Internet of Things in Education: A Brief Overview

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Abstract: The Internet of things (IoT) is essentially the connection of devices to the Internet. IoT network connects various types of devices like tablets, smartphones, personal computers, laptops, and wearable devices. The education sector is deploying IoT devices in order to make education more collaborative, interactive, and accessible to all. IoT devices are changing the way we process and absorb information for the better. IoT application has the potential to provide a better-connected and more collaborative way for educators to engage with students. Today, IoT is preferred as a means of learning, teaching, and research in education. This paper presents a short overview on the uses of the Internet of Things in education, highlighting potentialities and challenges.

Keywords: Internet of things, IoT, IoT devices, IoT in education.

INTRODUCTION

Today, the Internet has become an indispensable part of life. It has deeply rooted itself into every area of our lives and e-learning has become common practice in the American schools. When it comes to the Internet, the Internet of things (IoT) has taken center stage. The IoT is a giant network of connected things and people. The idea behind creating IoT was the amalgamation of the physical world into computer based systems. Some of the examples of IoT are cell phones, washing machines, laptops, etc. With IoT, anything that can be connected shall be connected. This is best illustrated in Figure 1 [1]. Internet of things is a tool for connecting physical objects to the virtual world using sensors and some Internet protocols to lessen human interventions.

The Internet of things refers to the billions of physical devices connected to the wireless Internet that allows exchanging data around the world. IoT is extending its tentacles in the field of education with a significant impact. With IoT technology, we are fast moving towards a society where everything and everyone will be connected. IoT is transforming the education sector and making learning simpler and faster. IoT can bring paradigm shifts in education in terms of pedagogical advancements, leadership roles, and innovation and creativity in learning. The role of the Internet of things (IoT) in education is not only limited to the teaching and learning process but also serves the educational institutes to manage and track their key resources effectively [2].

WHAT IS INTERNET OF THINGS?

The term “Internet of things” was introduced by Kevin Ashton from the United Kingdom in...
Internet of Things (IoT) is a network of connecting devices embedded with sensors. It is a collection of identifiable things with the ability to communicate over wired or wireless networks. The devices or things can be connected to the Internet through three main technology components: physical devices and sensors (connected things), connection and infrastructure, and analytics and applications.

The IoT is a worldwide network that connects devices to the Internet and to each other using wireless technology. IoT is expanding rapidly and it has been estimated that 50 billion devices will be connected to the Internet by 2020. These include smart phones, tablets, desktop computers, autonomous vehicles, refrigerators, toasters, thermostats, cameras, pet monitors, alarm systems, home appliances, insulin pumps, industrial machines, intelligent wheelchairs, wireless sensors, mobile robots, etc.

There are four main technologies that enable IoT [3]:

1. Radio-frequency identification (RFID) and near-field communication.
2. Optical tags and quick response codes: This is used for low cost tagging.
3. Bluetooth low energy (BLE).
4. Wireless sensor network: They are usually connected as wireless sensor networks to monitor physical properties in specific environments.

Other related technologies are cloud computing, machine learning, and big data.

The Internet of things (IoT) technology enables people and objects to interact with each other. It is employed in many areas such as smart transportation, smart cities, smart energy, emergency services, healthcare, data security, industrial control, logistics, retails, government, traffic congestion, manufacturing, industry, security, agriculture, environment, and waste management. Figure 2 shows the most widely used areas of IoT [4].

IoT supports many input-output devices such as camera, microphone, keyboard, speaker, displays, microcontrollers, and transceivers. It is the most promising trend in the healthcare industry. This rapidly proliferating collection of Internet-connected devices, including wearables, implants, skin sensors, smart scales, smart bandages, and home monitoring tools has the potential to connect patients and their providers in a unique way.

Today, smartphone acts as the main driver of IoT. The smartphone is provided with healthcare applications.

The narrowband version of IoT is known as narrowband IoT (NBIoT). This is an attractive technology for many sectors including healthcare because it has been standardized [5]. The main feature of NBIoT is that it can be easily deployed within the current cellular infrastructure with a software upgrade.

**WHY IOT IS IMPORTANT IN EDUCATION**

The IoT is a large platform comprised of an array of things such as computers, sensors, and networking elements that allow for a high degree of satisfaction in integrating necessary services around the world. Let us consider what IoT can do for education sector [6,7]:

1. **Paperless Environment**: IoT can create a paperless environment wherein the students can use laptops and tablets for the purpose of academics and activities.

2. **Enhancing the Performance of Students**: IoT will allow teacher to know which child needs personal attention and assist him/her accordingly. From improving student participation to guaranteeing in-class efficiency, IoT has many promising applications in the education field.

