Internet of Things (IoT) in Education: Opportunities and Challenges

Tira Nur Fitria[1], **Nurmala Elmin Simbolon[2], Afdaleni[3]**

Institut Teknologi Bisnis AAS Indonesia[1]

Politeknik Negeri Pontianak[2]

STBA Haji Agus Salim Bukittinggi[3]

Email: *tiranurfitria@gmail.com[1], simbolon73@gmail.com[2], afdaleni_09@yahoo.com[3]*

Abstract

This research describes the opportunities and challenges of the Internet of Things (IoT) in the education sector. This research applies to library research. The analysis shows that the use of IoT aims to improve education quality and efficiency. In this case, several applications of IoT in education are Smart Classrooms, E-Learning, Personalization of Learning, Digital Libraries, Security Systems, Student Health Monitoring, Student Attendance Systems, Interactive Whiteboards, Database Management, Management of Alumni Data, and Blended Learning. There are several opportunities for IoT in education, including the improvement of communication, collaboration, class engagement, students' comprehension, resource management, safety and security, teaching efficiency, administrative efficiency, and parental involvement. Besides, easy accessibility to resources, cost efficiency, real-time usage and updates, and remote monitoring, and increasing. During the implementation, the challenges in using IoT in education are 1) the high price to implement IoT technology because of the large amount of hardware and software required. 2) skilled technical team to ensure the effective implementation of the IoT system. 3) security and safety issues to various cyber risks and threats. 3) inadequate internet access for IoT devices, especially low-income rural households that cannot afford an internet connection. 4) blue light. Since most IoT devices require users to be exposed to a blue screen, overexposure caused by long-term use is detrimental to students' healthy development of eyesight. The solutions to overcome these challenges are: 1) increasing the understanding and competence of human resources. Supporting the IoT requires the readiness, skills, competence, and willingness of available human resources. 2) Planning for the implementation of the IoT. IoT schools/institutions must carry out careful planning related. 3) Budget allocation must be prepared. In the future, innovations will emerge in education that function to support and improve the quality of education what is called Cyber Schools, including Smart School Offices, Smart School Transportation, Smart School Building Management, Smart Student Health, Smart Classrooms, Smart Labs, Smart Cafeteria, Student Activity Tracking, and many more.

Keywords: *education, Internet of Things (IoT), technology*

Abstrak

Penelitian ini menjelaskan peluang dan tantangan Internet of Things (IoT) di bidang pendidikan. Penelitian ini berlaku untuk penelitian kepustakaan. Analisis menunjukkan bahwa penggunaan IoT bertujuan untuk meningkatkan kualitas dan efisiensi pendidikan. Dalam hal ini beberapa penerapan IoT dalam dunia pendidikan adalah Smart Classroom, E-Learning, Personalisasi Pembelajaran, Perpustakaan Digital, Sistem Keamanan, Monitoring Kesehatan Siswa, Sistem Absensi Siswa, Papan Tulis Interaktif, Pengelolaan Database, Pengelolaan Data Alumni, dan Blended Learning. . Ada beberapa peluang IoT dalam pendidikan, termasuk peningkatan komunikasi, kolaborasi, keterlibatan kelas, pemahaman

siswa, pengelolaan sumber daya, keselamatan dan keamanan, efisiensi pengajaran, efisiensi administrasi, dan keterlibatan orang tua. Selain itu, aksesibilitas yang mudah ke sumber daya, efisiensi biaya, penggunaan dan pembaruan real-time, serta pemantauan jarak jauh, dan peningkatan. Dalam implementasinya, tantangan penggunaan IoT dalam dunia pendidikan adalah 1) mahalnya harga penerapan teknologi IoT karena banyaknya perangkat keras dan perangkat lunak yang dibutuhkan. 2) tim teknis yang terampil untuk memastikan penerapan sistem IoT secara efektif. 3) permasalahan keamanan dan keselamatan terhadap berbagai risiko dan ancaman siber. 3) akses internet yang tidak memadai untuk perangkat IoT, terutama rumah tangga berpenghasilan rendah di pedesaan yang tidak mampu membeli koneksi internet. 4) cahaya biru. Karena sebagian besar perangkat IoT mengharuskan penggunanya terkena layar biru, paparan berlebih yang disebabkan oleh penggunaan jangka panjang akan merugikan perkembangan kesehatan penglihatan siswa. Solusi untuk mengatasi tantangan tersebut adalah: 1) meningkatkan pemahaman dan kompetensi sumber daya manusia. Mendukung IoT memerlukan kesiapan, keterampilan, kompetensi, dan kemauan sumber daya manusia yang tersedia. 2) Perencanaan implementasi IoT. Sekolah/lembaga IoT harus melakukan perencanaan terkait dengan matang. 3) Alokasi anggaran harus disiapkan. Ke depan akan muncul inovasi-inovasi di bidang pendidikan yang berfungsi untuk menunjang dan meningkatkan mutu pendidikan yang disebut dengan Cyber School, antara lain Smart School Office, Smart School Transportation, Smart School Building Management, Smart Student Health, Smart Classroom, Smart Labs, Smart Kafetaria, Pelacakan Aktivitas Siswa, dan masih banyak lagi.

Kata Kunci: pendidikan, Internet of Things (IoT), teknologi

Introduction

In the era of globalization, the development of science knowledge, and technology is very rapid, especially the development Internet (Elinda et al., 2022). Therefore, the field of education cannot be separated from the internet. This one technological innovation itself has a big impact on society's human life, including education. The internet has become a thing familiar to humans, so anyone and anytime can access it. Any form of work that will be overcome with Internet technology cannot be separated from its supporting devices. We know that everyday life is inseparable from the use of the internet. Even the various devices that we use can now connect to the internet. In the current era of globalization, the development of science and technology is very fast, especially the development of the Internet (Prihatmoko, 2016). This refers to the Internet of Things (IoT), where billions of physical devices around the world are now connected to the internet, where they all collect and share data. IoT is a concept that aims to expand the benefits of internet connectivity (Gojono et al., 2021). The IoT is a paradigm shift in the realm of IT (Information Technology), the use of computer networks for transferring information) (Sultana & Tamanna, 2021).

In the Industrial Revolution 4.0, all digital technology and physical capabilities were combined with artificial intelligence (Artificial intelligence), then integrated with the Internet of Things and several other types of technology to produce digital output that could facilitate everyday life. The process of integrating physical capabilities with digital technology requires a combination of several important elements in the Industrial Revolution 4.0, starting from Artificial

Intelligence, Cloud Computing, Big Data Analysis, and Cyber Security, to the Internet of Things (Megawati, 2021). The use of the internet in all sectors of life affects education services in terms of speed transactions or knowledge traffic. The Internet also changes the face of education because it can penetrate the boundaries classroom boundaries. Behind this, educators and students are required to be able to adapt and take advantage of Education in the Revolution 4.0 era by implementing the Internet of Things (IoT) (Pruwodidodo et al., 2023).

