# Adoption of IoT in e-Learning in Higher Educational Institutes : A Review

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**Abstract :**

**IoT is a fundamental enabling technology for creating smart spaces which can assist the effective face to face and online education system. The transition to smart education is appealing which has a concrete impact on learners engagement , motivation, attendance and deep learning. While capabilities are increasing day by day, there are still many limitations and challenges to utilizing these technologies within E-Learning in higher educational institutes (HEIs). This research aims to examine the factors influencing IoT adoption for E-Learning to be utilized in HEIs. The paper also focuses to investigate new strategies in context of IoT to integrate the recent ICT trends with educational system. Further, an adoption model is proposed for IoT-based E-Learning and provides recommendations for enhancing the IoT adoption for E-Learning in HEIs. This study describes (i) addresses the problems in the traditional education system with possible solutions (ii) the transition towards smart education (iii) increasing the understanding and competence of human resources in of Higher Educational Institutes.**

**Keywords : Education, IoT, e-learning, software system, learning process**

## I. Introduction

The Internet of Things (IoT) describes the internet of physical objects “things” that are embedded with sensors, software and other technologies for the purpose of connecting and exchanging data with other devices and systems over the Internet. The term “Internet of Things” refers to the three types of online interactions that occur between people, between machines and things, and between machine and other things. IoT can deliver unique services in a variety of domains including education manufacturing, health care, home automation, retail, medical and agriculture. Smarter and smaller devices are included . The IoT is already attracting a slew of academic and businesss of academic and business interests.

IoT technology has an important impact on education which has not only changed the traditional teaching practices but also has brought significant changes in the infrastructure of education institutions. IoT based e-Learning system is a method of teaching adopted in modern education system where virtual pedagogy of teaching

is implemented. The integration of the Internet of things (IoT) in education has brought a revolution the way we teach and learn.. IoT applications in education have grown exponentially, making learning more interactive, efficient and personalized. E-Learning systems have reached their peak with the revolution of smart technologies. IoT. Academic institutions are currently including IoT in their educational activities, however, there are still few review studies available that do a comprehensive sweep on the acceptance and adoption of IoT in higher education. Therefore, this research was developed with the aim of filling this research gap as well as exploring existing scenarios for their inclusion and implementation in higher education through a systematic review of the literature. The results obtained will be useful for use by researchers or practitioners in higher education in the future.

The Internet of things is a new actor in learning environments. It plays a significant role in bringing interactivity, improved learning, and understanding between academic staff and learners via virtual and physical objects within the HEIs environment. Also, there is more focus on smart education and the use of IoT technology to bring improvement to learners in a class. Hence, with the increasing rate of utilizing online teaching by HEIs, assessment of the adoption of IoT is becoming dominant among academics and researchers. Internet of things supports the changes in the HEIs environment in education, including teaching, learning, management, experiment, training, school, campus building, etc. This creates a new opportunity where innovative learning options result from the change in concepts from ubiquitous computing and technologies.

The educational system has been transformed in most of the developing countries. At the same time, new specifications are required to establish teaching and learning methods for success within their setups and the boundaries that may entail. Technology is progressively essential in answering and allowing for innovative outcomes in terms of teaching and learning, such as the inverted classroom, massive open online courses (MOOCs), and smart learning. Till now, the revolution of learning is divided into four groups including traditional, digital, E-Learning, and smart learning. Currently, we are living in the era of Smart learning.

In simple words, Smart learning is the combination of E-Learning and IoT, or it is also known as IoT based E- Learning (Verma and Singh, 2021; Verma et al., 2021).

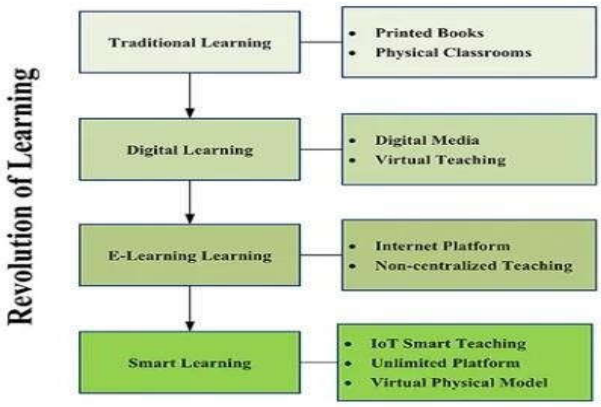
### *A.* e-Learning Overview

e-Learning is a part of smart education teaching, learning and managing paradigm encompasses smart technologies such as IoT, Artificial Intelligence and 5G which make it more effective , comprehensive and attractive. Smart education provides a digital environment to facilitates learners, teachers and administrators where more comprehension, interaction, transparency and motivation. With the recent development smart technology , educational institutions need to be transformed into smart institution rather than continue with the traditional institution. The points mentioned below highlights how the Smart Education dominates over the Traditional education system –[5]

- The traditional Education System focuses basically on the bookish theoretical pattern of education while the Smart Education System focuses on the practical learning and critical thinking .
- Traditional Education is not flexible and the student has to go to the classes, while the Smart Education is scientific in nature which allows the student to study in their own space.

