

Internet of Things for Sustainable Smart Education: An Overview

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Abstract: The requirement for a trained workforce will be high in fourth-generation industrialization. To meet this need, we must provide equitable and high-quality sustainable education. The needs of the Fourth Industrial Revolution (4IR) could not be met by traditional methods of organizing and delivering education. The Internet of Things (IoT) is one disruptive technology that can completely change how education is provided. Thus, the purpose of this research project is to provide a summary of what IoT applications may do in learning environments. Our study piece delves into current studies on IoT applications in education. It offers a thorough understanding of the subject from three distinct angles: those of instructors, students, and school administration. The current study clarifies how IoT has been used to help teachers, students, and school administrators—as shown in recent literature. The article also discusses IoT application bottlenecks and describes the primary barriers to IoT applications in educational contexts, which include security, privacy, scalability, dependability, and dehumanization.

Keywords: online learning, sustainable education, school administration, and Internet of Things for schools.

Overview

Traditional learning environments continue to be the weak point in sustainable education. New technology impacts our everyday lives in ways we never would have predicted. The last ten years have seen a significant global shift due

to technological breakthroughs and more digitalization. A technological revolution is happening all around us because of sudden advancements in digital gadgets and wireless technology. In this scenario, the fourth industrial revolution is bringing automation to all facets of life, including education. At this point in the development process, it is imperative to consider inclusive, egalitarian, and high-quality education. The digital gap is growing because the industrialized world has more significant resources than the underdeveloped world. The only thing that can close the gap is universal access to high-quality, long-lasting education. We must consider how technological progress might help raise the world's impoverished population. We must implement new educational strategies to keep up with the digital revolution and technological improvements.

One of the five strategies that the World Economic Forum highlighted is the implementation of workforce and education initiatives that foster exceptional potential [1]. Reforming educational environments and using new technology to enhance educational systems to provide high-quality instruction for sustainable development is one strategy to reduce the gap between developed and developing nations. Teachers may employ cutting-edge technology to build a trained workforce for future digital economies and improve educational systems.

As one of the disruptive technologies, IoT may significantly improve student performance and the quality of learning experiences. It can also help instructors in their day-to-day work, school building management, school transportation systems, and the provision of remote learning. The Internet of Things promises to provide sustainable, high-quality education and address the daily problems that managers and educators encounter. We believe the Internet of Things may contribute to sustainability and provide egalitarian, high-quality education. The fourth industrial revolution's cornerstone will be data-driven intelligent systems. As a result, in the future, the Internet of Things will primarily power data-driven intelligent systems. However, we do believe that there will be difficulties with IoT applications. In

this study, we investigate how the Internet of Things may help create data-driven, intelligent communities by facilitating intelligent schools. We consider this subject to be a novel area for investigation.

This article presents an overview based on current research on the use of IoT in education. After giving a brief overview of IoT, the study paper discusses how it might be used in education. We demonstrate how teachers, school managers, and students can use IoT in educational settings to build a sustainable, innovative school. The paper concludes by discussing the limitations of using IoT technologies in educational settings.

1. Methods and Research Questions

1.1. Research Issues

We want to provide answers to the following research questions in our study article:

Question 1 asks how the Internet of Things might be used in educational settings to offer sustainable, innovative education from the viewpoints of teachers, school administrators, and learners. We have divided Question 1 into the following three sections.

- What is smart education, and how is the idea of a “smart school” explained?
- What is meant by sustainable education? How can intelligent education also be sustainable?
- How school administrators, teachers, and students may use the Internet of Things in educational contexts

2. What are the primary obstacles to using the Internet of Things in educational environments?

1.2. Techniques

This study provides an overview by examining the scientific literature produced in the previous ten to eleven years, addressing the above research issues.