The Internet of Things (IoT) is a paradigm for connecting all physical objects in a global internet-based infrastructure for exchanging information and communication. The Internet of Things, often known as IoT, has quickly become recognized as the primary driving force behind the development of the technological infrastructure that is responsible for linking physical items to the Internet (Chowdary et al., 2023). The IoT is a system that can connect devices or objects through technology (Samsugi et al., 2021). IoT in its application can also identify, find, track, monitor objects, and trigger related events automatically and in real-time, development and computer application. IoT aims to properly identify, locate, track, monitor, and manage.

The form of acceleration of the development of a technology with the existence of the Internet of Things (IoT) which allows every item (things) owned to be connected to the internet and able to be controlled remotely using a smartphone and even with voice commands (Santika et al., 2022). IoT can be used to lighten the load, shorten the time, and make it easier to carry out human activities. To support an IoT system, a facility is needed that is equipped with sensors according to their use so that they can be monitored and controlled using the internet.

The Internet's operational functions are rapidly shifting from the Internet of Computers (IOC) to the Internet of Things (IoT) (Pal et al., 2022). The term "Internet" is included in the IoT (Haque, 2022). IoT is a concept that aims to extend the benefits of continuously connected internet connectivity (Irfan, 2019). The IoT is one of the Industrial Revolution 4.0's technological paradigms (Fuada et al., 2020). The era of the Industrial Revolution 4.0 was marked by the connection between humans and machines in the Internet of Things (IoT) system. (Kumar & Al-Besher, 2022)The Internet of Things is a collection of technologies that permit physically embedded objects to connect to the Internet and be extensively incorporated into human activities to support a variety of tasks. IoT can be translated as the interconnection between connected hardware and with internet (Dhika & Destiawati, 201).

According to Priyadarshini et al. (2022), the Internet of Things (IoT) is derived from the combination of two words: Internet and things. The Internet is a global computer network of various smart mobiles, computers, and modems that are governed by and interconnected via standard protocols for connected systems. The word 'thing' is used to refer to a physical object, an idea, or an activity without being specific. Thus, IoT enables objects or things to receive and send information using any path/network, such as mobiles, tablets, and computers, and enables the process of monitoring and controlling via the Internet. IoT is a vision in which objects become "smart" and behave like living entities by sensing, communicating through embedded devices, and computing interaction with remote-controlled objects (clouds, services, processes, and applications) or people via the Internet. The IoT is a concept that describes how various objects can connect and communicate with each other via an internet network. In IoT, smart devices such as sensors, actuators, and other related devices are connected and can send and receive data, making interactions between devices and between people and their surroundings easier and more efficient.

IoT is based on the idea that an object can transmit data over a network without human-to-human or human-to-computer interaction. (Meisarah et al., 2020). Today, the presence of the IoT has become a part of human life. Thus, the ability to understand and use a variety of IoT-based equipment for field education and teaching must be mastered. IoT is a condition that allows people or things to connect with anyone, anywhere, and anytime (Helaluddin et al., 2022).

IoT technology has been developing rapidly in recent years (Barolli et al., 2021). The IoT is the change cycle in various parts of our everyday life (Al-Sartawi et al., 2021). IoT transforms every aspect of our lives by making every device smart (Venkataraman et al., 2023). According to Wilianto & Kurniawan (2018), the way the IoT works is that every object must have an Internet Protocol (IP) address. IP is an internal identity network that makes these things possible to order from another object in its network. Next, the IP address in these objects will be connected to the network Internet. Currently, the internet connection is very easy to obtain. Thus the user can monitor objects and even give commands (remote control) to the object by connection Internet. Once an object has an IP address and is connected to the internet, on the thing too a sensor is installed. Sensors on objects allow it to obtain the information required. After obtaining the information, the object can process the information itself, and even communicate with other objects that have an IP address and are connected to the internet Also. There is an exchange of information in communication between these objects. After processing information is complete, the object can work with itself, or even command other objects as well will work.

The IoT is an advanced technology that refers to the many devices and systems around the world that are connected by using the internet and can share data, this technology includes sensors and software to communicate, control, connect, and exchange data through other devices as long as they are still connected to the internet and support performance without using cables, and wireless IoT-based has a close relationship with the term machine-to-machine or M2M. All devices that have M2M communication capabilities are often referred to as smart devices. This smart device is expected to help humans work in completing various existing affairs or tasks (Selay et al., 2022). IoT applications are already being utilized in a variety of domains, including the medical services industry, smart retail, customer service, smart residences, environmental monitoring, and industrial internet. The IoT is a network that connects physical devices such as machinery, automobiles, and household appliances as well as computers, microcontrollers, sensors, and actuators (Jose, 2018). IoT emphasizes the interconnection of all sensor-based devices, such as smart meters, cappuccino machines, and cell phones, among others.

The Internet of Things (IoT) is a new paradigm founded on the concept of an interconnected global network of devices (Cicirelli et al., 2018). IoT refers to the capacity to interconnect physical objects via the Internet (Xiao, 2018). The IoT is a network connecting millions of digital objects, the majority of which are outfitted with sensors (Cicirelli et al., 2018). IoT is a computing paradigm that has altered the way we live and function daily (Alam et al., 2020). IoT can be interpreted as communication between people and objects around us through the internet network, IoT technology has begun to be developed and applied such as sensors, robots, and cloud platforms that are connected via standard communication protocols to receive and transmit information. IoT itself can be applied in various fields such as industry, health, and education. Since the rapid growth of Information and Communication Technologies (ICT), the educational environment has changed (Mehmet, 2019).

The term "Internet of Things (IoT)" was coined for the first time by Kevin Ashton in 1999 (Hassanien et al., 2019; Spector, 2015). Previously, the coupling of devices required radio-frequency identification (RFID) products, which autonomously identify and track objects over short distances using radio frequencies (Spector, 2015). All of this changed with the advent of the Internet. With the proliferation of Wi-Fi and cellular technologies, connectivity, and identification capabilities have evolved further. IoT is a concept that aims to expand the benefits of internet connectivity. With IoT, it will be easier for humans to do things, shorten the time, and lighten the load. Objects that support IoT are usually equipped with sensors according to their designation so that these objects can be monitored and controlled from the internet. IoT has been applied in various fields such as finance, telecommunications, industry, agriculture, health, education, and so on. Now, the internet has been used in many other fields, including the field of education.

Nowadays, due to their pervasiveness, schools, and academic institutions are seeking to integrate IoT into educational activities for the benefit of students, teachers, and the entire educational system (DeFranco & Kassab, 2021). The proposed IoT applications address a wide variety of modalities, objectives, subjects, and perceptions in the education sector. The learning process that uses technology can have a significant effect on the quality of education (Meisarah et al., 2020). The quality of education plays an role important in the learning process so that learning has meaning and benefits for students. Therefore, learning technology can help lecturers support the learning they are designed to be students can understand a material so interactive, effective, and fun learning can be achieved.

Rapidly advancing digital technology has significantly altered the world of education. Digital technology has entered the era of the fourth industrial revolution, which is characterized by increased network connectivity, the growth of digital system interactions, and the development of artificial and virtual intelligence. The accelerated development of digital devices has led to the incorporation of the internet into daily life and educational systems. The Internet of Things (IoT) can be understood as the interconnection of internet-connected infrastructure. Life and educational behavior patterns have been altered as a result of the IoT, which has facilitated a more effective educational setting and altered the learning process (Hutasoit et al., 2022).