## II. Background

- Tradition Education is based on firm policies which is time and place dependent while Smart Education not confined to the place and time rather student can interact anywhere and any time.



Some of the drawbacks of traditional e-Learning systems include limitations in expanding and distributing computing power as well as exchanging information among system users which has encouraged the development of new technologies to overcome these obstacles and motivate the learning process.

E-learning is a type of online education, training, and knowledge sharing through electronic technologies that is conducted through Internet. Application of software in the learning process make teaching processes more effective , result oriented and dynamic. It involves delivering learning content and experiences through digital platforms, allowing for a flexible and comfortable learning environment that enables learners to study at their own pace and location. It can be utilized in various settings, such as academic education, corporate training, continuing professional development, and skill development courses. Although, IoT has been in process of e-Leraning from years, but the growth of e-Learning or online method of learning got momentum by the COVID-19 pandemic during which all the learning processes have had to migrate totally to e-Learning processes resulting the widespread adoption of computers and internet technology. Consequently the demand for online learning became the solutions of teaching and learning. [18]

Due to the launch of 5G mobile network that introduces real time communication and this superfast connectivity accompanied by the latest smart supportive devices brought revolution in launching the Smart Education vis-a-vis e-Learning. E-learning offers benefits such as flexibility, accessibility, and scalability, making it a popular choice for both personal learning and corporate training. It is increasingly used in various fields, including academia, professional development, and corporate education. E-Learning is prime for betterment of education from primary to higher and it is the main method to enhance skill of teacher as well as the comprehension of the students as it developed scientific methodology in pedagogy. The use of techniques in e-Learning like virtual class rooms, channels like Zoom, Google meet and Skype has contribute better impulse to the knowledge of learners and transforms the educational process into

a universal one. E-learning can take place through various platforms such as websites, mobile apps, and Learning Management Systems (LMS). [24]

e-Learning follows two kinds of technology - namely first is infrastructure based and the second is software based. The infrastructure is categorized into on-premises and on-cloud. E-Learning infrastructure includes mobile phones, computers, networking devices, servers and other devices which communicate data from one end to other end. On –premises infrastructure needs skilled man power for help while cloud based educational technology has some flexibility and it is comparatively less cost effective. The software category of learning may be Synchronous type an Asynchronous type . Synchronous type of learning include audio and video learning using conferences , live chat and application sharing while Asynchronous support learning resources management systems.[17]

IoT is one of the best technologies which has strong influence in various forums, education is considered one of these which plays a key role in the amelioration of quality of education and its development. The IoT enabled transformation from Teacher-centric education to Student –centric education in which student built their knowledge by enabling them to explore the reality around them. Integrating IoT smart objects, traditional e-Learning is converted into intelligent and interactive e-Learning It creates an appropriate and comfortable learning environment in addition to increasing performance. [9]

### *B.* Types of E-Learning

1. **Online Courses:** It is Synchronous and Asynchronous and courses offered by educational institutions in any mode. Synchronous mode of learning is instructor led in which participants are required physically while Asynchronous mode of learning is self directed need not participant present at the same time. be synchronous (live sessions) or asynchronous (pre-recorded lessons).[24]
2. **Virtual Classrooms:** Interactive, real-time sessions where students and instructors communicate through video conferencing, chat, or other collaborative tools.

3. **Mobile Learning :** Allows learners to access through smart phones or laptop. It allows users to access course content on the go.
4. **Blended Learning:** A hybrid approach that combines online learning with face to face
5. **Microlearning: P**rovides short bite-sized modules of information for just a few minutes. It is useful for skill-building or quick knowledge acquisition.
6. **Webinars and Video Lectures:** Live or recorded sessions that provide an opportunity for learners to engage with instructors, often with the ability to ask questions and participate in discussions.
7. **Massive Open Online Courses (MOOCs) :** Massive Open Online are large scale Courses accessible and affordable online to any one providing distance learning opportunities
8. **AR and VR learning:** Augmented reality (AR) adds something virtual on top of the real world, while virtual reality (VR) involves a virtual world

### *C .* Key Features of E-Learning:

E-learning or electronic learning implements digital technologies to educate learners. Some key features of e- learning include:

1. **Accessibility :** E-learning is available to anyone without consideration of geographical limitations through Internet connection.
2. **Flexibility :** Learners can access content at any time and from any place.
3. **Interactivity :** E-learning can be interactive, allowing learners to engage with content through quizzes, discussions, simulations, and more.
4. **Multimedia** : E-learning can incorporate multimedia elements like videos, animations, and graphics to make learning more engaging.
5. **Individualized learning :** E-learning can provide customized material recommendations based on users' interests, abilities, and progress.
6. **Collaboration tools:** Learners can access content on their own schedule, making it easier to balance with personal or professional commitments.
7. **Cloud hosting:** Cloud-based platforms ensure scalability, security, and accessibility.

