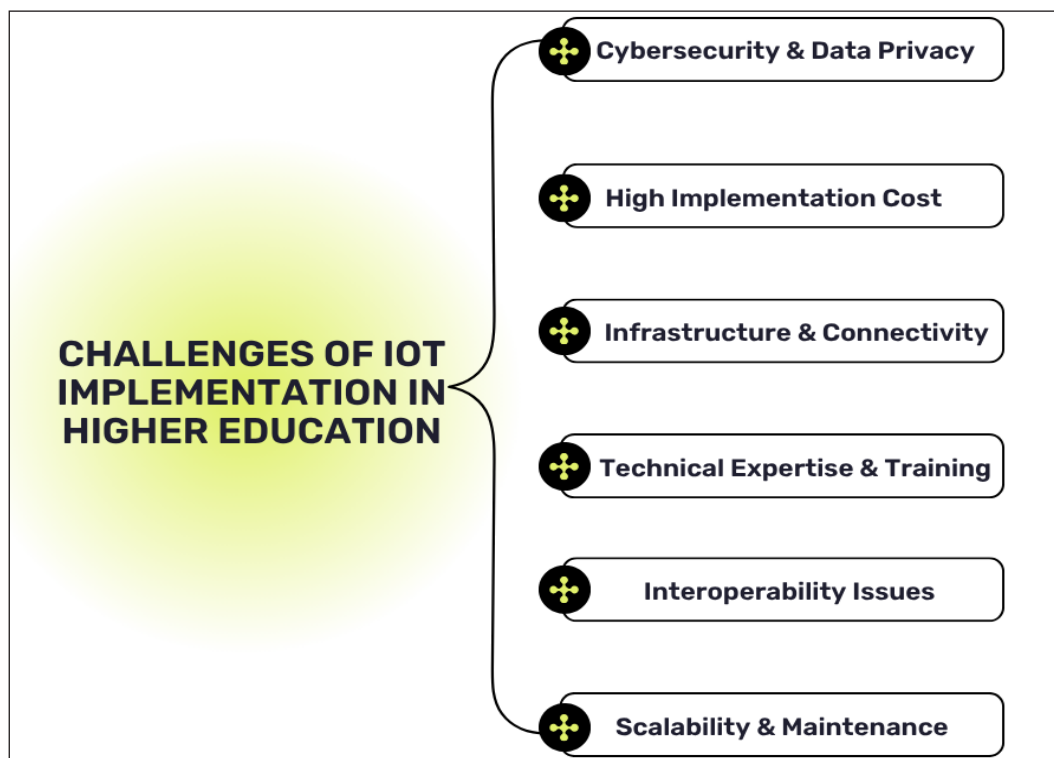


Fig. 4: Challenges of IoT Implementation in Higher Education

One of the major challenges is high cost of implementing the IoT sensors infrastructure and its maintenance. Deploying IoT infrastructure requires significant money and investment in network devices cloud services and system maintenance which cannot afforded by all the institutions technical limitations such as inadequate Internet bandwidth lack of interoperability among devices and system integration complexities hinder large scale adoptions. There is a digital skill gap between the educator and the students which restrict effective utilization of technologies and highlighting the continuous training and capability building program of the student and educators^[7]. Fig. 4 shows the Challenges of IoT Implementation in Higher Education.

Future scope of IoT in Higher Education

There is a very bright future in Integration of IoT in Higher Education and many technologies such as artificial intelligence, machine learning, blockchain and big data analytics. IoT systems which are AI enabled such as support intelligent tutoring predictive academic advising and automated assessment mechanism. Blockchain integration can enhance credential verification data transparency and academic record security. Digital Twin campuses, meta verse-based classroom, and smart examination systems, these technologies are expected to redefine teaching and learning experiences. And IoT based predictive models will help institutes to fulfil the student needs improve retention rates and align academic program with industry requirements. Educational Institution must protect and ensure Students Consent transparency and accountability in data collection and usage^[17].