The Internet of Things (IoT) is a network paradigm in which physical, digital, and virtual objects are equipped with identification, detection, networking, and processing functions to communicate with each other and with other devices and services on the Internet to perform the users' required tasks (Diène et al., 2020). IoT has the potential to change the way we live and work by making things easier and more efficient. For example, a smart home that utilizes IoT can control the lights and temperature in the house via a smartphone, make transportation safer and more efficient by leveraging data from sensors, and help address health problems by monitoring patient conditions in real-time. To make IoT work properly, devices must be connected to the internet network and be able to communicate with other devices. This requires sophisticated technologies such as sensors, the internet, cloud computing, and data analytics.

There are several previous studies related to the Internet of Things (IoT). First, Prihatmoko (2016) states that with the development of the IoT, the internet can also be used for other purposes that support learning, including utilizing the internet for theoretical and practical learning activities. Second, Gojono et al. (2021) state that in Indonesia, the use of the Internet of Things (IoT) in online learning is in the form of face-to-face meetings and virtual exams. It is intended

that students can take part in learning activities without having to crowd at school. The use of the Internet of Things in online learning aims to make it easier for teachers and students in the online learning process, as well as to facilitate the process of attendance and collection of student assignments. Third, Elinda et al. (2022) state that one of the applications contained in the Internet of Things (IoT) in the field of education is Google Classroom. Google Classroom can facilitate online learning that was carried out during the pandemic period it was supported by the many features available on Google classroom with different functions between features. Fourth, Mufid & Musafa (2022) add that IoT in the world of education during the pandemic covid 19 reinforces the world of education to a transformation of learning towards digitalization. Fifth, Yusuf (2022) states that IoT is very much needed during a pandemic for teaching and learning activities and preparing oneself for the 5.0 era through a curriculum oriented towards learning life-skills, collaboration in addition to hard skills, and the use of other technologies. Based on the explanation above, the researcher is interested to know more about the opportunities and challenges of the implementation of the Internet of Things (IoT). Therefore, the objective of this research is to describe the opportunities and challenges of the Internet of Things (IoT) in the education sector.

Method

This research applies to library research. Library research is a type of qualitative research that generally does not go into the field of searching for data sources (Fitria, Simbolon, et al., 2022). This is a method used in data search or a method of in-depth observation of the theme/topic under study to find a 'temporary answer' to the problem found at the beginning before the research is followed up. In other words, library research is a method of searching, collecting, and analyzing data sources to be processed and presented descriptively. In this research, this research describes the opportunities and challenges of the Internet of Things (IoT) in the education sector.

In this research, the documentation is used for collecting data. Documentation technique or documentation study is a data collection technique by collecting and analyzing documents, both written documents, images, and electronics. In this research, the researcher collects data from articles that are published in national journals. The researchers need to look for literature studies from research journals published in the last few years. In analyzing data, the researcher reads several literary sources. This activity requires the involvement of readers actively and critically to obtain maximum results; In reading research sources, readers must dig deeply into reading materials that allow them to find new ideas related to research titles. Furthermore, the researcher processes research notes, all sources that have been read are then processed or analyzed to obtain a drawn conclusion.

Findings and Discussion

This research describes the Internet of Things (IoT) in the education sector and both opportunities and challenges.

Findings
IoT Application in Education

The use and development of technology from time to time have had a big influence on the world of education. The use of the internet in the school system

also known as e-learning is the result of the digital technology revolution. The process of teaching and learning activities that use the IoT system will provide a more efficient and in-depth educational experience. In general, IoT is used more effectively in high school and university environments where students can switch from paper textbooks to e-books. In the field of education, the application of IoT aims to increase the efficiency and quality of education in an institution. The Internet of Things (IoT) has broad applications in various fields, including education. IoT helps in improving and modernizing the education system by providing new tools and technologies that assist teachers and students in achieving their goals. In the world of education, the use of IoT aims to improve education quality and efficiency. In this case, there are several applications of IoT in the education sector, including:

1. Smart Classroom

Smart Classroom or smart class is one of the most popular applications of IoT in education today. Mahmood et al. (2022) state that the Internet of Things has the potential to shape smart campuses and classrooms (IoT). An increasing number of smart classrooms are comprised of new technologies and equipment, which have become a potent force in the development of smart classrooms (Zhang & Li, 2021).

In education, the IoT is a system that facilitates an easier learning experience. The implementation of IoT technology in smart classrooms is an example of its application. The concept of smart classrooms combines apparatus such as sensors, actuators, and microcontrollers with a learning management system (LMS) portal. Smart classrooms in which the complete space is automatically controlled by technology (Hardyanto, 2017). This system allows teachers to easily control all aspects of the class through an application on a smartphone or tablet, from room temperature, and lighting, to audiovisuals. Not only that, teachers can also monitor and evaluate student performance in real-time, thereby providing timely and accurate feedback. In an increasingly advanced digital era, the application of IoT technology in Smart Classrooms is an important requirement in the world of education. This system makes the learning experience more interactive and effective and allows teachers to provide more personalized learning to students. Teachers can monitor student attendance and ensure class safety through an electronic door system.

Classrooms with various IoT facilities can add value to learning activities for students (Dhika & Destiawati, 2017). In addition, students can also access learning materials easily via the provided WiFi network, to speed up the teaching and learning process. Provide comfort with a variety of information and facilitate communication between lecturers as teachers to students. Detailed measurements can be directly monitored through gadgets that are owned without restrictions. This makes learning more conducive again so that the new paradigm of the world of education with IoT classrooms can help and support students to be more familiar with technological developments that have now developed.

2. E-Learning

The e-learning system is a system in the teaching and learning process that utilizes information technology and internet connectivity. E-learning is designed to make it easier to access and understand a material or topic of material being taught (Fitria, 2021a; Fitria, Afdaleni, et al., 2022). The advantages of this e-learning system are flexible learning schedules, learning rhythms that suit students, a better understanding of the material by students, saving more time and effort, and the ability to learn from the best teachers in their fields.

IoT facilitates more effective and personalized distance learning. With this technology, students can access lessons and learning materials from anywhere and

anytime, and interact in real-time with teachers and fellow students through applications or online learning platforms. This technology is very helpful in answering the challenges of distance learning, and with its capabilities, IoT can enrich students' learning experiences. IoT helps in making distance learning more efficient and effective by providing a platform that enables students and teachers to interact and coordinate even though they are far away. The e-learning system is a system that utilizes information technology and internet infrastructure in the teaching and learning process. Learning is structured to make it easier for students to be able to access and understand a topic or material. Some examples of the advantages of e-learning include a Flexible schedule, a Learning rhythm according to students' abilities, Students understanding the material better, Saving energy and time, the Opportunity to learn from the best teachers in their fields, Interactive Whiteboard.

During the Covid-19 pandemic, the IoT can be useful as a support in digital transformation in the education sector where many IoT innovations have been developed such as the use of attendance systems, borrowing learning books, learning systems, and boards. interactive write. All of these developments can be used as learning media that are more effective without being tied to time and are more energy efficient, moreover, they are very suitable for use during the Covid 19 pandemic that is currently happening in Indonesia (Fitria, 2021b).