Using a selection of keywords, including Internet of Things, innovative school, Internet of Things and education, web

learning, virtual learning, innovative sustainable education, and educational management and Internet of Things, we conducted our literature review using search engines like Google Scholar, IEEE, and ERIC. We used these primary search terms to gather most of the literature reviewed in this work. We chose Google Scholar, IEEE, and ERIC for our literature search since these sites had more current research relevant to our search. We obtained several recent research from these sources. With the keywords above, we were able to get about 65 articles. There are 58 references throughout the work. Of these, 11 relate to official websites and other reliable sources of information, and 47 refer to the featured articles. Since we are concentrating on publications published in the previous ten to eleven years, part of the inclusion criterion was based on the year of publication. Two articles were published before 2011. The articles were included because, in the writers' view, they provided a relevant explanation of sustainability and should be included in the paper. Second, the papers were chosen based on how much they contributed to discussing IoT in the educational setting. Other articles had debate overlaps (e.g., reviews on IoT, issues in IoT applications, and sustainable education), and others had been published more than 11 years ago, so we omitted them. It should be mentioned that most research on the subject has been published recently. We chose the most relevant papers from among all the accessible papers. Table 1 summarizes the data about the search and collection of research publications.

The research also examined relevant material accessible online from reputable sources, including the official websites of the UN, UNESCO, and UNDP (United Nations Educational, Scientific, and Cultural Organizations). It should be mentioned that little research has been done on this issue, which is new since IoT implementation in education is still in its infancy and is a novel field of study.

The papers we found were categorized into three areas: (1) Internet of Things applications to address issues related to school administration, (2) applications to support instructors in their day-to-day work, and (3) applications to support students. Additionally, we searched for IoT application

obstacles from an educational standpoint. After conducting a content analysis [2] of the gathered research papers, the writers provide a thorough synopsis of the subject under discussion.

2. Astute and Ecological Teaching

The existing traditional education system has the potential to transform because of the Internet of Things. According to a recent study, IoT applications can potentially constitute a paradigm change in educational settings. According to a recent study, IoT offers various capabilities to school administrators, instructors, and students. This portion of the article overviews IoT applications for schools from current research. Innovative schools powered by information and communications technology (ICT) are not a novel idea, but much research hasn't been done.

2.1. A Smart School: What Is It?

An intelligent school is an interactive learning, engagement, teaching, and administration environment powered by physical or virtual technology. It has contemporary tools, gadgets, and software [3]. The qualities of knowledge, efficacy, efficiency, and intellect are referred to as "smart." Thus, "smart education" describes a learning environment that empowers students to behave wisely, think critically, and solve issues successfully. Therefore, the goal of an innovative school is to provide an intelligent learning environment with interactive and collaborative tools accessible to all students without restriction. This environment is built on student-centric, customized, and adaptable learning services [3].

There are many different types of intelligence schools across the world. Malaysian innovative schools prioritize the development of students' 21st-century abilities via the promotion of technology-driven, individualized learning, creativity, and critical thinking [4]. Singaporean schools have embraced technology-based learning to provide students with more sophisticated educational opportunities. Singaporean schools have created a national curriculum and learning architecture to support lifelong learning. Australia's schools pioneered the idea of the "smart school," creating

a transdisciplinary, learner-centered curriculum, offering digital learning tools, interactive technology for instructors and students, flexible curricula, and intelligent monitoring systems [5].

Finland's schools have been setting the global standard in implementing student-centered, project-based pedagogical techniques, technology integration in everyday schoolwork, and user-driven, motivational learning solutions [6]. New York schools have already begun implementing intelligent school initiatives that prioritize the development of 21st-century skills. New York City schools have created technologically advanced classrooms emphasizing student performance and cooperative learning [7]. The Mohammed Bin Rashid Smart Learning Program (MBRSLP), which seeks to transform the learning environment and school culture into technology-based, interactive, and collaborative smart classrooms, was developed by schools in the United Arab Emirates (UAE) in 2012 [8]. China's educational institutions have created innovative systems emphasizing digital resources, ICT applications, information literacy, ICT infrastructure, and safety precautions [9].

