"ED-IOT": SCOPE, APPLICATION AND CHALLENGES, OF THE INTERNET OF THINGS IN EFFECTIVE EDUCATION

Abstract

Education is derived from the Latin word "Educare," meaning 'to train.' It involves teaching, learning, and skill development in schools and colleges to enhance knowledge and abilities. Education holds immense importance in life, providing skills, information, and understanding to fulfill societal, family, and national duties. It empowers individuals, instills confidence, aids in decision-making, and fosters mental agility, problem-solving, and logical thinking. Education brings stability, financial security, and contributes to a safe and peaceful world. The COVID-19 pandemic caused unprecedented disruptions worldwide, significantly impacting education. The sector faced challenges as teachers and students shifted to crisis-mode and adopted online education to a certain extent. Smartphones became essential tools for educational and entertainment purposes, with more than 82 percent of children aged 10 to 17 using them. As new technologies, including the Internet of Things (IoT), emerged, the education sector saw a transformative shift, giving rise to Ed-IoT (Education based on the Internet of Things). The primary objective of Ed-IoT is to enhance the educational sector through intelligent networking, rather than mere programming. It combines hardware and software, utilizing smart boards, RFID, wearables, and other interconnected devices, allowing data sharing through mobile applications. Ed-IoT benefits not only students and teachers but also institutions by facilitating better functionality and administration. Moreover, it breaks barriers of age, geography, and time, catering to formal, informal, and non-formal education. Ed-IoT's applications in education are

Authors

Shafi Shereef
TKDM GVHSS
Kerala VHSE
Kollam, India.

Nisha Varghese
Department of Computer Science
Christ University
Bangalore, India.

extensive, including interactive learning, smart board enhancements, augmented reality implementation, remote class management, student and staff progress monitoring, special education for disabled students, safety enhancement, real-time data collection, exam surveillance, smart energy management, and more. By reducing reliance on physical aspects and human resources, Ed-IoT helps minimize time and cost, offering a globalized education experience. However, implementing Ed-IoT poses challenges, such as infrastructural costs, data storage, and ensuring data safety and security. Addressing these issues is crucial for the successful integration of Ed-IoT and its transformative impact on education.

Keywords: IoT; Education; Augmented Reality; Virtual Reality

I. INTRODUCTION

The history of the Internet of Things (IoT) started in the year 1999, when Kevin Ashton implemented an inventory tracking system using Radio Frequency Identification (RFID)[1]. He hindsighted that, if all devices were connected together with a computer that can manage and track inventory and thereby reduce human efforts and time. It was the prime start of a new technology called "the Internet of Things (IoT)". The term "things" (humans, animals, buildings, vehicles, hardware, electronic appliances, software based equipment) is the source of IoT. The Internet of Things (IoT) is a network of physical devices, vehicles, buildings, and other objects embedded with electronics, software, sensors, and connectivity, which enables them to collect and exchange data[2]. The concept of IoT is based on the idea of connecting devices to the internet to make them smart, allowing them to communicate with other devices and perform tasks without human intervention. IoT devices can be programmed to collect data from sensors, process that data using built-in algorithms, and communicate the results to other devices or to a central system. This allows for the creation of smart homes, smart cities, smart healthcare, smart education, and smart industries, where devices can be monitored, controlled, and optimized in real-time. The development of the Internet of Things (IoT) is leading to an intelligent, sophisticated, and autonomous environment in every sense, which enhances our lives' economy, accuracy, sustainability, and efficiency. IoT technology is constantly evolving, and as more devices become connected to the internet, the potential applications of this technology are virtually limitless (Fig. 1).

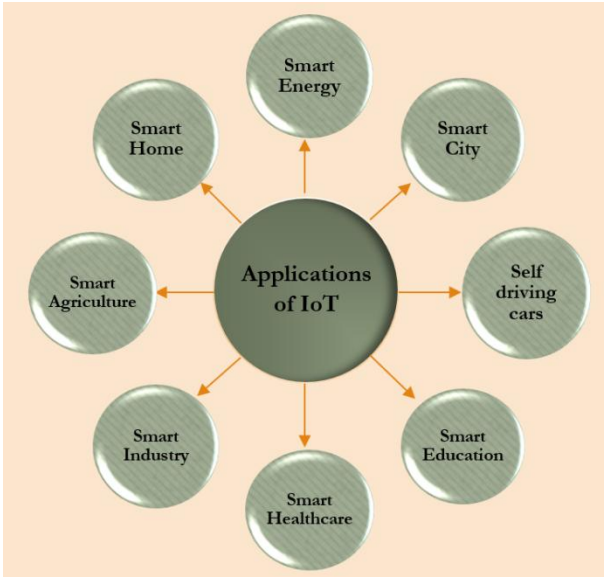

Figure 1: Applications of IoT

The IoT works by connecting physical devices to the internet and enabling them to communicate with each other and with a central system. The IoT process involves four steps: sensing, connectivity, processing, and user interface. Sensing involves IoT devices equipped with sensors that detect changes in the environment or device state (Fig. 2). Connectivity is needed for devices to exchange data with others and with a central system. Data are then processed, which may include filtering and analysis, and

communicated to users through various interfaces such as mobile apps and dashboards. This allows for real-time monitoring and control of IoT devices [3].