3. Personalization of Learning

A personalized learning model is constructed based on the distributed computing method of the Internet of Things (IoT) and the clustering algorithm of deep learning (DL) (Wang & Zhihan, 2022). IoT also enables more sophisticated personalization of learning. This system enables teachers to tailor learning materials and teaching methods to the unique needs and preferences of each student. In addition, this system can also help teachers identify the weaknesses and strengths of each student to provide more effective feedback and guidance. This will make the teaching and learning process more optimal and efficient, with better results.

With IoT devices, teachers and administrators can collect data about students' learning styles, progress, and areas of difficulty. This information can be used to create customized lesson plans and learning experiences tailored to the needs of individual students. For example, a student who is struggling with a certain concept might be provided with additional resources and support to help them understand the material better. On the other hand, a student who excels in a subject may be challenged with more sophisticated content to help them continue to grow and develop. Overall, personalized learning can help ensure that every student receives the support and guidance they need to succeed in their studies.

4. Digital Libraries

IoT has paved the way for the development of more effective digital libraries. Through this sophisticated system, students can easily access books and learning materials from anywhere and anytime using only mobile devices such as smartphones or tablets. Not only that, teachers can easily arrange learning materials in a digital format that is more interactive and interesting, thus enabling students to learn more fun. This will certainly have a positive impact on the world of education in the future.

In general, the process of borrowing books is aimed at facilitating and expediting transactions and recording book stock. By using IoT, students can carry out the process of borrowing books from their respective homes and then taking them while in the school environment. So an analysis of students' interest in reading can be carried out through statistics on borrowing the book using the IoT

system. The process of borrowing books that have been running is generally only aimed at expediting and facilitating the process of recording stock and book transactions. With IoT, students and parents can borrow books from home and then pick them up while at school. So not only can the system perform an analysis of children's reading interests seen from the statistics of books borrowed. IoT is an essential trend for libraries because it can facilitate the enhancement of service quality, facilities, and cost reductions when users and librarians access information online. For instance, overseas museums use cloud computing for online services, building illumination controls, and storage in the Library (Handayani, 2019)

5. **Security System**

Safety in the school environment is a top priority. With IoT, this security can be maintained more effectively. This system allows the school to monitor the activities of students and visitors more easily and accurately, including in restricted areas, and maintain the security of the school environment. In addition, technology such as CCTV cameras and temperature detectors can be integrated with this system so that monitoring environmental security becomes more effective and sophisticated. All of that will certainly provide peace for students, teachers, and the school.

With IoT, the security of the school environment can be monitored more effectively and efficiently. This system utilizes temperature sensors and security detector technology to ensure safety in the school environment. In addition, by using technology to monitor vehicle traffic around the school environment, the risk of accidents can be reduced so students can feel safer and more comfortable while at school. With an IoT solution that can monitor security continuously, students can focus on studying without worrying about their safety.

6. **Student Health Monitoring**

Not only increasing security, but IoT is also capable of being a reliable guardian of student health. This system allows monitoring of the temperature, heart rate, pulse rate, blood pressure, and body temperature of students in real-time to monitor students' health regularly (Zhong & Li, 2020). Thus, the school can easily identify emerging health problems and provide appropriate treatment, keeping students' health well maintained. We hope that this technology will be used more and more in the world of education in Indonesia, which we love.

7. **Student Attendance System**

The student attendance system is a system that functions to record attendance in teaching and learning activities. So far, the attendance data collection process is still done manually, this process is prone to loss of data and errors in inputting. With the IoT era, the student attendance process will be much easier, students only need to scan their fingerprints when they come and go home. Another way is to give each student a device in the form of a chip card that can be read by the sensors in the classroom. The data will be on the server which will then be presented in the form of Web applications and Mobile Applications. So that the data can be accessed in real-time by the student's guardian and the school. It is a system that is useful for storing student attendance in learning. So far, the attendance data collection process is still done manually, this process is prone to loss of data and errors in inputting. With the IoT era, the student attendance process will be much easier, students only need to fill in electronic absences through students digital devices such as their smartphones or laptops during the learning process. The data is later on the server and will then be presented in the form of a Web application or mobile application. So that the data can be accessed by students and institutions in real-time.

Fingerprints are one of the unique human body parts that can be used as personal identifiers with the assistance of fingerprint biometric technology. This technology identifies a person's unique fingerprint. It also can reduce student attendance fraud by preventing manipulation and fabrication. The Internet of Things (IoT) assumes that electronic devices can be connected to communicate or exchange data independently through internet networks that use protocols, such as the lightweight MQTT (Message Queue Telemetry Transport protocol) for devices with limited resources. Thus, an Internet of Things-based attendance system using fingerprint sensor technology on the MQTT protocol was designed to help schools improve attendance tracking performance and ease student attendance (Utami et al., 2019).

Other biometric data, such as facial or retina scans can be used to monitor student attendance. Students who want to enter a class are asked to scan fingerprints and when the student's fingerprints match the fingerprints stored in the database, the door to the room will automatically open. One oar, two islands exceeded. This has two benefits at once, namely ensuring student attendance by preventing students from being sent absent while maintaining classroom security. Because the automatic door will not open if the fingerprint is entered incorrectly.

8. Interactive Whiteboard

An interactive whiteboard is a digital whiteboard that has a touch-sensitive layer and works like a computer system because this whiteboard can store information that has been written on it. Interactive This interactive whiteboard is mostly used as a medium for learning presentations or materials. In this interactive board, there is a feature that can record the presenter and the material presented during the presentation process. Therefore, students can deepen the material by re-watching the recorded presentation of the material.

Interactive whiteboard has several features in its use, including Software that has recording capabilities during the presentation process. The recordings include the voices of the presenters, as well as presentation materials, both existing ones and those that have undergone an editing process. 1) Ability to conduct Conference Presentations, 2) Interactive zoom technology. Because of the high technology contained in it, it can convert handwriting into text on a computer screen (LCD). When we want to change or edit presentations, data, etc., we can do it directly on the interactive whiteboard LCD screen, without having to use a PC/laptop. In addition to being text, the blackboard can also change handwriting to images. For example, in the form of a signature. We can directly on the interactive whiteboard LCD screen without having to print the presentation document first. Cutting System Technology. This system can cut text that is on the interactive whiteboard LCD screen.

9. Database Management

The Internet of Things (IoT) can help make education database management more practical. For example, with smart libraries, students can borrow and return their thesis or books independently without the help of staff. Thus, the library can be accessed 24 hours and officers only need to return the books to the shelves. Another example is with more integrated database management, officers can access data on students, lecturers, and other education personnel using only one particular website or application so that when there is a new recruitment, data can be easily entered.

10. Management of Alumni data

In contrast to schools, generally, campuses need alumni data for various purposes, such as industrial cooperation or community improvement. Therefore, it is not surprising that currently, several campuses in Indonesia are developing

special applications for alumni. In this application, alumni can access various services, such as smart library services if needed, alumni services to apply for legalization or other administrative needs, to access job vacancy information provided by campus partner companies. Conversely, campuses can use this application to collect alumni data, disseminate campus-related information to alumni, and so on.