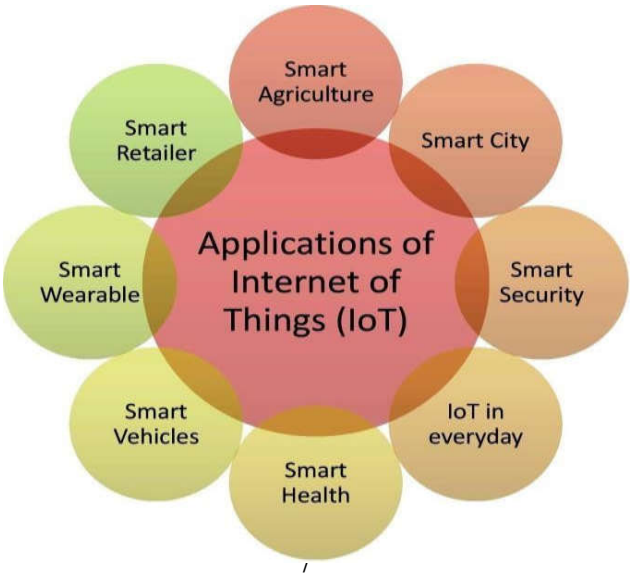
8. **Add-ons :** E-learning platforms can have add-ons applications as per needed that can help with things like generating reports, translating content into multiple languages, and hosting live online classes.

### *D.* Internet of Things Overview

The Internet of Things (IoT) technology comprises of interconnection of devices, vehicles, appliances and other objects embedded with sensors, software and connectivity, enabling to gather and exchange of data over the network. The significant property of IoT to have good control over objects and transform in to smart object. In this way it generates smart environment. It is ubiquitous since communication and association between physical and virtual object is established. In this way IoT has brought smart systems by connecting smart gadgets.

IoT technology is increasing by leaps and bounds and offering benefits to all the domains. The educational sector is not untouched. The teaching process is progressing towards digitization. Patton investigated digitization and discussed the key impact and challenges in the process. In due course not only students and teachers but also curriculum and institution would take benefit of digitization applied in education. Bidya Nand etal discussed smart education to solve traditional deficiencies in the prevalent traditional education system.

Zhu et al discussed smart education to solve traditional educational issues. He focused on personalized and seamless learning.



### *E.* Technologies behind IoT

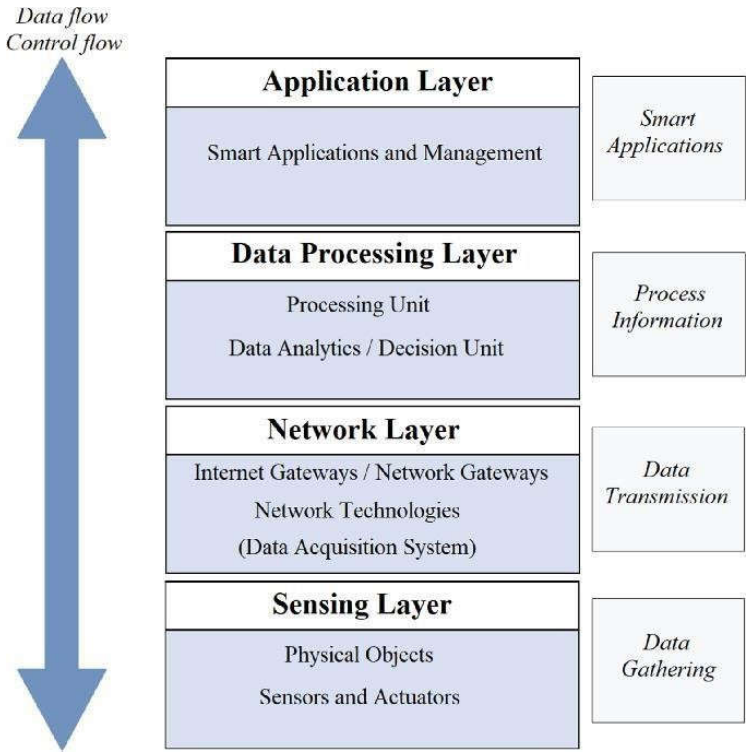
While the idea of IoT has been in existence for a long time, a collection of recent advances in a number of different technologies such as standard protocols and networking has made it practical. However, the major enabling technologies and protocols of IoT are RFID, NFC, low-energy Bluetooth, low-energy wireless, low-energy radio protocols, LTE-A, and WiFi-Direct. These technologies support the specific networking functionality needed in an IoT system in contrast to a standard uniform network of common systems.[8]