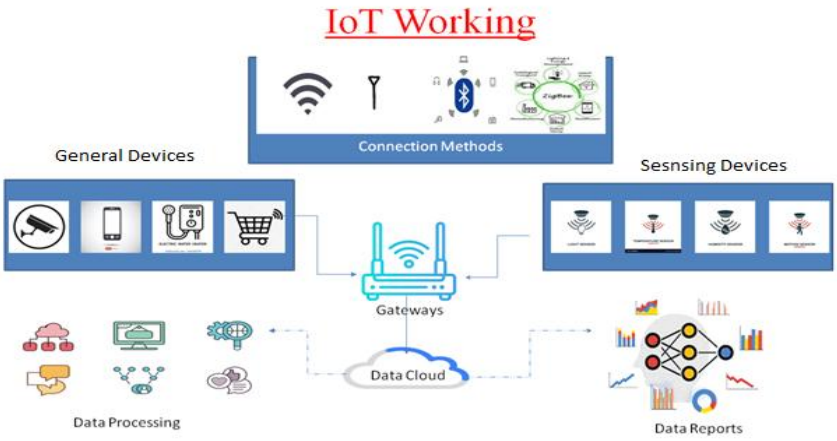

Figure 2: Working of IoT

In 2015, "the global IIoT market is estimated to be worth $151 billion, with predictions for exponential growth over the next decade and in 2017, the IIoT market reaches $170 billion, with growth projected to continue at a compound annual rate of 24.3% over the next five years. The global IIoT (Industrial Internet of Things) market size was valued at USD 77.3 billion in 2020, and it is expected to reach USD 110.6 billion by 2025, growing at a Compound Annual Growth Rate (CAGR) of 7.4% during the forecast period" [10]. The revenue generated from IIoT varies greatly across industries and companies. Some companies may generate millions of dollars from IIoT solutions, while others may generate only a fraction of that amount. This revenue from various domains such as Mining and quarrying, Information and communication, transportation and storage, Manufacturing, Agriculture, Forestry, fishing, water supply, waste management, retail and whole sale, finance and insurance, administrative, electricity, gas, education, health, entertainment and much more.

The workings of the IoT are not limited to just these components. In addition to these four components, the IoT also involves cloud computing, artificial intelligence, and security mechanisms to ensure the safety and privacy of the data being transmitted. With the advancement of technology, the scope and applications of IoT are constantly expanding, and it can transform various industries, including healthcare, transportation, manufacturing, and education, among others. One of the major uses of IoT is in the field of education. Education is the process of acquiring knowledge, skills, values, beliefs, and habits through various means such as teaching, training, research, or self-study [4]. It involves the transfer of knowledge from one generation to another and is essential for the development and growth of individuals and societies. Education can take many forms, including formal education provided in schools and universities, informal education gained through life experiences, and non-formal education provided through workshops, seminars, and other training programs. Its purpose is to help individuals develop their intellectual, social, and emotional capacities, enabling them to lead productive, fulfilling lives and contribute to the betterment of society.

The field of education is facing many challenges that affect students, educators, and institutions alike. One of the primary issues is access and equity, where many students, particularly those in underdeveloped and rural areas, are still unable to receive quality education. This disparity in opportunities can lead to long-term social and economic inequalities. Another challenge is the rapid technological change, which brings both opportunities and challenges to education. Incorporating technology into education can improve learning outcomes and prepare students for the future. However, education systems often face budget constraints that lead to underinvestment in infrastructure and teacher training. Additionally, outdated curricula and pedagogical approaches fail to prepare students for the challenges of the modern world, emphasizing the need for more relevant, flexible, and personalized teaching methods. As the world becomes more interconnected, education systems must adapt to cultural diversity and global perspectives, promoting intercultural competencies and diversity. Mental health concerns have also grown, impacting academic performance and well-being. Finally, the COVID-19 pandemic has resulted in significant learning loss, particularly for marginalized students. Addressing these challenges requires a collective effort from policymakers, educators, parents, and students to create inclusive and effective education systems that meet the needs of all learners[5].

The Internet of Things in Education (Ed-IoT) can revolutionize education by addressing some current challenges in the field. One way Ed-IoT can do this is by promoting educational equity, providing equal access to learning resources for all students, regardless of their location, socio-economic status, or ability level. Ed-IoT devices can also be used to customize learning experiences and provide individualized instruction based on each student's needs. Another benefit of Ed-IoT in education is its potential to save school money by reducing the need for traditional learning materials such as textbooks and paper, while also reducing energy costs through smart lighting, heating, and cooling systems. Additionally, Ed-IoT can help improve mental health by providing students with access to wellness resources and stress-reducing tools, while also monitoring behavior for potential signs of stress or anxiety. Furthermore, Ed-IoT can help prepare students for a globalized world by providing access to international learning resources and connecting students with peers from around the world, as well as providing personalized learning experiences to address learning loss. Finally, Ed-IoT can help to improve curriculum and pedagogy by providing personalized and adaptive learning experiences for students based on their individual needs and learning styles and by providing access to the latest digital tools and resources to create immersive and engaging learning experiences.

The Ed-IoT is poised to revolutionize the field of education by offering new opportunities for personalized learning, improved efficiency, and an enhanced overall learning experience. The ability of Ed-IoT devices to collect data on student performance and behavior can create a personalized learning environment that meets the individual needs and preferences of each student. By automating routine tasks such as attendance tracking, scheduling, and resource allocation, Ed-IoT can improve school and university operations, freeing educators to concentrate on teaching and learning. Additionally, Ed-IoT can promote interactive and engaging learning environments, such as virtual laboratories and smart classrooms, and teach students about coding, robotics, and other emerging technologies. Ed-IoT can also be used to monitor energy use, reduce waste, and promote conservation, providing valuable opportunities for sustainability education. Ed-IoT enables students to connect with each other and educational resources in real-time, irrespective of their location,

fostering interactive and collaborative learning. Finally, Ed-IoT inspires innovation and creativity by encouraging students to come up with new ideas and solutions, leading to the development of innovative Ed-IoT applications that could transform various industries.

Ed-IoT technology can transform education and enhance learning outcomes by creating interactive and engaging learning environments. One way to achieve this is by creating smart classrooms using Ed-IoT, where sensors and devices can detect and respond to changes in the environment to provide a comfortable and conducive learning experience for students and teachers. Ed-IoT can also be used for personalized learning, by collecting data on individual learning styles and progress to create tailored learning experiences. Virtual and augmented reality technologies can be used to simulate real-world scenarios and provide hands-on learning opportunities, while Ed-IoT can support remote learning by providing access to educational resources and tools regardless of location. Additionally, real-time data analytics using Ed-IoT devices can help teachers track student performance and engagement, and provide personalized feedback to improve learning outcomes. The potential of implementing Ed-IoT in education is huge, but it is important to address the challenges that may arise. Privacy and security concerns must be taken seriously to ensure that the personal information of students and teachers is protected from unauthorized access. Additionally, implementing Ed-IoT in education requires significant infrastructure and technical expertiz, which can be expensive for schools, especially in low-income areas. The digital divide should also be taken into account to prevent the creation of disparities between students who have access to advanced technologies and those who do not. Implementing Ed-IoT in education will require significant investment in terms of time and resources. While Ed-IoT can transform education, ensuring that educational benefits through Ed-IoT are realized while minimizing negative impacts is a key challenge.