11.   Blended Learning

Blended learning is a learning method that combines online and offline learning. Although it has become increasingly popular in recent years, this learning method has been around for a long time as a complement to e-learning. In this blended learning, students are required to actively look for complementary learning materials independently on the internet, so that learning is not only centered on the teacher. In addition, this e-learning method also accommodates teachers who live far from school or campus locations to continue teaching, even though online. This resulted in learning in schools and campuses to be more effective and efficient.

Benefits of Implementing IoT in Education

There are several benefits of implementing IoT in the education sector, as follows:

1. Improved Communication and Collaboration

IoT devices can facilitate real-time communication and collaboration between teachers and students, as well as between students themselves. For example, a teacher can use a smart whiteboard to present material in class. Students can use their tablets to ask questions, share ideas, or collaborate on group projects. This technology can make it easier for teachers to connect with their students and for students to work together, regardless of location. It can also help break down geographic barriers, allowing students from different parts of the world to connect and collaborate in real-time. To build software using IoT, we will have to hire a mobile app development service.

2. Increased Class Engagement

IoT devices create more engaging and interactive lessons that keep students interested and motivated. For example, a teacher might use an interactive whiteboard to present multimedia content, such as videos and graphics, to help illustrate a concept. Students can then use tablets or other devices to answer questions, participate in discussions, or complete interactive activities related to the lesson. E-Learning solutions with IoT technology can also facilitate collaboration and communication between students, enabling them to collaborate on projects and share ideas and resources in real-time. This can help create a more dynamic and engaging learning environment that is conducive to active learning and problem-solving.

3. Increase Students' Comprehension

Not all subjects can be absorbed easily if teachers only use text or pictures on the blackboard. Students often need hands-on practice or concrete drawings on a subject, such as human anatomy or the rotation of the planets in orbits. The use of IoT, especially Augmented Reality (AR) and Virtual Reality (VR) can overcome this problem. With AR and VR, students can see a picture of the anatomy of the human body or the rotation of the planet around the orbit with a three-dimensional view, so that it looks more real and easy to understand (Fitria, 2023). With the IoT, the subject matter is not only in the form of boring writing or text but can also be in the form of animations, videos and even learning materials using Artificial

Intelligence (AI). Thus, the class becomes more exciting and students are more interested in learning more.

4. Improved Resource Management

With an IoT system, teachers and administrators can more efficiently monitor and manage class resources, such as textbooks and materials. For example, an IoT school management solution can track the use and availability of books and other materials, alerting teachers when supplies need to be replenished. This can help ensure that students have the resources they need to succeed and can reduce waste by eliminating the need for unnecessary duplication of material. Additionally, IoT technologies can monitor and manage school facilities and equipment, such as classrooms, laboratories, and athletic facilities. This can help optimize the use of these resources and ensure they are efficient and effective. Overall, using IoT systems in the education industry can help improve resource management.

5. Enhanced Safety and Security

With IoT devices, schools can monitor and secure their buildings, yards, and buses, helping to ensure the safety and wellbeing of students and staff. For example, IoT-enabled security cameras can monitor school grounds and buildings, alerting authorities to potential threats or suspicious activity. Likewise, an IoT-enabled GPS tracking system can monitor the location and movement of school buses, helping to ensure the safety of students as they travel to and from school. IoT technologies can also monitor and control access to school buildings, using smart locks and other security systems to limit access to only authorized personnel. As a result, it can help prevent unauthorized access and protect against potential threats. Overall, using IoT technology in the education industry can help improve safety and security. Not only is it needed to form smart classrooms in class, but the Internet of Things (IoT) can also be applied to create safer schools. In this case, all school resources, from lights to CCTV can be accessed through a special application by the officer concerned. Thus, when an emergency occurs, such as a fire or an unknown person entering the school area, the officer can immediately take the necessary action.

6. Improved Teaching Efficiency

With the IoT system, teachers and administrators can streamline many of their time-consuming administrative tasks, such as tracking attendance and grading. This can free up more time for teaching and learning and allows educators to focus on the core functions of their job. For example, an IoT system to automate attendance tracking eliminates the need for teachers to manually record attendance every day. Likewise, an IoT system for grading assignments and exams reduces the time and effort required to provide feedback to students. IoT technologies can automate other administrative tasks, such as scheduling and communications. This can help increase the overall efficiency of the education system by reducing the time and effort required to complete routine tasks. Overall, using IoT systems in the education industry can help improve efficiency.

7. Improving Administrative Efficiency

In a school environment, IoT can help improve administrative efficiency with advanced technology. With this system, the use of applications and online platforms can help manage school administration. With better efficiency, teachers can focus more on teaching activities and students can get a better learning experience as well. With this advanced technology, school administration capabilities can be more efficient and can improve the quality of education. Feel free to adopt this technology and prove its effectiveness.

8. Easy Accessibility to Resources

From databases to printers, the use of IoT technology makes it easy for students and teachers to access various types of resources. Depending on the security level of student, teacher, or school employee authority, certain types of resources can be accessed without the need for tedious and lengthy approval processes. For example, if a student wants to borrow certain laboratory equipment, the paper trail of approval requests can be eliminated by using an online inventory system for laboratory equipment loans. The IoT is also useful for creating smart libraries. Smart libraries are facilities that allow students to visit the school library even outside working hours. With these smart libraries, students can borrow or return books independently, and access library computers when there are no staff at the library.

9. Cost Efficiency

Various equipment, systems, and operations can be integrated through the use of IoT technology. Some routine functions, such as turning lights and air conditioning on or off at certain times of the day or under certain conditions, can be programmed. In the world of education, saving operational costs is very important to ensure the availability of sufficient resources for teaching and learning activities. With the presence of IoT, operational costs in the school environment can be reduced significantly. This system allows the use of advanced technology such as temperature sensors and automatic lighting to optimize the use of electrical energy and reduce electricity costs. In addition, this technology also allows the use of other resources such as water and fuel to be optimized so that school operational costs can be reduced. With these operational cost savings, the school can allocate available resources to improve the quality of education for students. The Internet of Things (IoT) will monitor and conserve water and energy in schools and universities (Dodds et al., 2021). For example, sensors could be installed in a classroom that would detect the presence and number of people. This sensor can send information automatically to the control system to set optimal lighting and temperature. Many other building functions such as CCTV and water systems can be integrated into an IoT network. This will help save on electricity and other utility bills. We can even involve students in setting this up so they learn how it all works.

10. Real-Time Usage and Updates

IoT systems have built-in means of sharing information among different networked devices and sensors. For example, it's easy to keep track of how many times an office printer is used and by whom. Likewise, the movement of personnel in a facility can be tracked using Radio Frequency Identification (RFID). In the school environment, this system is useful for checking attendance and finding employees or students on campus.

11. Remote Monitoring

Remote monitoring is useful for monitoring your network devices that are in multiple locations and can monitor network devices anywhere and anytime. The educational applications of remote monitoring are extensive. For example, a laboratory experiment that requires constant evaluation may be monitored collectively by students and teachers who have access to the cameras and sensors associated with a particular experiment setup.