- **Access to low-cost, low-power sensor technology:** Affordable and reliable sensors are making IoT technology possible for more manufacturers. These devices are at the heart of IoT, as they allow machines and devices to interact with the physical world
- **Connectivity:** Connectivity is significant that facilitates availability of IoT infrastructure. Anywhere, any time it can be connected. In order to data transmission across the cloud from sensors and actuators, IoT devices need to be connected to the internet. There are several connectivity technologies that are used in IoT, including wifi, Bluetooth, cellular, Zigbee, and LoRaWAN.
- **Automation:** Integration of Sensors and Actuators allow machines and devices to interact with the physical world. Automation is possible when sensors and actuators work to resolve issues without human intervention.
- **Cloud computing platform:** The increase in the availability of cloud platform enables IoT devices to stored, process, and analyze the data. as well as to build and deploy IoT applications.
- **Big data analytics**: Extraction of knowledge from generated data by IoT devices, businesses need to use advanced analytics tools to extract insights and identify patterns. These tools can include machine learning algorithms, data visualization tools and predictive analytics models.
- **Interoperability:** Regardless of their manufacturer or operating system, IoT systems can work seamlessly with other systems and

devices. As a result, a variety of devices and systems can be integrated into IoT systems.

- **Scalability:** The number of elements connected to the IoT zone is increasing day by day. Hence, an IoT setup should be capable of handling the massive expansion. The data generated as an outcome is enormous, and it should be handled appropriately.

- **Security and privacy technologies:** As IoT deployments become more widespread, IoT security and privacy become increasingly important. Technologies such as encryption, access controls and intrusion detection systems are used to protect IoT devices and the data they generate from cyber threat
- **Distributed Real-time architecture:** IoT systems often have a distributed architecture, with devices and sensors located at the edge of the network, rather than centrally located [35]. This decentralized architecture allows for the Real-time collection and processing of data from many devices and sensors.



### *F.* Benefits of IoT in education

Smart devices brought significant changes in education sector. It has affected the method of teaching, learning, administration in respect of students as well as teachers and improved communication and collaboration.

- **Smart Administration:** Monitoring teachers and learners progress is critical. In an institution, the most important is to monitor and getting feedback. With the proper evaluation of teachers and institution the performance can be improved to a significant extent as well. The smart system can transparently manage all the issues as the excess workload can be alleviated. For example the IoT management solution in schools can track the availability of material s like number of books in the library, alerting the concerned person when supplies need replenishment. In addition , IoT technology can monitor and manage school resources and help optimize these resources use and ensure these are efficient and effective and also make cost effective.[28]
- **Smart Classroom engagement:** With IoT devices, classes can be interesting as well as interactive a teachers can create more engaging and interactive lessons that keep student interested and motivated. Using interactive smart whiteboard, the teacher can present lecture in audio video media. Specially, in the technical institution IoT devices are key to present design, models, graphics and such topics that cannot be discussed in traditional chalk board can be discussed very effectively in lucid style.

  Overall, using IoT system, in education sector can bring improvement in the resource management, leading to cost saving and more efficient and effective use of resources.[3]
- **Smart attendance:** Manual or Biometric attendance is time taking and sometimes lead some boring. RFID Smart cards may be used to automate the attendance system of the schools. This mark the learners and teacher’s attendance as they enter the class. This smart system notifies

the head of the institution data of the present students and staffs instantly.[38]

- **Smart reports:** Latest technology based IoT devices and artificial intelligence based software Sheet+, AjeLix represents very effective report Microsoft Text Analytics for Excel add-in enables to analyze text data within Excel using AI-powered sentiment analysis and key phrase extraction. Power Query incorporates AI-driven capabilities for data cleaning, transformation, and enrichment. It utilizes machine learning algorithms to detect patterns, recognize data types, and suggest transformations based on user input. Azure Machine Learning provides a comprehensive platform for building, training, and deploying machine learning models enabling seamless access to AI-powered capabilities within your spreadsheets. The introduction of smart system minimizes corruption and curves illegal practices.
- **Smart Security:** With IoT devices safety and security can be ensured in the campus of the institution. The intelligent system pays a major role in security by installing cameras and sensors.
- **Smart Engagement:** e-Learning solutions through IoT technologies can enhance collaboration allowing collaborative approach on projects and share ideas and resources in real time. It can help create more dynamic and engagement learning environment conducive to active learning and problem solving. To optimize the quality of education, learner's engagement must be enhanced and it can be done using IoT which keeps learners motivated and engaged in a particular domain.
- **Personalized Learning:** IoT based solutions can also be used to provide personalized learning to the students. The idea is to use IoT devices and sensors to gather data, track performance, and provide real- time feedback to both students and educators. By gathering data of student's preferences and learning style and needs, these systems can create tailored curriculum.
- **Real-Time Data Analytics:** IoT-enabled devices can track student engagement, attention, and performance in real time. Wearables, smart

glasses, or biometric devices can monitor how students are responding to lessons. This data can be analyzed to adjust the pace of the class, the type of content being delivered, and the level of difficulty, providing a highly personalized learning path for each student.