II. ARCHITECTURE OF ED-IOT

The layered architecture of the IoT can be applied in education to improve the learning experience and enhance the educational process. Figure below shows the common layered architecture of Ed-IoT [6] as depicted in Fig.3. The Perception Layer in IoT education can involve the use of IoT devices such as smart boards, sensors, and wearables, which can collect data on student behaviour, attendance, and performance. For example, sensors placed in a classroom can track students' attendance and behaviour, and smart boards can collect data on students' interaction with the learning materials. The Network Layer in IoT education can involve the use of wireless networks, cloud platforms, and data centers to store and process the data collected by the Perception layer. This layer can help connect IoT devices to the internet, enabling real-time data collection and analysis. In the Data Processing Layer in Educational IoT, data is analysed, processed, the result may be stored, if needed, and sent to the next lavel. It uses different analytic tools and machine learning algorithms to process and analyze the data collected by the Perception layer. The Application Layer in IoT education can provide insights into student behaviour and learning patterns, enabling teachers to personalize the learning experience and optimize their teaching strategies through different data representation systems.

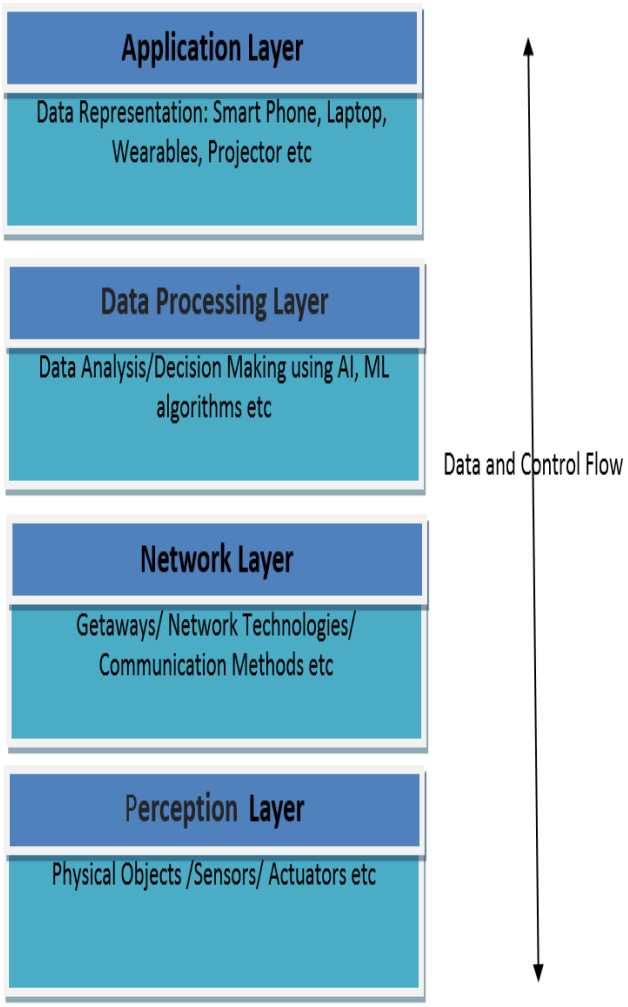

Figure 3: Architecture of IoT

III. APPLICATIONS OF ED-IOT

During the pandemic COVID-19, one of the most affected sectors was education. The teacher- student interaction and teaching was established through zoom meetings, developed by Microsoft. the major boom of Ed-IoT starts in the pandemic situation. The application of Ed-IoT starts from the time when a student leaves home to school and reaches back. The remaining topic discusses the applications of Ed-IoT in detail, in different areas.

1. **Smart Class Room:** For Ed-IoT, the primary step is to set up a class room called a Smart Class Room. Recently, the classroom has become smarter. The old generation blackboard has been replaced with a smart white board, which is an interactive and dust-free device. The old chalk and sponge duster was spared with a smart pen and erazer. Using smart board, teachers can easily deliver interactive visual content.

    - **Smart projection systems**: It is a portable device that has advanced display technology with integrated functionality such as connectivity with mobile phones, home networks, and content services. Today, the smart projector can do most of the activities that can be done by a smart TV with large projection. Eye protection,

automatic hue control, short throw, auto focusing, built-in speaker and compatible connective ports are special features of modern smart projectors[7]

- **Laptop & Tablet-** The devices help teachers and students to access and provide seamless, reliable, and consistent content for their education. They reduce the burden of the weight of school bags. For teachers, it helps to prepare and deliver content effectively.

- **Camera & Recording Microphones-** The lectures of teachers can be recorded for future reference. Using the camera and recording microphones we can record all classroom activities for further reference. It also helps to find the mood swings of students. Other smart devices such as digital podiums and smart TV can also be used for setting smart class rooms. All devices are connected to the internet for a smart and effective learning experience [8].

2. **IoT Enabled Smart Security Systeme:** Using the Ed-IoT, we can provide a different type of security for students, teachers, institutions. Security starts when a student leaves home. When he boards the bus, the Radio Frequency Identification (RFID) reader reads the details of the student - such as name and time, using RFID-enabled id-card. On his return, when he enters the bus, that information will be passed to the parents. It also informs the driver if someone is missing [9]. In the classroom, the door will open only when they show their Identity card. When an intruder is spotted in the campus, the camera placed around the campus detects it, and automatically it will sound an alarm for intimation in the campus and shut down the door of the classroom. At the same time, it informs cops by sending messages with photographs of the intruder. This system provides security for students and teachers [10].

   Violence on campus is difficult to manage. The camera placed around the campus will capture the picture if there were any scenes of violence. The AI-enabled camera will identify the students who are involved in it and inform the teachers and management by providing details of these people with their name and class. Through this, the organization can manage discipline in the campus. The security system must be reasonable, expandable, and versatile enough to fit the needs of various companies [11].