It is reasonable to assume that the foundation of intelligent school concepts is built on professional development for teachers, dependable ICT infrastructures, contemporary curriculum designs, the use of tools and devices for collaboration and interaction, the application of interactive and collaborative technologies, user-friendly, customized learning environments, and intelligent school management systems. Thus, the following are the primary goals of an innovative school, which define their benefits over traditional educational settings:

- To develop digital literacy and an ICT-savvy labor force in the future.
- To attain a more participatory, team-based learning environment and improved educational standards
- To attain inclusive education by establishing virtual learning environments in remote locations without school infrastructure.

- To provide educators with cutting-edge resources and software to enhance productivity and quality of instruction in their day-to-day jobs.
- To manage resources sustainably while delivering high-quality education.
- To assist and create sustainable communities to meet sustainable development aims [10].

2.2. What Is Involved in Sustainable Education?

Sustainability is a synonym for tenacity, nourishment, or endurance. It may also allude to preserving buildings, settings, or cultural traditions. Another definition of sustainability is the capacity to maintain a system at a certain level without exhausting resources or risking breaking it. Sustainability may also be explained regarding a system's consistency and dependability.

The United Nations World Commission on Environment and Development defines sustainability as "the development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [11].

According to the Sustainability Committee Charter of the University of California, Los Angeles (UCLA), sustainability is "the integration of environmental health, social equity, and economic vitality to create thriving, healthy, diverse, and resilient communities for this generation and future generations." Sustainability as a profession acknowledges the interconnectedness of these problems and calls for a systems perspective and an appreciation of complexity [12].

There are several methods to describe sustainable education (SE) in the context of sustainable development. In 2009, Reynolds, an Australian researcher, established the concept of sustainable education using "sustainability quotients," which apply to many types of sustainability and indicate a balance between resource availability and consumption. Reynolds contends that as a social institution, education must meaningfully contribute to maintaining sustainability on a local, societal, and global scale. As per additional research, sustainable education (SE) may be characterized by four

attributes [14]: Sustaining: It aids in maintaining individuals, communities, and ecosystems; Tenable: It

offers fairness, honesty, justice, and inclusivity; Healthy: It supports systems, encouraging healthy lifestyles; Durable: It is long-lasting and reasonably priced, ensuring that the systems remain accessible to everyone and unbroken.

Sustainable education is vital to society because it equips students with ethical and economic reasoning. According to a 2018 UNESCO report, education is crucial for sustainable development. It also called for changes in educational systems, focusing on innovative pedagogies and technology-driven, intelligent, and efficient learning environments accessible to everyone with equity, justice, and equality. According to UNESCO, one of the main goals to be accomplished by 2030 is sustainable education for sustainable development (environmental, social, and economic) [15].

3. Key Elements of an Eco-Friendly Smart School

What qualities make an intelligent school sustainable? There is currently no ideal definition or standard for this crucial topic. On the other hand, according to current research, a fundamental definition of an innovative school is one that provides students with laptops, tablets, multimedia displays, projectors, and free internet access dependably and sustainably [10]. Applications should be safe, accessible, and free from service interruptions, according to this definition of reliability. Applications that meet these criteria may also be cost-effective, environmentally friendly, secure, and readily available. A school can improve its innovative features by adopting cutting-edge tools and technologies, such as sensors, cameras, intelligent and interactive whiteboards, virtual reality, augmented reality tools and applications, interactive learning games and learning environments, and technology-based assessment and feedback tools in sustainable ways. Thus, a school that has technology-driven physical and virtual classrooms, sustainable resource management systems, innovative pedagogies, and individualized learning management systems (LMS) together with a secure and dependable ICT infrastructure may be referred to as a clever school [10].

Similarly, when discussing e-learning, we usually picture a virtual classroom with distance learning. E-schools allow students to study at home without having to go to a campus by offering instruction online, offline, or in virtual classrooms. There are several benefits to this virtual or distant learning education, including its ability to reach remote locations and provide instruction. Distance learning is powerful and convenient in the COVID-19 and post-COVID-19 age. Consequently, an intelligent school can provide remote learning to kids who reside in remote areas. Distance learning is more affordable and convenient than creating a physical school in remote places or traveling daily.