3. **Personalized Learning**: With IoT devices, teachers and administrators can collect data about a student's learning style, progress, and areas of difficulty. This information can be used to create customized lesson plans and learning experiences tailored to each student's individual needs.
4. **Enhanced Student Engagement:** The attention span of children has significantly decreased after the advent of social media. IoT can also engage and motivate students by providing them with learning experiences that are relevant and meaningful to their needs and interests. With IoT devices, teachers can create more engaging and interactive lessons that keep students interested and motivated.

5. **Enhanced Safety and Security:** Using IoT technologies, schools can monitor and secure their buildings, grounds, and buses, helping to ensure the safety and well-being of students and staff. IoT devices can help enhance safety and security.

6. **Increased Efficiency:** IoT can help improve the education system's overall efficiency by reducing the time and effort required to complete routine tasks, such as taking attendance and grading. With IoT systems, teachers can focus on teaching and learning and provide students with a more effective and efficient learning experience.

7. **Wearable Devices:** The use of wearable devices is more frequent in education. The demand to integrate these devices with IoT keeps on increasing. In schools, wearable IoT devices are used to monitor students’ activities and movements.

8. **IoT Technologies:** Researchers have suggested the use of the following IoT tools and technologies for teaching in the classroom [8]:
   - Microcontroller development boards
   - Advanced embedded systems
   - Electronic white boards
   - Mobile phones, iPads, laptops and tablets
   - Automatic electric lighting
   - Smart HVAC systems
   - RFID enabled student ID cards
   - Wireless door locks
   - Security cameras and video conferencing
   - Biometric attendance tracking
   - eBooks
   - Augmented reality
   - Virtual reality
   - Additive manufacturing devices to create 3D objects
   - MOOCs

**APPLICATIONS**

IoT solutions for education have come up with answers to enhance the quality of education across the globe by making it easy to understand and available to all. The IoT can begin disrupting the education process as early as kindergarten and can continue to do so through 12th grade. There are several IoT applications in education such as personalized learning, smart classroom, e-learning, security, attendance management system, environment monitoring system, etc. Some of the common areas of application of IoT technology in education include the following [9-14]:

- **K–12 Schools:** Children are more connected to the Internet today than in previous generations. On average, students have smartphone by the age of ten. Virtually all public schools in the US have an Internet connection. Schools are increasingly using IoT technologies to support classroom learning. They use IoT devices for coding, computer
science, and robotics. IoT devices in the classroom are changing the way educators teach and the ways students learn. Students are using wearables in schools to track their activity, heart rate, and other wellness data. Figure 3 shows IoT in school [13]. Children can learn from the Internet of Toys, which consists of connected toys, like IoT.

- **Higher Education:** Perhaps the most profound effects of IoT on education occur in higher education. IoT in higher education allows access to the vast body of knowledge in educational blogs, wikis, eBooks, tutorials, and recorded lectures. Knowledge resources are available at reasonable cost and can be accessed anywhere anytime. Students are increasingly moving away from paper books toward tablets and laptops. With all of the necessary information at their fingertips, students can now learn at their own pace. Teachers do not need to manually grade tests on paper or perform other routine tasks. Universities can use connected devices to monitor their students, staff, and resources and equipment at a reduced cost [9].

- **Laboratory:** Students can do science experiments without being physically present in the laboratory. IoT-based laboratories have significant advantages in uplifting students’ academic performance through interaction, motivation, creativity, and practical learning.

- **Automated Attendance Recording:** Measuring attendance is something that educational institutions have struggled with for a long time. Attendance of the student is an inescapably task for teachers. IoT technology can help in providing a solution to the task of recording attendance. Biometric attendance or barcode-based with the identity card number of the student can be used in automatically recording the attendance as they enter the classroom.

- **Safety in Premises:** Most schools do not have the necessary infrastructure to detect red flags for theft, abuse, sexual assault, and other crimes. IoT-based sensors can activate cameras and alarms with the exact area of the problem. They will immediately detect the problem and send out an instant alert to reverse the situation.

- **E-Learning:** E-learning concepts and digital technologies enable students to learn from a safe distance while continuing their educational pursuits. E-Learning has improved the way of learning for students. Its concepts and digital technologies enable students to learn from a safe distance while continuing their educational pursuits. IoT devices will transform the learning process for students. Students can easily transmit data digitally through smart phones and can interact with educators, mentors, and peers across the world.

- **Personalized Education:** Personalized education is becoming more popular since the beginning of the Covid-19 pandemic, when people realized that a traditional “one size” education model does not fit all. In a rapidly changing society, it is important for us to educate students using the most personalized approaches.