3. **IoT Enabled Smart Attendance System:** Student attendance is essential. Their discipline and performance in the exam depend on attendance. When a child enters school, his attendance is marked either through a RFID-enabled ID card or fingerprint sensing device or through a face recognition camera. This RFID reader / camera is connected to the server system through internet-enabled WiFi. The server evaluates the data and makes the corresponding update in the database[12]. The students' attendance is also notified to the parents through a message. At the end of the month, the attendance average of each student is tabulated and the same is sent to the parents. By automating attendance, schools save time. Accurate results with less human interaction, and real-time attendance mapping are possible. When a child is out of class or school, intimation is given to his class teacher in due time. Apart from this, the same system can be implemented for staff, their leave, salary, etc[13]. It can be done on a time-bound basis.

4. **IoT Enabled Smart Health Monitoring Systems:** Health care in institutions is essential. The face-to-face interaction between students is more prevent on the campus. Hence, there is an increasing chance of spreading diseases in the campus. During the COVID-19 pandemic, temperature monitoring, oxygen monitoring, wearing masks and social distancing are key remedies for prevention. If we implement an IoT-enabled health monitoring system in the campus, it will help us to stop spreading epidemics. In the K-12 education system, students must take different types of vaccinations at different age levels. If the system is connected with the student health card, it can automatically inform the health department and parents about the status of vaccination[14]. This will help the health department to make proper arrangements to conduct vaccination camps.

   The IoT-enabled health monitoring system consists of an IR temperature sensor, heart beat sensor and SpO2 sensors. When a student enters the class room, the IR temperature sensor senses the temperature of the student and sends it to the health monitoring system. It will check the students temperature with the reference range. If it is above, it will automatically inform parents, class mentors and health departments of the institution. The same thing is happening with the heartbeat sensors and SpO2 machines. If the system finds anything abnormal in reading, the IoT-enabled health system will an send alert signal to the corresponding persons[15]. It will help to stop the spreading of diseases across the campus

5. **IoT Enabled Examination and Evaluation:** In traditional educational systems, the examinations arte conducted by a physical observer in the examination hall, and he will monitor each student to prevent malpractises. However, some students have their own ideas and tricks to violate the attention of the invigilators and to involve in malpractises. This is a violation of academic ethics. In the IoT-enabled smart examination hall, the system uses psychological sensors to sense the behaviour of the students during the time of writing the examination. If any misbehaviour by the students is found, it will be reported to the examination department and the observer who is monitoring the examination[16][17].

   During the pandemic, most of the exams were conducted online. There was more chance of malpractise in the examination. Major cheating in online examinations was impersonation, seeking help from friends or family members for common problems, and finding solutions through surfing. In the online exam, the entire activity is carefully assessed by an AI-enabled system. During the time of examination, AI-enabled proctoring software will check for any suspicious movement happening from students through live steaming using a webcam and will report any suspicious behavior noticed. It also recognizes the presence of any surrounding sounds. Evaluation of student answer paper is always a tedious topic. To assess their internal marks, which include not only their answer paper evaluation mark but also their attentiveness in class and their behavior. It is a time-consuming task. While conducting the online exam, the exam software can calculate the marks using artificial intelligence quickly and can easily calculate the internal marks by linking the attendance database. New AI technology can easily understand each student's handwriting [18]. Thus, we can not only conduct MCQ-type examinations but also conduct informational answer-type questions. The same may be evaluated using AI-empowered software. The AI-based evaluation techniques help teachers recognise

which students are poor in which area [19]. Thus, the teacher can make a strategic plan to concentrate on that area, which helps the students to learn the concepts easily.

6. **IoT Enabled Smart Waste Management:** Waste generation is high in educational institutions. They are facing different types of garbage such as e-waste, plastic wastage, edible wastage etc. for creating sustainable and green campus, the management of waste is essential. In the traditional trash collection system, cleaning staff constancy checks whether the dustbin is filled or not. Often the cleaning staff will only know that the dustbin is full of it sticks out. Due to this, children's hygiene is affected, there is a chance of multiple breeding of mosquitoes that leads to ailments. Foul smell due to rotting food also hampers a healthy campus environment. Also, there is the chance of stray dogs coming inside the campus to eat the waste and there is a chance of them harming the children. The implementation of IoT-enabled waste management system in the campus, a proper and effective management of garbage- to support social, economic and environmental sustainability, is possible. A smart waste management system requires less managerial time and cost [20][21].

   IoT-enabled smart waste management systems consist of a smart dustbin sensor. This ultrasonic and proximity-based sensor automatically checks the fill level of the dustbin. If the garbage collection reaches a certain level, it automatically generates an alert message to the cleaning department [22]. The system also contains temperature monitoring system that monitors the temperature to prevent unwanted accidents such as explosion and firing. AI and computer vision algorithm implemented dustbins also recognize streams that need to be separated and the door of the dustbin will automatically open accordingly.

   IoT-enabled smart waste management helps institutions plan better distribution of bins to avoid incorrect disposal practices, better and timely waste management at low cost, and create a beautiful green campus.

7. **IoT Enabled Smart Energy Management System:** Energy is one of the crucial resources for an institution. The demand for energy increases day by day. At the same time, the cost of energy is proportional to its demand. Nowadays climate change has become a crucial problem. Controlling energy consumption contributes to social commitment for sustaining an ecological balance. Problems related to energy in the institution such as electricity wastage, electricity-related accidents, electrical short circuit situation. These problems can cause danger to students and institutions. Hence, institutions should find a smart way to monitor control and save of energy. Before IoT, it was a herculean task.

   IoT-based smart energy management systems promises to save energy, improving security, and enhance efficiency. This system provides a variety of control over energy consumption and energy management. For example, an IoT-enabled energy management system automatically switches off fans and dims lights when it senses the absence of students in the class room. The AC of the classroom automatically works and sets the cooling according to the present weather condition. The street lights automatically switch on and off according to the sunlight[23]. This smart energy management system will reduce the consumption of energy and hence the expenses. This system also reduces the

carbon emissions. The energy motioning sensor in the system performance and record consumption data, utilities so that we can make a decision as to how to maximize the conservation strategy of renewable energy.