We propose that the United Nations' sustainable development objectives may be more easily attained using ICT and contemporary technology in an intelligent school model. Figure 1 [4] illustrates the 17 sustainable development objectives set forward by the United Nations. Applying the small school model may help accomplish a more extensive range of objectives, including improving education quality (Goal 4), decreasing discrimination in society (Goal 10), and creating sustainable societies (Goal 11) [4]. As elucidated by the United Nations, Sustainable Development Goal 4 [4] promotes inclusivity and equitable access to high-quality education for everyone. Sustainability evokes the notion of mass development, not just for addressing current issues but also for fostering future generations' capacity to handle future problems and provide for their own needs. Sustainability seems to be facilitated by the advancement of education made possible by cutting-edge technology. We need high-quality education to improve the present and brighten the future. Consequently, information and communication technology-enabled innovative schools will generate a trained labor force and high-quality education for sustainable development. Figure 2 summarizes the key components of a creative and sustainable school.



Figure 1. Sustainable Development Goals of the UN.



Figure 2. A sustainable and intelligent school.

3. An Overview of the Internet of Things

The Auto-ID Center's co-founder, Kevin Ashton, coined the phrase "Internet of Things" (IoT) in 1999 [16]. Subsequently, IoT was described as "enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies" (International Telecommunications Union, 2012) [17]. The ITU provided this definition. The Internet of Things is a technological advancement that collects and sends data to other internet-connected gadgets. IoT interacts with its surroundings near other networked devices in this manner. A "thing" can collect and send data to different linked devices in the context of the Internet of Things. Several

cutting-edge technologies enable the Internet of Things. For instance, artificial intelligence and wireless connectivity are two of the primary enabling technologies of the Internet of Things. IoT relies on the integration of many cutting-edge technologies to provide services. The term “things” in the context of the Internet of Things refers not just to electrical devices but also to objects like food, clothing, costumes, sports equipment, art, and crafts [18]. The Internet of Things ensures quick connection through data collection and transfer, device interaction, and information reception and transmission.

Internet of Things Architecture

Figure 3 illustrates the four levels that make up the IoT architecture. The first layer represents the physical layer comprising radio frequency identification tags (RFID), wearable technology, actuators, and sensors. As a result, we may state that data collection devices comprise the physical layer. Devices that transform energy into motion are called actuators. Actuators are essentially the motion creators. Linear, rotatory, and oscillatory motion are all possible [19].

The network layer is situated underneath the physical layer. It serves as the foundation layer and may include wireless networks (3G, 4G, and 5G), satellite networks, optical fiber networks, ethernet networks, and cloud networks. The network layer makes mobility management, IoT terminal accounting, and the authentication and authorization of IoT applications possible [20].

The software layer, sometimes called the data processing layer, comes after the network layer. The software layer functions like an engine for processing data. This layer comprises databases, data processing devices, and high-power data processing servers to process the gathered data. As a result, by guaranteeing communication protocol for data management and communication, the software layer makes the functioning possible.

The application layer is the final tier of an Internet of Things architecture. It leverages smart devices to enable machine-to-machine (M-M) and machine-to-human (M-H) interactions. The application layer also interfaces with the infrastructure and external apps.

Three primary characteristics define an Internet of Things system: (1) intelligent processing, (2) dependable transmission, and (3) comprehensive perception.

Smart industry and bright city ideas, which include innovative commerce, innovative health, innovative education, and intelligent transportation systems, are only a few of the many uses for the Internet of Things [20].