12. Increasing Parental Involvement

Undeniably, IoT can be a key driver in increasing parental involvement in the educational process. Through innovative online apps and platforms, parents can easily monitor their child's progress and provide real-time feedback to teachers. This will help build a strong relationship between parents and the school and provide students with the necessary support and guidance. In this way, students can reach their true potential and achieve greater success in the future.

Challenges in Using IoT in Education

The internet has had a big impact on many things, especially in education. Currently, more and more schools or campuses are implementing IoT systems to improve the quality of education. For example, E-learning has become something that is commonly used in many schools with different implementations in each school. Teachers can use this technology for smart lesson planning instead of manual lesson planning. The application of IoT in education simplifies the process of the education system and makes learning faster, safer, and more efficient. But behind that convenience, the risk of attacks on educational networks will increase as they become more dependent on the use of mobile technology and the Internet of Things. By knowing the main threats to the education network, we can apply the right tools and strategies to all educational institutions. That way these threats can be avoided to protect important data from students, teachers, employees, and other important things related to schools.

There are still some challenges to using IoT in the education sector. Below are some of the key challenges educational institutions and typical households face that hinder successful IoT applications, such as: 1) High price: Budget comes first! It is very expensive to implement IoT technology in education because of the large amount of hardware and software required. In addition, it is necessary to employ a skilled technology team to ensure the effective implementation of the IoT system. 2) Security and safety issues: Security is another major factor that we must consider. Nearly all cloud software is subject to various cyber risks and threats, and the deployment of IoT in the education sector also underscores the rule. It is very important to increase data security awareness and establish contingency plans for attacks or other threats. 3) Inadequate internet access for IoT devices: Even though the Internet has become widespread in most households, there are still some households, especially low-income rural households, that cannot afford an internet connection. This will be a challenge when students are expected to access learning materials online from home. 4) Blue light: Since most IoT devices require users to be exposed to a blue screen, this can impact students' eyes. In particular, overexposure caused by long-term use is detrimental to students' healthy development of eyesight.

Several factors cause why a school institution is so good at implementing IoT. First, is human resources (HR). The first main issue is human resources (HR). The readiness, ability, and willingness of human resources (HR), school principals, teachers, and other education personnel are the keys to change. Readiness to face change, ability to implement change, and willingness to make changes. Open, progressive, creative, and innovative thinking is the foundation for an agency to continue to make changes for the better from day to day. Second, costs. The implementation of the Internet of Things (IoT) requires a lot of money at first. Requires a fairly large initial investment. However, when juxtaposed with broad and long-term benefits, the large costs are insignificant. A school principal must have a far-reaching vision and mission so that obstacles can be overcome properly and long-term goals can be achieved step by step in stages. Third, caring. The mastery of the Indonesian people regarding IoT is still very minimal, even though the ability to apply IoT will be very useful for increasing productivity and solving various problems in society. This implies that they are less concerned about the benefits of implementing the Internet of Things (IoT) for the jobs they face.

The solutions to these challenges are: First, increasing the understanding and competence of human resources. Supporting the implementation of the Internet of Things (IoT) requires the readiness, skills, and willingness of available

human resources. For this reason, socialization to increase awareness and increase understanding must be carried out. Competence improvement related to IOT must also be carried out. With increased understanding and skills, there will be a push that the Internet of Things (IoT) is a necessity. Second, Planning for the implementation of the Internet of Things (IoT). In implementing IOT schools must carry out careful planning related. Starting from preparing a plan in the form of a road map for implementing IOT and then gradually carrying out the implementation. Third, budget allocation. Proper planning in terms of budgeting must be done. Which priority scale needs to come first for the implementation of IOT?

Future of IoT in the Education Sector

With the rapid development of information technology, innovations will emerge in education to support and improve the quality of education. In the future, what is called Cyber Schools with IoT will emerge, such as:

1. SmartSchool Office. Smart School Office is a system that makes school administration easier. With the application of IoT, all systems regarding school needs will be integrated into one so that it will be easy to manage them.

2. Smart School Transportation. Smart School Transportation is a system that allows schools, students, and parents to monitor the shuttle process. With this system, arrival, and departure times, driver information, vehicle information, location information, and information on the contents of the vehicle can be known in real-time. Inside the bus, several sensors can be installed to be able to read the number of students, the temperature in the bus, the speed of the bus, and the physical condition of the bus being used. Any information obtained by the sensor will be sent to a server via the internet to be processed and presented to parents and schools through a web-based and mobile application.

3. Smart School Building Management. Smart School Building Management is a system that can facilitate schools in carrying out maintenance, security, and monitoring of school facilities. For example, sensors can be placed in the classroom to determine humidity, temperature, lighting levels, and so on. For example to set the lighting level. In a room a sensor can be placed that can read when the teaching and learning process is being carried out, how is the current light condition in the room, and whether there are students in the room. From these conditions, the sensor will make a decision when the light will turn on and when it will turn off, thereby improving the teaching and learning process and increasing efficiency in finance.

4. Smart Student Health. Smart Student Health is a system that can monitor student health. By equipping students with a tool that is always installed during activities, the system will be able to send information about students' activities and physical conditions. The system will provide information about the distance traveled, calories burned, body temperature, pulse, and so on. So that schools can monitor the health of students.

5. Smart Classroom. Smart Class Room is a facility in which there is a combination of various sensors and tools that can support teaching and learning activities. Some examples of sensors and tools in the class include Temperature Sensors, Exposure Sensors, Interactive whiteboards, Attendance systems, etc.

6. Smart Labs. Smart Lab is a concept that can facilitate the research and implementation of a case. With the smart lab system in the field of biology, students do not need to carry out the dissection of an object directly, students can carry out the dissection process virtually via a smartphone or Virtual

Reality glasses. This will facilitate the teaching and learning process and can increase efficiency in financing practice tools.

7. Smart Cafeteria. Smart Cafeteria is a system that can monitor the buying and selling of food, what students can buy, as well as the nutritional content of the food eaten. From the system, it will be processed by the system and can be used by the Smart Student Health system as supporting data.

8. Student Activity Tracking. Student Activity Tracking is a system that can monitor student activities both inside and outside the room. The system can use GPS sensors and other sensors that can show the history of locations visited by students and the current whereabouts of students. This can support the school's security system. So that schools can monitor vulnerable locations that can endanger students.

Discussion

We have understood that education is a very important thing for the people of Indonesia and every person in Indonesia has the right to get an education. Therefore, even though we are currently still in a pandemic, learning and education must continue. To continue implementing this learning is carried out in a network (online) or online that implements the Internet of Things (IoT) system as a learning tool. This is done because educational technology greatly influences the continuity of learning and reflects the quality of education in a country.

Technology has brought major changes in various aspects of human life. In the world of education, technology is a great hope for improving the way we learn and teach. One of the newest technologies that is becoming a trend in the world of education is the Internet of Things (IoT). These technologies have great potential to improve education systems by helping to optimize learning, create more personalized learning experiences, help improve the quality of learning, and build a better educational future. In an era of increasingly advanced technology, the application of IoT can bring significant changes in education.