This system also detects and creates alerts of energy leakage due to the fault of the machine or prevention of energy abuse. If the system finds any abnormality in the transportation of energy, or leakage, it will send an alert to the staff through messages or sound for taking necessary precautions, which prevents further damage. This system will help the institution make a smart decision on the use of energy and the type of energy implemented in their institution[24].

8. **IoT Enabled Smart Room Scheduling System:** In an institution, the proper management of buildings is essential. Classroom allocation, meeting room allocation, and its management are important. Each room and its facilities such as room size, facilities available in the room, maximum number of chairs that can be occupied in the room, and types and locations of the rooms are also saved in a database. Improper management of allocating class rooms leads to waste of resources. For example, the maximum number of students in a class is fifty. Also if this class room is allocated to a class of 80, the resources such as energy, seats, multimedia facility, etc., will not be effective. At the same time, some other classes having more than 60 students may want to wait or they are to allocate a conjectured class room that has a maximum capacity of 50 with less resources. In a college or school having different departments and clubs. Each of them organizes activities. For that, they require room for smooth conducting of these programs. Some programs may be conducted in a class room, which requires minimal facilities. Some of these programs require medium-type rooms corresponding facilities, and some programs may require large auditoriums. More than one program may be conducted on the same day. Hence, if there is no proper allocation of the auditorium and meeting rooms, it may lead to a flop of the program and eventually affect the reputation of the institution. This problem can be avoided by setting a smart IoT-based classroom / meeting hall allocation system[25].

With this IoT, the class rooms are allocated depending on the number of students and the kind of resources needed for that class. The IoT occupancy sensor and its connected devices such as laptops or mobile phones, staff, students, and management can easily see if the conference room or classrooms are available or not. It also shows the facilities available in unallocated rooms. It will help to set the classrooms before starting class[26].

During the examination time, the arrangement of the examination hall is essential. The system will collect information on the maximum number of students appearing for an examination on that day and the maximum number of rooms needed for conducting examination without affecting the normal class if any. The system automatically allocates hall and seat numbers for the students. Hence, it will reduce the time and cost and headache of the examination cell.

9. **Library Management System:** Library plays an important role in educational institutions, which provides a wide variety of text books like resources for reading and learning. In a library, students and staff can access not only text books but also magazines, journals, news papers, and digital media supporting documents for assignments and research. For students and staff, the library helps to promote literacy with access to a wide range of books and other materials. It also supports academic success, independent learning, and critical thinking skills.

   By implementing an IoT-enabled smart library management system, we can arrange shelves that can automatically track books and other materials easily. It will help both the librarian, the students and the staff for quick access to text books and other materials[27]. It also enhances the user experience by providing support to find the availability of books, when it will be available if it is currently not available in the shelves, other books by the same author, and related books on the same topic by other authors[28][29].

   IoT-enabled library management systems contain cameras and sensors, which help the librarian detect suspicious behaviour of students or sense any security violation that may occur. It also helps to prevent the theft of books. This system may also contain RFID tags for books and other materials, which helps the librarian manage issues and collect books effectively.

10. **IoT Enabled Smart Disabled Students Supporting System:** Any student may find learning challenging, but a student with a disability may find learning particularly challenging. Physical, cognitive, intellectual, invisible, and undiscovered disabilities are just a few. They may also have cognitive or sensory perception impairments. People with disabilities may become overly dependent on family and friends for help or experience social isolation. Students with disabilities may experience a various issues at school that may harm both their academic performance and general well-being. Young children with disabilities may have more difficulties in the classroom than other children due to the rigid and inflexible curriculum-based framework executed in the school. Peer bullying and social exclusion for children with disabilities can have a negative influence on their mental health and academic performance. The teachers and others stigmatize and discriminate disabled students from others. An IoT can be a useful tool for assisting students with disabilities in gaining access to technology and learning materials.

    IoT is a way to improve the quality of life of children with disabilities and promote participation in social and economic sectors. IoT-based academic and learning aids (eg, computer-based software, portable word processors), communication aids (eg, captioning devices, smart glasses, augmentative communication devices), and mobility aids are a groundbreaking ways to provide independent living opportunities for individuals with disabilities. This increases their level of participation in society and thus, empowers persons with disabilities. With IoT, a smart classroom may be built using gadgets such as interactive projectors, smart boards, and virtual assistants. This can make it easier for students with impairments to access educational resources and take part in class activities. By setting up the virtual reality and augmented reality classrooms, disabled students belonging to even remote areas get access to educational resources. AI-based programs in the IoT-enabled system automatically find the type of disability of the

students and simplify the system according to their disability and needs. Students with visual, auditory, or motor challenges benefit from the use of IoT devices such as smart glasses, gloves, or hearing aids. They can interact with their surroundings and access educational content with the aid of these gadgets. The screen reader reads computer and Internet-related information, which helps those who are blind or visually handicapped, a magnification tool called a screen magnifier is used for enlarging screen material . High contrast themes that let persons with vision difficulties adjust the colours to a more comfortable setting (such white on black), people with mobility disabilities to "type" using an on-screen keyboard. Using a pointing device, people can pick letters and words on the screen. On-screen alerts benefit those who are deaf or hard of hearing, and visual messages can take the place of audio ones[30]. Students with disabilities' health and wellbeing can be tracked and monitored via IoT wearables, such as smart watches. This may entail keeping tabs on health indicators, keeping track of prescription schedules, and sending out therapist appointment reminders.

The Smart Wheelchair is wirelessly connected to the IoT, thus increasing user independence. The IoT-based wheelchair system enables comfortable care for the disabled person and real-time monitoring for their caregivers. Also, smart doors like facilities can make it easier for children in wheelchairs to move around the school premises. IoT is an effective tool for assisting students with disabilities in gaining access to technology and learning materials. We can build more inclusive learning environments that meet the requirements of all students by using the power of the IoT.

11. **IoT Enabled Smart Learning System:** Learning is the acquisition of knowledge or skills through study, experience, or by being taught. Learning causes students to develop new perspectives on concepts, ideas, and/or the world. It is directly related to how students respond to and interpret their experiences. learning helps in critical thinking and decision making at the right time and in the right place. The leaning process starts right from a person's birth and continues throughout all stages of life. Nowadays for effective learning, the IoT plays an important role. IoT offers new opportunities for individualised and interactive learning experiences, which can alter the way we teach and learn.