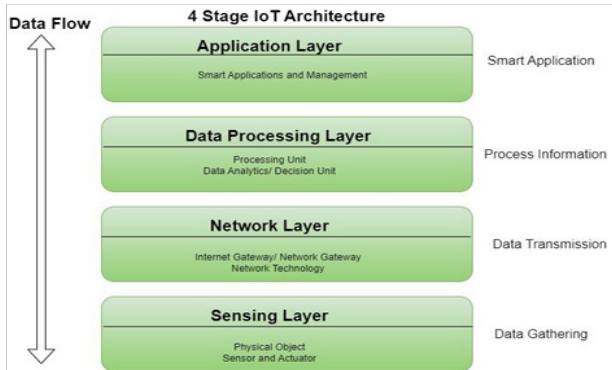


Figure 3. Internet of Things architecture.

4. IoT as a Tool for Smart and Sustainable Education

In this part, we address the use of IoT from three distinct angles: student, instructor, and school administration. Figure 4 depicts the IoT-driven Smart School as it is conceived.



Figure 4. Smart classroom powered by IoT.

4.1. IoT in Smart School Administration

- **Energy management:** Interconnectivity and interoperability are essential for energy management in the interest of sustainability. Energy-smart management might save educational institutions millions of dollars. IoT sensors on school property enable using energy only when needed, as opposed to wasting energy, as with electricity. By doing this, educational institutions may reduce their carbon impact and the cost of power per unit. Thus, the management system may get information about energy use via an Internet of Things-based communication structure. To provide intelligent energy management for schools, an IoT-based energy-management platform has been created [21]; as a result, it offers a system based on demand resource energy management (DR). Another interesting approach to managing intelligent school buildings is provided in [22], where an open-source IoT infrastructure offers an inexpensive way to monitor environmental conditions and energy use. In many German school buildings, the solution is in place.

- **On-campus security:** Keeping school grounds secure may be difficult, particularly for larger establishments. The infrastructure of most educational buildings is not adequately guarded. As a result, it is tough to find evidence of events like sexual assault, arson, theft, or physical violence on campuses. By combining gadgets with real-time cameras, school administration can improve campus security. In this manner, the school administration can swiftly locate the incident site and immediately start the response plan. Cloud-based networks, wireless connectivity, improved cellular technologies, sensing technologies, and sensitive cameras are all part of IoT-based security systems [23].

- **Student monitoring system:** In a different study, researchers created an Internet of Things (IoT)-based system for monitoring students that uses IP-based closed-circuit television (CCTV) and Bluetooth low-energy technology (BLE) cards. Here, the object's location is ascertained using fingerprinting technology via the

beacon chips, and the student's identity is ascertained using facial recognition. It would be simpler to keep an eye on and recognize the students carrying the BLE cards in this manner [24].

- Handling kids who require more support: It may be difficult for educators to accommodate pupils with unique needs. Students with mental and physical challenges need comprehensive solutions to support their learning. IoT can foster the growth of learners.

Welcoming, individualized learning settings. Recent research studies have shown the potential of IoT for kids with special needs [25–27]. One helpful example is a pair of gloves with sensors and a speech-generating tablet that may assist mute and deaf students with communication and involvement in the classroom. One kind of educational technology that aids visually challenged pupils in text-to-speech recognition is the screen reader. Screen magnifiers, which expand screen material; on-screen keyboards, which facilitate typing for students with mobility impairments; and on-screen alerts, which provide visual cues to deaf or hard-of-hearing students, are further features of screen readers [28]. A wearable Internet of Things (IoT) gadget for the early diagnosis of autism and data management is presented by the study in [29].

- Smart transportation for schools: School administration may use IoT to provide safe transportation for students. [30] presents an Internet of Things (IoT)-based car monitoring system. The offered notion explains the mechanism: a microcontroller and a cellular device application. The global positioning system (GPS) uses a cellular device to determine the school bus's location. For the students' safety, the system uses a panic switch and an alcohol sensor. Managers at the school and parents may see the vehicle's current status in real time. Another suggested IoT-based bus monitoring system allows parents, school administrators, and bus drivers to follow school transportation via an Android application and tracking website [31].