With advances in Information and Communication Technology (ICT), the internet, sensors, and nanotechnology, the IoT has great potential to be utilized in supporting more effective learning processes. Characteristics of the Internet of Things is capable of scaling up interactivity and intelligent response between objects, is sufficient capital to contribute to the teaching and learning process, especially in increasing the interactivity between participants learning with learning objects, between fellow study participants, and between learning object (Bakri, 2016). The use of devices connected to the internet is one way to create inclusivity in education. With devices connected to the internet, whether smartphones, tablets, or computers and laptops, students can access learning materials and contact their teachers directly.

The IoT is an important tool for making education more accessible, interactive, and collaborative. This can facilitate online and real-time interactions between students and teachers. This has expanded the classroom into cyberspace. Physical distance is no longer a barrier to learning. Even now that in-person classes have returned post-pandemic, the role of IoT in education remains important. It can make classroom instruction more engaging and interactive and collaborative group projects much easier, from design through to the prototyping phase. But more than that, IoT is important in education because we give students the skills, knowledge, and tools they will need for the future. IoT is becoming such an integral part of our lives that students will be missing out if they do not learn it from an early age.

Application of IoT in educational activities and learning in school can start from when students go to school, while studying in class, giving assignments, class schedules, attendance, exams, systems learning management, payment of school fees, health activities in schools such as communication with parents of students, and reporting learning outcomes in digital report form (Jamaludin, 2020). All of these activities can be using internet technology by applying according to activities which applications learning and education.

IoT has penetrated the education sector practically and its integration is getting stronger. IoT in education comes in many forms and serves both general and specific purposes, for both students and teachers. Today, it is playing an important role in changing the traditional education system. There is no doubt that IoT has a wide scope of implementation in the education industry. The relationship between technology and education has been going on for a long time. With the idea of developing the Internet of Things (IoT), the use of technology for learning is increasingly showing significant progress (Bakri, 2016).

According to Mahmood et al. (2022), As the potential for IoT applications increases, so will the educational benefits of IoT. Currently, IoT devices are being used to enhance educational environments for children of all ages, and there are some creative ways for IoT applications to have a positive impact on schools. IoT networks employ connected devices such as colored lighting, digital signage, door locking, and sensors to build customized security systems. Some schools use an IoT network to create a variety of security-related programs in response to intruders, poor weather, and other hazards. In the classroom, IoT technology can be used to provide solutions such as incorporated emergency alarm buttons. Teachers can use IoT security tools to take action and protect their students. Programming and automating lighting and other IoT-connected devices is conceivable. For instance, lights can be programmed to turn on and off at specific times or connected to occupancy sensors to turn off when a classroom is vacant. Connectivity to the IoT increases building efficiency and reduces energy consumption, saving money. The IoT has the potential to shape intelligent campuses and classrooms. In addition to ensuring students have access to high-quality healthcare and enhancing the teaching and learning process, one of the primary objectives of implementing.

With IoT, this is also considered capable of making lessons in class and discussion lively among students. Even with IoT students will also be able to explore other learning methods. For example, students can study at home by viewing videos, engaging in projects then discussing the results of learning outside the class back to school. IoT also provides jobs that are more efficient for teachers and students. For example, teachers can optimize the tasks that must be done by students. By using the cloud, the teachers too able to see the results as well as the statistics of each student with more information quickly by collecting data results. With this IoT access to information that is easy to access from anywhere and anytime also, will make students able learn everything new (Setiawan, 2018). It will even encourage students to learn more. Thus, teachers can study student learning development directly even though they are not in the same location as these students. Not only in learning but IoT can also be used in the management of teaching support facilities at schools and campuses, such as the use of biometrics in attendance, alumni data management, borrowing books, and school facilities.

The teacher as the admin/manager of the class has several tasks. Accumulating learning analytics, namely seeing student progress from learning interactions with IoT. Maintain material in synchronous (email/blog) and asynchronous (chat/instant messaging) forms. And in the end, it is the teacher who assesses and

evaluates teaching and learning activities with IoT integration. In essence, this opportunity exists and has the potential to be implemented. Even though infrastructure, maintenance, security, and training constraints for teaching and learning activities still exist, especially in Indonesia. IoT will be a part of life, and education, in the future. A thing that may be unavoidable when the millennial generation is more "familiar" with technology. Educators who are too conservative and old-fashioned may still exist. However, it will be more difficult to recognize existing technology to support teaching.

As IoT applications grow, so will their educational advantages. IoT devices are improving educational environments for children of all ages in a variety of imaginative ways. IoT networks use sensors, digital signs, door locks, and colored lights to create personalized security systems. Some schools employ IoT networks to establish security plans for intruders, bad weather, and other threats. IoT technology can give classroom emergency alarm buttons. IoT security tools help teachers protect students. Programming lights and other IoT devices are possible. For instance, lights may be set or coupled to occupancy sensors to turn off when a classroom is empty. Building efficiency and energy savings rise with the Internet of Things connectivity. IoT can create smart campuses and schools. IoT in higher education creates a safe and secure learning environment in addition to improving teaching and healthcare.

The development and use of technology have brought major changes to the world of education. The digital revolution has resulted in the implementation of the internet in the school system with e-learning. IoT adds another dimension to this phenomenon that will in turn change the way teaching and learning processes by providing a more efficient and immersive educational experience. The data obtained from IoT can help in tracking resources to make better student plans. IoT can be used effectively in high school and university environments, where students have moved from paper textbooks to e-books. With the IoT system, it will help detect the presence of students in class, eliminating the need to take attendance manually, so that it can save more time. Some of the applications of IoT in education below can be done to improve quality for students, teachers, and the school itself.

The IoT is a big concept today that is considered capable of revolutionizing all industries and society. Even in education, the Internet of Things is one of the technologies currently being considered by educators and members of government related to education to use to innovate and improve learning. With this Internet, learning becomes more dynamic by integrating traditional methods with new methods (IoT). In addition, the impact of learning with IoT is also considered to be able to make lessons in class and discussions between students more lively. Even with IoT students will also be able to explore other learning methods. For example, students can study at home by watching videos, getting involved in projects, and then discussing learning outcomes outside of the classroom when they return to school. In addition, modern technology and IoT are not limited to how students learn but can also improve the security of IoT itself and wider access to information. Apart from that it can also track key resources.

The IoT has the potential to support the digital transformation of education in readiness for the 5.0 era of society (Arsana, 2021). The IoT has the potential to support the digital transformation of education during the COVID-19 pandemic and in readiness to face the era of society 5.0. This paper reveals that innovation and adaptation of technology especially. According to Arsana (2021), the IoT is urgently needed during a pandemic for teaching and learning activities and preparing oneself for the 5.0 era through a curriculum oriented towards learning life skills, collaboration in addition to hard skills and use of technology such as the

Internet of things (IoT), Artificial Intelligence, Indonesian Research and Education Network (IdRen), and cloud computing.