Teachers can tailor their instruction to each student's needs by using IoT devices to monitor and analyse their behaviour, learning habits, and progress. IoT-enabled learning systems may adjust to each student's unique requirements and preferences based on the data gathered. This technology may also offer students customized information that caters to their tastes and needs in terms of learning. For instance, an IoT-enabled learning platform can assess a student's learning style and provide pertinent materials and activities to support their academic objectives.

IoT gadgets are capable of gathering information about students' learning habits, preferences, and performance. It can be used to remotely monitor and track student progress, including their attendance, participation, and assignment completion. Wearable technology, for instance, can monitor a student's level of physical activity and sleeping patterns. These data can be examined to understand more about the learning styles, aptitudes, and weaknesses of the pupils and helps to offer necessary support to students. Hence, teachers can make a personalized education system. IoT devices can give students

real-time feedback, enabling them to monitor their development and modify their learning tactics as necessary.

By establishing real-time connections between students and educators in various places, the IoT can promote collaborative learning. This enables students to work together on group projects and share ideas and insights with one other. Remote learning is made possible by IoT devices that, give users access to online learning material and hence enable the virtual interaction.

By exposing students to real-world applications and scenarios, IoT devices can be used to facilitate hands-on learning experiences. IoT sensors, for instance, can be used to track and analyse data from traffic, environmental, and other sources, which can subsequently be utilised to instruct students about the real-world uses.

Some IoT applications in learning are:

- **Gamification:** The Internet of Things (IoT) can be used to develop interactive games that motivate students to interact with the course material. These games can assist students in applying what they have learned in an enjoyable and interesting way by adding real-world data and feedback[31].
- **Virtual labs:** The Internet of Things (IoT) can be used to build online labs that let students conduct experiments and run simulations. Students can conduct experiments and gather data from anywhere in the world using IoT sensors and devices[32].
- **Virtual classrooms:** IoT can support virtual classrooms by enabling students to take part in discussions and team projects in real-time. IoT-enabled chatbots and video conferencing tools can be used to support and give feedback to students during virtual classroom sessions.
- **Online resources:** Students can access a various of online resources, including educational videos, podcasts, and interactive simulations, using IoT devices. These tools, which can be accessed from any location with an internet connection, can assist students in engaging with the material in fresh and creative ways.
- **Virtual and augmented reality:** By utilising IoT devices, virtual and augmented reality technology can be used to create immersive learning experiences. IoT sensors, for instance, can be used to monitor students' movements and interactions with virtual objects, allowing for the creation of fun and dynamic learning scenarios[33][34].

12. **Use of Augmented Reality in Learning:** By providing students immersive and interactive experiences, augmented reality (AR) can be used to improve education in a various subject areas. Here are some instances of how the AR can be applied to various fields of study:

- **Science:** Using augmented reality, scientists can create interactive 3D models of phenomena and concepts, such as the human body, cells, and atoms. Through hands-on exploration of these models, students can better understand challenging ideas. Virtual anatomy can be produced using the IoT, giving students a more interactive and interesting learning experience. Students can explore and interact with 3D models of the human body in real time using augmented reality or virtual reality devices, for

instance. IoT-enabled surgical instruments can provide real-time data on the status of the operation and the patient's condition. Sensors can be used to track physiological indicators of health and well-being, such as blood flow, oxygen levels, or other physiological indicators. By using this information, surgeons can make educated decisions and modifications that will improve patient outcomes. The Internet of Things (IoT) can be used to build smart systems for internal organ and tissue imaging. For instance, machine learning algorithms can be used to analyse MRI or CT scans to find early indications of illness or abnormalities.

- **History:** AR can be used to bring historical events and locations to life, giving students a more immersive and engaging experience. For instance, using augmented reality, students can explore historic sites or watch events unfold.
- **Art:** Through the use of interactive 3D models of well-known works of art, augmented reality can improve art education. Students can thoroughly examine these models while learning about the artist's methods and supplies.
- **Mathematical** concepts, such as geometric shapes and equations, can be interactively visualised using augmented reality (AR). These interactive visualisations allow students to interact with mathematical ideas in real-time, which helps them understand them better.
- **Language learning:** Using augmented reality, instructors can create fully immersive lessons that let students practice their language skills in a simulated real-world setting. For instance, students can use augmented reality to place a takeout order or find their way around a strange city.
- **Civil Engineering:** Monitoring the condition of buildings, bridges, and other structures in real-time is possible with IoT sensors. By utilising these data, potential issues can be identified before they become serious and maintenance can be planned accordingly. IoT sensors can be used to track noise levels, air and water quality, and other environmental elements that affect both people and animals' health and safety. These data can be used in order to identify potential risks and guide decision-making in construction projects. With the help of IoT, engineers can identify potential issues like landslides or soil liquefaction before they happen. The sensors are also used to monitor soil and groundwater conditions.
- **Physics:** IoT can be used to create simulation software that aids students in visualising difficult physics concepts. Software can be used, for instance, to simulate the movement of planets in our solar system or the behaviour of subatomic particles.

IV. BENEFITS OF ED-IOT

The Ed-IoT can revolutionise education by providing some advantages.

1. **Improved Learning:** Ed-IoT-enabled tools can offer immersive and interactive learning environments that will be interesting to students and help them understand difficult ideas better. IoT sensors, for instance, can be used to build digital simulations that make students explore and test various real-time scenarios.

   Studies show that only 20% of the content in the syllabus is difficult and new, while the other 80% is predicated on past knowledge. One of the difficulties teachers

encounter when developing lesson plans, is their inability to know with certainty what their students have already learned or how quickly they absorb new content. With the continuous data collection from IoT systems, teachers can monitor when their students are paying attention, when they have stepped out of the focus. Teachers can use AI Conventional Neural Networks (CNNs) to recognise and classify students' facial expressions so that they can be alerted when a student has lost interest. Whenever a student loses focus during a session, teachers can use smart whiteboards or other presentation tools to pinpoint where their students are have difficulty.