- **Smart Boards:** Interactive digital media such as smart whiteboards, AR, VR, etc. help educators make learning engaging. A smart board is an interactive white board that projects subject images. It enables the teachers and students to interact with it by simply writing on it or moving it around the class. It is much more fun and exciting.

- **Monitoring Student's Health:** Monitoring patients and preventing diseases is made easy through IoT. The cost of care also decreases with the implementation of IoT. Smartwatches and fitness bands are the most commonly used devices for health monitoring. These wearable IoT devices can monitor physical health and blood pressure and generate robust reports suggesting solutions to improve health. Education can be also enhanced with the wearable devices

**BENEFITS**

Internet of things refers to the concept of connecting any device to the Internet and to other devices. Integrating IoT in the education sector will benefit the students, teachers, and authorities. For any school or institution, the advantage of using IOT is that it will make their
campus smarter, safer, and can also help cut down the amount of money spent for the use of paper every year. IoT learning is capable of changing the way education is presented. IoT in education may demonstrate support for those who are disabled. A major benefit of using IoT devices in education is their increased flexibility. Other benefits of IoT in education include the following [15,16]:

- **Improved Management**: IoT arrangements in the education industry lay the foundation for a quicker, hazard-free, and interconnected dynamic system.
- **Global Connectivity**: The Internet of things can uphold worldwide shared proficient preparing apparatuses, where instructors everywhere in the world can trade tips and best practices.
- **Improved Teaching Efficiency**: Several activities of teachers can be implemented using IoT. IoT improves teaching efficiency, which is the prime factor that needed to be upgraded in the education industry.
- **Security**: Increased use of IoT in schools means having a larger network with more access points. Maintaining security in school premises is necessary. Security can be improved for students, teachers, and staff by using IoT-enabled security equipment like wireless door locks, facial recognition technology, surveillance cameras, etc.
- **Accommodating Disability**: IoT devices can be helpful for students with certain disabilities such as difficulty in seeing or hearing. For example, visually impaired students may use IoT tools like a smart stick, a headset, and a smartphone app to recognize things.
- **Remote Learning**: IoT technology allows the possibility of remote learning and teaching. Whether working from home or learning from home, everything is now possible because of IoT technology. IoT makes self-learning, smart learning, e-learning, and distance learning possible using tablets and mobile applications.
- **Enhanced Collaboration**: By using IoT devices across classrooms, teachers can facilitate effective collaboration among students. This encourages creativity and problem-solving skills among them.

**CHALLENGES**

While learners and educators can communicate online, access to learning is limited. They must spend extra time adapting content to remote lessons. In spite of its growing popularity, there are still some challenges that need to be addressed for IoT technology to be more widely adopted in the education sector. First and foremost, there are security and privacy concerns. Since IoT devices are all connected, if a hacker manages to get access to one of them, they can access all of them. Educating the industrial workers that face unemployment due to automation is an important ethical matter. Other challenges include [17-19]:

- **Cost**: The cost of devices and equipment represents a major challenge for the educational institutions. While the benefits of using IoT technology are clear, some schools are balking at the costs associated with adoption.
- **Lack of Resources**: Schools often lack the necessary infrastructure and funding to purchase and implement IoT devices. They also may not have adequate IT personnel to manage the network. Some teachers lack the necessary tools and learning materials to teach a lesson.
- **Data privacy Concerns**: As IoT technology collects vast amounts of data from student, schools must ensure that it is stored securely and only accessible by authorized personnel.
- **Security Risks**: Without proper security protocols in place, malicious actors can gain access to sensitive data stored on connected devices, leading to potential safety and security issues.
Effect on Children: There have been concerns that IoT devices are collecting too much personal data from minors. Some children can use an IoT device to search for and access age-inappropriate content, either accidentally or intentionally. Figure 4 shows the negative effect of IoT on children [20].

In spite of these challenges, the IoT offers immense potential to revolutionize the education domain.

CONCLUSION

Although the benefits of IoT in education are clear and many, it will still take time for such innovations to become ubiquitous across the world’s markets. Education is not yet on of the areas where IoT is widely applied. IoT has a long way to go in the education industry. It might take a while before IoT incorporates mainstream education. In the near future, IoT benefits will be understood and experienced across all institutions of learning.

Some academic institutions are offering IoT certificate programs. The programs explore the topics, technology, and skills required to gain practice in the successful implementation of IoT solutions [21]. More information about IoT in education can be found in the books in [22-25].

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**Figure 1** Anything that can be connected is connected to IoT [1].

**Figure 2** The most widely used IoT application areas [4].

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Figure 3 IoT in school [13].

Figure 4 The negative effect of IoT on children [20].