When innovations such as IoT become part of human life. No doubt that this discourse will become literacy. IoT itself is a big part of digital literacy, and the possibility of its integration into education is also potential. IoT in education itself will be more about its application to support teaching. Just like CMD or Computer-Mediated Learning which is currently being applied to the classroom. IoT also has the dynamics of supporting the teaching and learning process. Then what kind of "shape" IoT will be in the classroom? IoT itself develops the physical form of technology for human life. These objects are connected to the wireless sensor network protocol within one complex infrastructure. A simple example right now is the LED light in the living room that we can control with our cell phones. Or a CCTV system that is connected to our gadgets for a more secure feeling. Again, what forms of IoT can be used in the classroom?

The researcher imagines that teaching English in the IoT context will be more colorful. Simply put, students will talk and consult with the "robot". The teacher himself will be the admin in the interaction. Even now we can use the "robot". For example the voice search feature on Google/Siri/Cortana on our cell phones. Say the word when Google/Siri/Cortana is turned on in English. If our pronunciation is wrong/inaccurate then our search results will be messy. Handphone features as above may be very simple. What if this IoT is not just voice recognition for our English pronunciation? Currently, there is face recognition, error spelling check, etc. on the internet. Maybe there will be a robot that can translate, correct speech/writing, or even "active conversation".

IoT, which is part of digital literacy, cannot be denied anymore. When we are more obsessed with social media and gadgets. Its potential to support education is not impossible. Even though paper-and-chalkboard is the pedagogical foundation of educators. Understanding, applying, and evaluating technology in teaching and learning activities is also an opportunity for progress. IoT will also be an opportunity for teachers to view technology as part of education. And in our mindset, technology is a cultural artifact of the current millennial generation.

The influence of IoT also has further effects on students. In higher education, for example, universities, students may now be bored with using books, and most of them prefer technology such as smartphones, tablets, laptops, and other gadgets. With this IoT access to information that is easy to access from anywhere and anytime, will make students able to learn everything new. It will even encourage students to learn more. In addition, IoT also provides more efficient work for teachers and students. An example is, that teachers can optimize the tasks that must be done by students. By using the cloud, teachers are also able to see the results and statistics of each student with faster information by collecting study results data. Given the enormous impact that the intelligent Internet of Things will have on students' educational experiences (Kavitha et al., 2022).

The use of technology in education is something that no longer needs to be debated, Information and communication Technology (ICT) has had a positive impact on the world of education, especially in terms of increasing the quality and quantity of teaching and learning processes. In addition, information and communication technology will also grow rapidly with the addition of the application of the Internet of Things in various fields, one of which is the field of Education. The IoT has the potential to support the learning process by optimizing communication and interactivity, both between humans and humans, humans and objects, and objects and objects.

The rapid development of information technology will create innovations in the world of education that will further support and improve the quality of education. The Internet of Things is also believed to have great potential to be utilized in supporting a more effective learning process. The application in education is that IoT has great potential to improve and modernize the education system. IoT helps make learning more interactive and fun, makes it easier to monitor student performance, helps control access to school rooms and equipment, and makes distance learning easier. Overall, IoT helps in improving and modernizing the education system by providing new tools and technologies that assist teachers and students in achieving their goals. IoT helps make learning more interactive, makes it easier to monitor student performance, and helps ensure that school equipment works properly.

There are several roles for technology in education, most of which can be categorized into three categories: accessibility, interactivity, and collaboration. 1) Accessibility - technology in the form of computers (both handheld and desktop), computer peripherals, electronic equipment, audio-visual devices, mechanical devices, and the Internet of Things is making education more accessible to more students. Educational materials and classes can also be accessed easily through online platforms. 2) Interactivity - technology is used not only to access enormous online information but also as a means of communication and interaction between students and teachers. Learning materials can be made more dynamic and interactive. For example, those who are just starting to learn coding and programming can test their program on an online platform. Virtual experiments on structural designs can also be carried out using specific applications before prototyping the design. Some schools have 3D printers that students can use to design prototypes or create scaled-down models. 3) Collaboration - technology makes it possible to collaborate at multiple levels, both online and face-to-face. For example, students can collaborate on research papers using cloud storage such as Google Drive. Documents can be edited in real-time among various group members. They can also easily share information.

Even though IoT has many benefits, there are still some challenges that must be overcome such as data security and privacy issues with the continuous development of technology and standards. Security is one of the main challenges because smart devices connected to the internet network can become targets of cyber attacks. In addition, other challenges include privacy, data issues, and compliance issues. However, with the continuous development of technology and standards, IoT is expected to provide effective solutions to existing problems and make people's lives better. IoT is expected to provide effective solutions to existing problems and make the education system better. Overall, IoT proves that technology can help solve existing problems and make human life better. The application of IoT in education is one example of how technology can help improve education systems and make learning more effective and enjoyable for students and teachers.

Today's, IoT is a must in the world of education, especially schools, they cannot but apply the use of the IoT in their schools to support administrative processes and learning processes. With the application of the IoT, it will be able to increase the effectiveness and efficiency of implementing learning in schools, on the other hand, it can brand schools as advanced schools. School human resources (HR) must have the readiness, ability, and willingness to always change for the better, especially in the field of the Internet of Things to improve the quality of their schools. Open-mindedness, creativity, and innovation are the main keys to accepting change and moving towards a better change. Good collaboration is

needed between internal parties, including school principals, teachers, and other education personnel to realize the vision and mission of being a digital-based school. Likewise, the support of the authorities is needed.

Conclusion

In education, the use of IoT aims to improve education quality and efficiency. In this case, several applications of IoT in education are Smart Classrooms, E-Learning, Personalization of Learning, Digital Libraries, Security Systems, Student Health Monitoring, Student Attendance Systems, Interactive Whiteboards, Database Management, Management of Alumni Data, and Blended Learning. Several opportunities for IoT in education, including the improvement of communication, collaboration, class engagement, students' comprehension, resource management, safety and security, teaching efficiency, administrative efficiency, and parental involvement. Besides, easy accessibility to resources, cost efficiency, real-time usage and updates, and remote monitoring, and increasing. During the implementation, the challenges in using IoT in education are 1) the high price to implement IoT technology because of the large amount of hardware and software required. 2) skilled technical team to ensure the effective implementation of the IoT system. 3) security and safety issues to various cyber risks and threats. 3) inadequate internet access for IoT devices, especially low-income rural households that cannot afford an internet connection. 4) blue light. Since most IoT devices require users to be exposed to a blue screen, overexposure caused by long-term use is detrimental to students' healthy development of eyesight. The solutions to overcome these challenges are: 1) increasing the understanding and competence of human resources. Supporting the IoT requires the readiness, skills, competence, and willingness of available human resources. 2) Planning for the implementation of the IoT. IOT schools/institutions must carry out careful planning. 3) Budget allocation must be prepared. However, the results obtained are also getting bigger. In the future, innovations will emerge in education that function to support and improve the quality of education what is called Cyber Schools, including Smart School Offices, Smart School Transportation, Smart School Building Management, Smart Student Health, Smart Classrooms, Smart Labs, Smart Cafeteria, Student Activity Tracking, and many more. Further research is very likely to be carried out, especially in optimizing learning through simulation, virtual, mobile, and gamification with the help of the Internet of Things (IoT).

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