Teachers can use information from IoT sensors to plan appropriate courses that are specific to the requirements of each individual student, contradictory to potentially irrelevant, whole-class content. One approach to do this is to employ intelligent teaching robots that can modify the curriculum's pace and material, based on how accurately pupils answer questions. Teachers get a greater grasp of what is and is not working in the classroom through the use of IoT in education to create student-centered curricula, allowing them to enhance their instruction even more.

It is a common practice in many schools to teach students a second or third language. Instead of stumbling through online courses and "realistic" speaking websites, students can use VR goggles to involve themselves in the reality of the language they are learning. When wearing VR goggles, students can communicate with animated characters using the target language. In order to fully immerse themselves in the culture of the countries whose language they are learning, students can virtually travel there.

The conventional mode of instruction, employing textbooks and chalkboards, is no longer used when instructing students. So upgrading textbooks is essential. Technology innovation has led to the replacement of textbooks with Quick Response (QR) codes. Students can download or save textbooks as ebooks on their device from any location using QR codes. They have access to it as well. Moreover, whenever you use an e-book, you can directly search for a certain piece of information. You can get a quick response in this manner rather than wasting time by turning pages. QR code also provides other information like how to pronounce a word or location map and pictures, related content information etc. QR code scanner enables students to receive feedback, submit assignments, and download other relevant information. Because of this, educational content on IoT devices is constantly up to date and can be modified to suit the needs of pupils**.**

2. **Choice-based Learning:** Ed-IoT can support individualized learning by tailoring feedback and resources to each student's learning preferences, skills, and shortcomings. IoT-enabled tools, for instance, can monitor students' progress and modify the learning environment as necessary. Students are free to go through the area which they like more. Depending on the interest of the learner and his environment, content and presentation can be changed. It makes learning more enjoyable.

3. **Classroom Management:** IoT-enabled devices in Ed-IoT can help make classroom administration processes more efficient so that instructors can concentrate on teaching and learning. Ed-IoT will automatically manage student attendance, classroom allocation, and progress evaluation of students and staff. Smart boards, wireless door

locking systems, security cameras, smart classroom environmental management, arrangements suitable for disabled students, real-time monitoring, and correlations are some of the features of Ed-IoT.

4. **Cost Saving:** By automating and improving numerous processes, such as lighting, heating, and cooling, based on usage patterns and occupancy levels, the Ed-IoT can assist educational institutions in saving money. The library clouds help the students access various books and journals that may not be physically available in the library. This will help the institution not to spend money to buy rare copies of valuable books. The Ed-IoT at the earliest prevents the chance of damages to instruments and machinery due to different catastrophic errors. Most of the works are carried out automatically in Ed-IoT. In fact, we can reduce the number of persons needed for doing a particular work.

5. **Improved Safety and Security**: The Ed-IoT can contribute to improving safety and security at educational facilities by keeping an eye on spotting possible dangers such as fires or attack by intruders. It can make real-time alerts. It also informs students of their' status to their parents.

6. **Environmental Sustainability:** By monitoring and managing energy use minimising, waste and optimizing resource consumption, the Ed-IoT can support environmental sustainability. Due to the use of the devices such as mobile phones and other gadgets, we can reduce the use of paper. Smart waste management helps to keep the campus clean and clear. Hence, it can offer better health to students and staff. It helps to take decisions on the type of energy suitable for institutions.

7. **Fit for all Types of Education:** Ed-IoT systems can be applied in all types of education, whether online or offline, and in all types of education methodologies, whether formal, informal, or non formal. It can be used for all age groups and sex. It can be easily adaptable and changeable for any occasion and can be used in any condition. Ed-IoT is equally applicable from Montessori to research education. Ed-IoT is suitable for all types of institutions such as schools- KG to K-12, colleges -arts and science. All branches of studies such as medical, electrical, electronics, mechanical, computer, chemical, astrological, astronomical, oceanography, marine, agricultural, social and psychological, motor driving institutions and so on.

8. **It is Quick and Less Prone:** Since most of the processes are carried out in the Ed-IoT automatically, there is less chance of errors. Attendance of students, its evaluations, alerts (related to health of students and staff, security, disaster), management of classrooms and meeting halls, energy management etc are automated and hence the chances of occurring errors are less.

V. CHALLENGES OF ED-IOT

Web-enabled devices are metamorphosing our universal rights into a larger, switched-on space to live in all over the world. The goal of IoT is not only to offer enhanced device, system, and service connectivity and extended machine-to-machine communications but also to encompass a range of protocols, domains, and applications. In education, the success of the

IoT will depend on how students, teachers, and management live, interact, and run their institutions. The Internet of Things is facing a variety of difficulties. Despite the many advantages of IoT in education, there are also some difficulties that management and officials must be aware of and work to resolve. So, we might have to deal with these difficulties if we are integrating IoT in institutions [35] [36]

1. **High Cost:** Implementing IoT in educational institutions can be expensive due to the costs of the systems, devices, software, hardware, and power needed to run them. Maintaining these systems also requires skilled professionals, which can be costly for small institutions and publicly funded schools. However, efforts are being made to develop more affordable and easier to implement IoT-enabled systems. Institutions can hire a small team of experts, either in-house or on a contractual basis, to reduce costs.

2. **Data Security and Privacy:** Data security and privacy are serious concerns when implementing IoT in educational institutions. With large volumes of data being collected and processed by IoT devices, institutions must be wary of cyber threats such as data stealing, phishing stacks, man-in-the-middle attacks, and ransomware. If unsecured properly, such threats can have disastrous consequences for institutions in terms of money, fame, and student and parent trust. To address these concerns, institutions must use security policies and technologies to protect data from attackers and spread awareness about these measures among staff and students. Additionally, it is important to secure collected data and ensure privacy for all stakeholders, especially in cases where children are involved. Institutions and parents should seek assurance from IoT service providers regarding the systems they will and effectively apply security and privacy measures using reliable open platforms.

3. **Data Storage Issues:** Organizations should implement efficient data management and storage solutions, such as distributed databases and data lakes, to handle the increased volume of data. These solutions can also offer real-time processing and analysis of data, enabling educational institutions to make informed decisions quickly. By adopting modern storage systems, institutions can ensure that their data are secure, accessible, and properly managed, reducing the risk of data loss or exposure.