- **Smart Activities:** Learning by doing increases the retention and understanding of the learners. A case study survey has concluded that students retain 10% from reading, 20% from listening from a teacher, 30%from watching, 50% from watching and listening at a time, 70% from participating, in discussion and continuing practical or workshop, and more than 90% of information remains in memory from teaching to others. Smart objects are helpful in apprehension, retaining, recalling.
- **Smart Marking and Question Bank:** During preparation of questions, the answer is loaded in the database and while answering, the suitable an answer is verified through databases. Smart testing services are used to assess students as well as to evaluate teachers and then store the result on fog servers.
- **Smart Classrooms:** Smart class rooms are becoming increasingly popular in educational institutions. Unlike traditional classroom teaching pedagogy, flipped classroom teaching pedagogy is emerging in many leading universities of the world. In flipped classroom teaching pedagogy, this content is recorded in the form of video lectures. These video lectures are made available to students using some platform/technology. Students are expected to see the video lectures before coming to class. Now, based upon this content, the students will do the problems/numerical/questions in class with instructor offering more personalized guidance and interaction with students.
- **Gamification and Learning through IoT :** IoT can enable gamified learning experiences, where students use connected devices to participate in interactive and engaging lessons. Sensors could track a student's progress in real time, allowing the system to provide rewards or level-ups based on the student's performance, making learning more enjoyable and tailored to

the individual.

***G.*** **IoT application in e-Learning:** In the context of e-learning, smart devices powered by the Internet of Things (IoT) enhance and personalize the learning experience by gathering data and provide feedback. It creates an interactive environment that supports various learning needs. Following are smart devices contributing qualitative approach in e-learning to optimize the educational process. [12][17]

- **MCU** – MCU is a single board computer, working as a hub to connect all devices and make decisions as per the sensors input. A number of MCU models are available which are selected as per requirements. In educational institutions, they may be used to collect data from different sensors and smart devices.
- **RFID** - RFID chip is embedded in the card which is identified through the radio frequency. They can help in the automatic attendance of the teacher as well as of the students automatically. It will improve the efficiency and performance of learners and teachers.
- **Interactive boards** – Through Interactive Smart board, the learner scan learn practical aspects of the lessons other than only the theoretical education. It gives deep and almost permanent impact on the brain of the learners.
- **Smartphone** – It helps to manage Flip class rooms where students, teachers and parents can easily communicate.
- **Sensors and Actuators** - These are the core component of IoT infrastructure
- **VR and AR** - VR and AR is becoming a part of teaching and learning. This helps the teachers to teach the concept in a three-dimensional environment just like real physical objects. ‘is simulates the real environment for learners.
- **Smart Speakers and Smart Microphones -** Smart speakers have di, erent connectivity options. They may be connected by Wi-Fi, Bluetooth, or direct IP access. ‘is may be used for announcement and timetable management. ‘e smart microphone may be used in classes with VR capabilities to automatically update the home assignment.

- **Alexia -** Alexia is a smart voice assistant. It uses AI and Voice Recognition (VR) to interpret voice commands. This put great e, ort into educational institution automation. Instead of using notification systems, Alexia may verbally explain the situation.
- **Biometrics and Face Detection -** Manual attendance is an issue and time-consuming. It is also not secure. Biometric and face detection technologies may be used in the a‹ endance system. This can help to keep the exact arrival and departure information.
- **Scan Marker** - Scan marker is a device which scans the text and converts it into different languages. This may be used in reading other languages and converting text into audio. Scan marker is also called a digital highlighter.

## III. Related Work

In terms of education, IoT is dignified to play the role of a big game-changer as this technology is now utilized by many educational institutions. Along with that, connected smart devices are used by many institutions for supporting the even now available e-learning and smart board infrastructure. The value of the IoT was demonstrated by [6] by developing and enhancing education, as well as the scope of their significance in higher education institutions via smart coursework utilizing the latest methods in the classroom setting, smart labs to run tests more efficiently and enable tests, including the use of gadgets to enhance student communication with their classmates and teachers, and also scientific content.