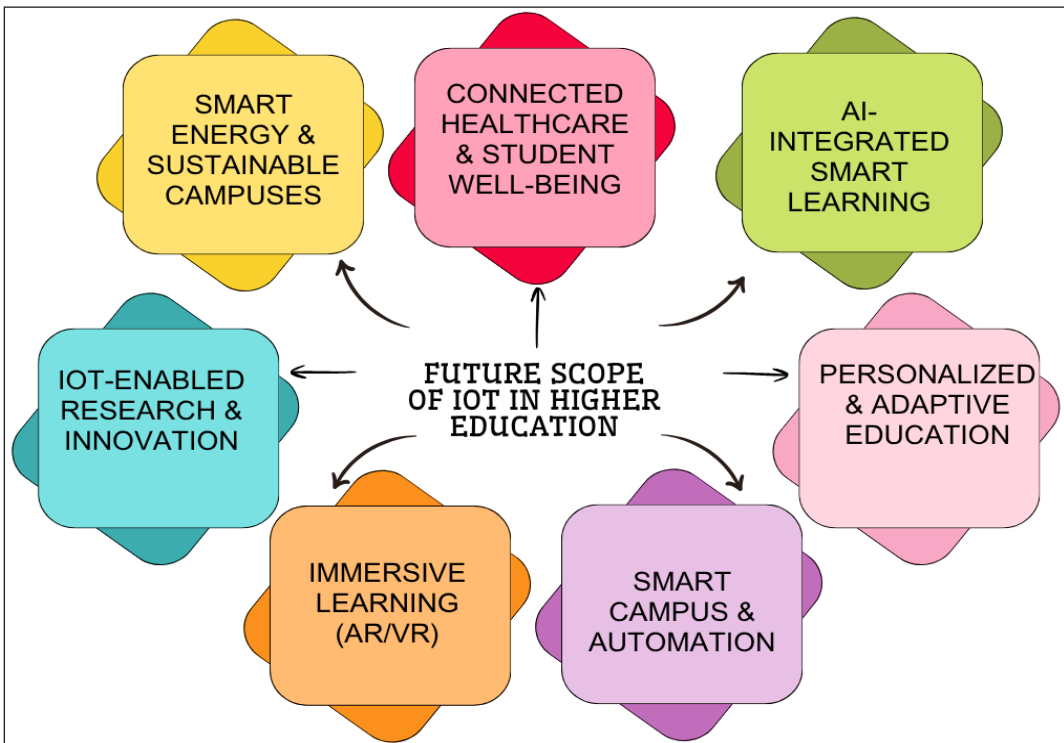


Fig. 5: Future Scope of IoT in Higher Education

And there should be a institutional policy and comp with the national and international data protection regulations that are important to maintain the trust. Balancing technological benefits with individual privacy Rights is very important for Ethical deployment of IoT. Standardized frameworks and guidelines should be developed by government and educational authorities to regulate the IoT usage in academic environment and there are many ethical and policy challenges that should solved to have a sustainable and responsible implementation of IoT in higher education. The Fig. 5 shows the details of the Future Scope of IoT in Higher Education.

CONCLUSION

IoT emerged as a transformative technology in higher education. It has provided many things like smart campuses, personalized learning environment, and efficient institutional management. And this review highlights the enhancement in teaching quality, student engagement, operational efficiency, and data driven decision making not only advantages, it has given some of the Challenges are also there such as Security risk high-cost skill gaps persist and this can also be mitigated through appropriate policies and some development in infrastructure and initiatives. Challenges such as data privacy cyber security threats and high infrastructure and maintenance cost technical complexity and limited digital literacy among stakeholder remains significant concern. As these devices continuously collect and analyse the sensitive data of the student and institution, that raises a question about the protection policies transparent governance framework and strong cyber security measures. When the Institute adopt successfully IoT enabled Environment, they required the help of digital infrastructure, reliable Internet connections, and continuous training program for the educators and administrators so that they can use all the tools carefully with a good knowledge. It plays an important role in shaping bright future of higher education innovation, sustainability and academic excellence.

GENERATIVE AI DECLARATION

The author(s) confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript, and no images were manipulated using AI. The authors developed and verified all scientific content, data analysis, interpretation of results, and conclusions. The authors take full responsibility for the accuracy, integrity, and originality of the work presented, and no AI tool was listed as an author.

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