4. **Complexity:** Additionally, educational institutions can provide training and support to help students, educators, and management adapt to the new technology and understand how to use it effectively. This can include workshops, tutorials, and online resources. Furthermore, educational institutions can collaborate with technology providers and experts to ensure that IoT systems and devices are user-friendly and easy to use. By transitioning to IoT as smooth as possible, educational institutions can reap the benefits of this technology and enhance the learning experience for all stakeholders**.**

5. **Interoperability and Standardization:** Interoperability is a significant challenge that education institutions face when implementing IoT systems. The educational sector is highly fragmented, with different schools, colleges, and universities using different technologies, software, and devices. To overcome this challenge, educational institutions must choose IoT systems compatible with existing technologies and devices. By addressing interoperability challenges, educational institutions can leverage the full

potential of IoT systems, enabling them to work together effectively and efficiently, thereby enhancing the learning experience for students and teachers.

The lack of standardization in the IoT can cause difficulties in communication and data exchange between devices, leading to an inefficient and fragmented system. To address the lack of standardization in IoT devices, organizations and manufacturers should come together and establish standard protocols that all devices must adhere to. This will make it easier for devices to communicate with each other, leading to increased interoperability and security. Efforts are being made to establish industry standards, such as the Open Connectivity Foundations, which work toward creating a standard for IoT devices to communicate with each other. As the adoption of IoT in education increases, stakeholders need to demand standardization to ensure the compatibility and security of their devices and systems.

6. **Scalability:** Scalability is a critical challenge that educational institutions must address when implementing IoT solutions. As the number of connected devices continues to increase, it is important to ensure that systems can handle the growing volume of data and communication. One approach to address scalability is to adopt cloud computing architectures that can accommodate the growing number of IoT devices and the data they generate. In addition, educational institutions should consider implementing efficient data management and storage solutions, such as distributed databases and data lakes. By prioritizing scalability, educational institutions can ensure that their IoT systems can handle the growing number of connected devices and continue to deliver high performance and efficiency in the classroom.

7. **Reliability:** For better and more effective management of an educational institution, the reliability of the IoT is important. Even a single device failure can have significant consequences. There are several challenges to achieve reliability in IoT systems, including device failure, network connectivity, and data accuracy. To address these challenges, organizations should prioritize robust and reliable hardware and software designs, regular testing and maintenance, and the implementation of redundant systems and allover mechanisms. Prioritizing reliability can help ensure that IoT systems perform consistently and without failure, delivering the intended benefits and results even despite of hardware or software failures.

While the integration of IoT in education has great potential for improving the learning experience, there are significant challenges to its implementation. These challenges include; the lack of standardization, the need for infrastructure such as ensuring sufficient network capacity and storage, interoperability, interoperability, concerns about data privacy and security, and the need for proper training and support for educators. Addressing these challenges will require collaboration between educators, policymakers, and technology providers. By working together to overcome these obstacles, we can unlock the full potential of IoT in education and provide students with personalized and adaptive learning experiences that are both effective and engaging.

VI. FUTURE OF ED-IOT

The Internet of Things (IoT) can transform education by giving students access to more personalised and connected learning opportunities. Teachers may deliver more specialised education and support by using IoT devices and sensors to gather information on student behaviour and performance. Moreover, IoT devices can be used to provide a more connected and collaborative learning environment, facilitating easier collaboration and resource sharing among students. We may anticipate seeing even more ground-breaking and useful IoT applications in education as technology advances.

Personalized learning is one of the most exciting applications of IoT in education. IoT devices and sensors can assist teachers in identifying specific student needs and delivering individualised training and support by gathering data on student behaviour and performance. Wearable technology can be used to monitor students' health and wellbeing, while sensors built into classrooms can assess students' involvement and participation. Personalized learning plans and interventions that are catered to the needs of each student can be created using this data. Collaboration and communication are other possible applications of IoT in education. IoT devices and sensors can be used to create more connected and collaborative learning environments, allowing students to work together and share resources more easily. Wearable technology, for instance, can be utilised to enable real-time communication between students and professors and interactive whiteboards and displays can be used to set up a shared workspace where students can work together on projects and tasks.

IoT can be utilised to develop more engaging and immersive learning environments. Virtual and augmented reality technologies can be used to create immersive learning environments that allow students to explore complex concepts in a more engaging and interactive way. For instance, students may use AR apps to deliver real-time information and feedback during classroom activities, or they could use VR headsets to explore historical sites or scientific phenomena. As the IoT continues to evolve, we can expect to see even more innovative applications of the technology in education. For example, IoT devices and sensors could be used to automate administrative tasks such as attendance tracking and grading, freeing up teachers to focus on instruction and student support. Additionally, IoT could be used to create more efficient and sustainable learning environments by optimizing energy usage and reducing waste.

Yet, as IoT continues to take off in education, there are also difficulties and issues that need to be resolved. Security and privacy are top priorities. It is crucial to ensure that this data is safeguarded against unwanted use and access as more information is collected and transmitted through IoT devices and sensors. Additionally, there are concerns about the potential for bias and discrimination in the algorithms and systems used to analyze and interpret IoT data. Another challenge is the need for professional development and training for educators. Since IoT technologies have become more commonplace in education, teachers will need to acquire new skills and competences to successfully incorporate IoT technology into their teaching practices. This will require ongoing professional development and support to ensure that teachers are equipped to use IoT effectively and ethically. It must ensure that IoT is used in a way that benefits students, teachers, and society by addressing the issues and challenges associated with it. Overall, the future of IoT in education is bright, but it is important to approach this technology with care and caution.

VII. CONCLUSION

In conclusion, the future of IoT in education is exciting and full of potential. IoT can create more connected and personalized learning experiences for students, as well as more efficient and sustainable learning environments. However, it is important to address the challenges and concerns associated with IoT, such as privacy, security, and the need for professional development and training. These challenges related to IoT should be solved by ensuring that it is used in a way that benefits students, educators, and society as a whole. As technology continues to evolve, it is crucial to prioritize innovation and collaboration in education to ensure that students receive the best possible learning experience. With the right approach, IoT can transform education and help prepare students for the challenges and opportunities of the 21st-century.

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