S.Gul.et.al investigated the role of emergent technology, such as smart materials, artificial intelligence, and augmented reality, in the future of e-learning. In Zhang and Zhou, the importance of locality, interaction, intelligence, openness, and cloud computing were analyzed from the standpoint of e-learning‟s future vision. The use of smartphones in e-learning was emphasized by Mohammed and Isa [25] emphasized the significance of IoT in enhancing human-machine connection, which contributes to people's social isolation. Mountec. These gadgets must be integrated into distance learning systems. These gadgets became more widely

available and easier to operate as time went on. The authors suggest a platform that has an intelligent agent on a student's smartphone. The necessary information about the students' obsessions, participation in the course, and other factors is collected and sent to the artificial intelligence system for evaluation. The artificial intelligence algorithms look at student data, comments, and ratings of course materials to figure out what course content is suitable. The authors suggested analyzing student behavior with smartphones to make sure that the course content was customized correctly. Tobarra, et al. put the app of the virtual laboratory to the test to see how well it worked. The learners' acceptance was evaluated using the Unified Theory of Acceptance and Use of Technology (UTAUT) model, as well as time allocation, learner‟s behavior in relation to evaluation items, and material sources. The main result of this research is that the suggested lab has a high level of student acceptability, as measured by several factors (ease of use, perceived usefulness, and attitude, intention to use, social influence, and estimated effort).

In the same way, IT expertise is required when dealing with IoT apps or devices. Individuals prefer to interact personally with another person rather than with a machine. Others may believe that revealing medical details to the machine will compromise their privacy. Such factors represent considerable obstacles to the use of IoT applications to control the virus‟s spread [25]. Dodero, et al. look at what needs to be done to make the e- learning future a reality. Issues related to IoT and elearning integration, including CPU and storage limitations, throughput, and bandwidth constraints, should be addressed for successful integration. Accordingly, the trade- off between data-collection efficiency and interoperability may be considered to enhance this integration. In their work, Chituc looked at standards interoperability and pointed out the problems with interoperability that need to be fixed for the IoT and e-learning visions of the future to come true. Perales, et al. demonstrated an online system utilized by the International University of La Rioja. The online service is a remote online lab that delivers experiential learning using engineering experimental tools. The teacher might move from one online workspace to another to help students with their lab instructions. Even though this method is used to offer online labs, it doesn't consider how and why the students

interact with each other. In the work of, the authors recommended using a context-aware system to capture a vast amount of data about the learner's surroundings. The system automatically adjusts to the customer's wishes based on these facts. Contextawareness incorporation into an e-learning system would be an effective strategy for improving learning. Zaguia, et al. [24] showed learners a new way to use synchronous e-learning for intelligent e-learning. The paradigm is a new way of thinking about distance learning in which the teacher has more control over the students. Tools for artificial intelligence, IoT, and virtual reality are put together to make a more powerful system that helps the teacher keep an eye on the students during lessons and tests. Most of the changes we will make to our systems in the future will involve adding more computer-aided services to help teachers see and respond to how students are acting. In the work of, the authors proposed that artificial intelligence approaches such as data mining and fuzzy logic be used to smarten up e-learning tactics and augment students' learning. Most of these systems are limited by the time to finish the assessment exam, the learner's evaluation criteria, history, and so on [24]. Similarly, Leahy, et al. investigated the role of emergent technology, such as smart materials, artificial intelligence, and augmented reality, in the future of e-learning. In Zhang and Zhou, the importance of locality, interaction, intelligence, openness, and cloud computing were analyzed from the standpoint of e-learning‟s future vision. The use of Smart phones in e-learning was emphasized by. These gadgets must be integrated into distance learning systems. These gadgets became more widely available and easier to operate as time went on. The authors suggest a platform that has an intelligent agent on a student's smartphone. The necessary information about the students' obsessions, participation in the course, and other factors is collected and sent to the artificial intelligence system for evaluation. The artificial intelligence algorithms look at student data, comments, and ratings of course materials to figure out what course content is suitable. The authors suggested analyzing student behavior with smart phones to make sure that the course content was customized correctly. Tobarra, et al. put the app of the virtual laboratory to the test to see how well it worked. The learners' acceptance was evaluated using the Unified Theory of

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According to Marquez, Villanueva, Solarte , Garcia in “ IOT in education: Integration of objects with virtual academic communities” the students, teachers, and physical and virtual things can interact effectively and via efficiently using IOT. Due to the significance of IOT, the Open University in the UK presented a course and named it “My Digital Life” that depends on IOT basics for undergraduate students in the computer science department. The students learned in this course how to deal with IOT for understanding the world and know their role. Melissa Burns, journalist says Smart learning environments are equipped with digital components that create better, more efficient, and smoother learning process. Ideally, they produce an ideal action between physical and digital realities, permitting students to absorb data from their surroundings and making opportunities for seamless transitions between a spread of learning approaches. Individual and group learning, formal and informal settings, in analogue and digital formats. IOT can track whether homework was done and collect data about how much time a student needed to complete an assignment. This data can help teachers better understand whether their methods are working, which students need additional help, and which tasks they struggle with the most. Literature review shows that almost all of the recent studies propose completely different models for classroom. Several advanced and innovative ideas square measure being projected or introduced in education like introducing IOT technology with crowd sourcing in e-education may be helpful for up learning and teaching processes.

## IV. E-Learning-based IoT adoption model for Higher Educational Institutes

Adoption of the IoT is vital for effective E-Learning. Individuals and organizations must work in a technological environment where specific processes must be followed in order for learning to be successful and effective. For this

purpose, E-Learning influencing factors of the IoT adoption model in HEIs are classified into four groups:

- Individuals,
- Organizational
- Technological
- Environmental,

Individuals are based on instructors and students, organizations depend on institutes and universities, technology is based on devices and tools, and the environment depends on classrooms and homes. Furthermore, details are described given below.[49]

**Individual:** Individuals consist of instructors or students who must possess specific IoT-based E-Learning skills to function successfully. Individuals must have computing abilities, and it is recommended that they remain self-motivated by realizing and learning a lot from IoT based E-Learning approaches. They must be cautious in their actions, attitudes, and everyone must maintain a high level of morality. In order to learn effectively, students and instructors must engage in interactive learning sessions. Instructors may obtain feedback from students on how the learning process is going on and if they understand the learning material correctly or need clarification. Instructors can also automatically use the IoT-based E-Learning sign-in record to automatically save attendance. (Agrawal et al., 2020)

**Organizational:** Organizations consist of institutes and universities. On the other hand, organizations must keep a few things in mind, such as designing the course before publishing it and making the website user- friendly. They should also examine if they are financially ready to publish a course and can meet all the requirements in the future before doing so. Also, they should make sure that the website is infrastructure-ready so that an online exam/test/quiz can be taken and monitored if all goes as planned. (Ahmad et al., 2021)

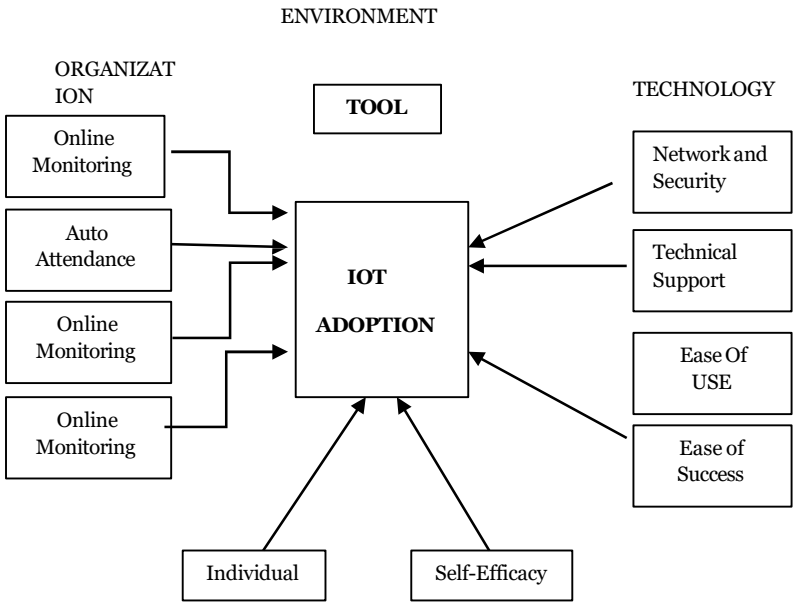



**Fig: E-Learning-based IoT adoption model for HEI**

**Technological:** Technical devices or tools are one of the essential considerations when it comes to implementing IoT-based E-Learning. Instructors and students must know how to utilize technology, and IoT- based devices and platforms must be simple for them to access and use. IoT-based E-Learning systems should have a solid framework and have the ability to add any needed content easily and quickly. They must also have sufficient IoT resources to make effective use of it. (Razzaque and Hamdan, 2020a)

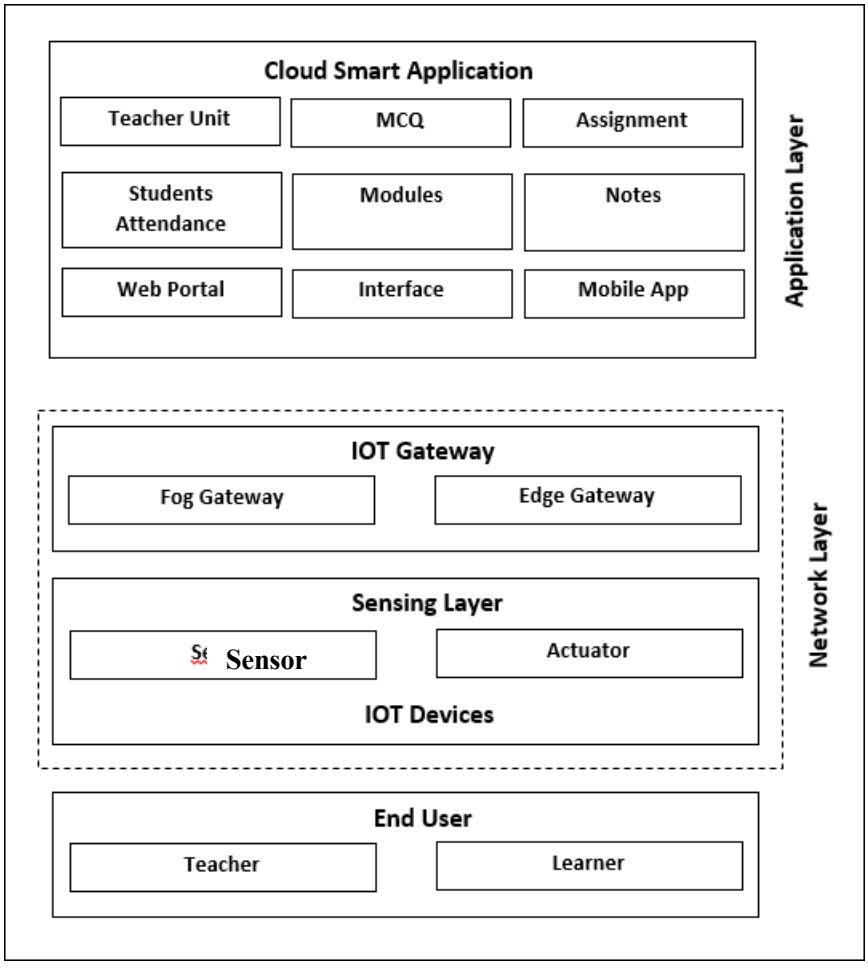
**Environmental:** The learning environment is based on classrooms and homes. Furthermore, it should be preferable to teach their students and instructors before publishing the course to understand the IoT-based E- Learning system entirely. Again, several particular problems, such as privacy and ethical issues, should be considered while operating an online classroom. Moreover, the meeting or conference room, class capacity, and internet speed must be considered. (Amasha et al., 2020).

## V. Proposed e-Learning Entity Model integrating IoT

The proposed model describes the communication system in via network using IoT

devices utilizing IoT devices sensors and actuators. End user teacher and learner both connects themselves with various apps residin cloud through IoT gateways. Sensors detect a physical entity's feature and transform them into digital data that can be interpreted by humans. Actuators use digital instructions to operate on or affect the attributes of physical things.[42]

**Application Layer:** Application Layer is cloud layer which includes business application like e-Learning system. This layer will include all the services that can be provided to learners and teachers. All the information is available in this area.



## V. Challenges and Future Directions

The research study examines the influencing factors that are significant for the IoT adoption of E- Learning in HLIs by proposed designing an E-Learning-based IoT adoption Model and e-Learning Entity Model integrating IoT. The research study stands on two categories of challenges 1) computational challenges and 2) Social challenges. As the area and dimension of Higher Institutional systems are growing, it is exigent to find out the remedies to cope up with such a growth regarding IoT adoption.

1. **Computational Challenges;** Computational challenges run parallel to the installation and integration of smart system. Major challenges in the part of smart education in Internet connectivity, privacy issue, compatibility and interoperability, data pollution, artificial intelligence,
2. **Social Challenges:** Despite the countless benefits, the smart system faces many challenges from the social side. The most general one is the use of modern technologies because the new person and non-technical persons are not friendly with smart devices. Another major challenge is the lack of funds. Generally students are addicted to mobile phones. Therefore, one of the challenges with digitization is that students may addict to different applications instead of giving time to learning. It is the primary concern for the students for overcoming such a kind of attitude.

## VI. Conclusion

This article explored the IoT and smart devices integration in education and proposed a possible framework for smart education. This further explored the issues related to the traditional educational system and how the Information and Communication Technology (ICT) with smart devices can change the academy into digitized methodology. Smart devices convert the traditional activities of the higher educational institution to smart activities such as smart attendance, smart reporting, smart lesson planning, smart pedagogy and smart learner engagement. IoT technology removes presence of teachers and learner's physical presence and expands the access perimeter of teachers, tools facilitating the E-learning

efficiently anywhere and anytime. IoT promises a significant impact on the process of learning in higher education by offering access to the international resources and possibilities for students and teachers. Therefore, one of the major impacts of the IoT-based learning environments is that the conventional student and instructors' tasks can be changed considerably. Students and teachers can retain didactic materials and/or laboratory virtually at any time, from anywhere they can connect. The Internet of things is projected to promote the large number of investigation opportunities for educators, students and researchers around the world. Cloud computing is an innovative technology that can provide huge benefits to universities to improve their teaching and learning processes. While it has been widely adopted for e-Learning across universities in developed countries, its adoption in developing countries is very low and there is a lack of empirical studies that investigate the factors that influence its adoption by university students.

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