- **Student health monitoring system:** A student's health affects academic performance. A student's academic performance will decrease if they deal with health issues since it will be tough to concentrate on academics. In this instance, IoT is rather important. IoT sensors use wearable technology to collect health-related data. After processing, the gathered data provides accurate measurements of the health parameters of the students. Research has suggested an ambient intelligence-assisted health monitoring system (AmIHMS) based on Internet of Things devices [32]. Researchers proposed a cloud-centric IoT-based health monitoring platform [33]. A method for detecting emotions via the use of physiological markers and long short-term memory (LSTM) is presented in research work [34]. Researchers who studied remote learning during the epidemic have offered an Internet of Things (IoT)-based platform for healthcare. In [35], a data-driven air quality forecast system for educational institutions is proposed.

4.2. Internet of Things for Teachers

- **Autonomous attendance system:** Teachers are responsible for recording every student's attendance. Teaching and assisting students in learning are educators' primary responsibilities. Using a barcode-equipped ID card, each student may be uniquely identified using an automated attendance system provided by the biometric attendance system. Every pupil is recognized thanks to the system's connection to facial recognition. Instructors and parents will know the student's presence or absence [36–38].

- **Advanced pedagogies:** These days, learning environments aren't only found in traditional classroom settings. Learning now takes place in three formats: online, in-person, and hybrid. There are virtual and actual classrooms. Other terms for the same idea include digital, remote, e-learning, online, and mobile learning. In that case, teachers need new pedagogies that complement virtual learning environments. Educators need to use advanced ideas and pedagogies in a relevant way while teaching and facilitating learning. One practical example is the flipped classroom, where the instructor guides the pupils. In this instance, the computer network course used the flipped classroom as an IoT component [39].

- **System for assessment, evaluation, and feedback:** The Internet of Things (IoT) may be used as an embedded technology to evaluate, appraise, and provide student feedback. These automated assessment systems allow teachers to work quickly and efficiently while getting detailed information on their students' performance. A paradigm for student interactions employing attention score evaluation in e-learning was developed by research work provided in [40]. One more

A research paper [41] presented an IoT-based real-time data mining method for student assessment. A study published in [42] suggested using Raspberry Pi to create an IoT-based student engagement evaluation.

- **IoT-based STEM education:** In STEM (science, technology, engineering, and math) programs, IoT devices may conduct practical experiments and provide hands-on learning opportunities. Additionally, the students can analyze the information gathered by sensors or other equipment. One of the STEM skills that students may build is design thinking, which they can do by using IoT kits for design-based learning [43]. IoT technologies may be used for laboratory experimentation and physics teaching [44]. A research study in [45] suggested including IoT in STEM education. Analytical abilities may be developed by utilizing multimodal data acquired by IoT devices [46]. IoT-based innovative learning environments support students' development of critical thinking and problem-solving abilities, according to research in [47].

4.3. Internet of Things for Learners

- **Distance learning:** In the pandemic, in-person instruction proved unfeasible, and distance learning became a viable option. IoT can significantly improve online or distance learning [48]. According to [49], IoT solutions may improve distant learning and increase student performance and efficiency by up to 20 percent. IoT sensors captured the feedback and monitored brain activity throughout learning sessions. IoT sensors monitored the participants' fatigue in this study [49] and sent messages to keep the brain engaged.

- **Increased productivity and interaction:** Students who participate in online, virtual, or e-classes via a smartphone become more interactive. Students' motivation to participate in various activities and actively participate in the feedback and evaluation procedures is developed via interaction-based learning. IoT-based learning environments thereby improve student engagement and productivity. For instance, barcode-enabled e-books facilitate interactive reading for pupils. An Internet of Things gadget called Scanmaker can swiftly scan editable text from books, papers, and other materials straight into a computer, tablet, or phone. Text may be translated into 40 different languages with this gadget [50].

- **Tailored learning environments:** Learners' requirements are the focus of these digital learning environments. One digital learning environment that has been popular as a practical online learning option for instructors and students is Blackboard [51]. Blackboard is a virtual classroom technology that uses an interactive learning management system (LMS) to increase collaboration while facilitating learning. These personalized digital learning environments inform Parents and children about the daily schedule, student grades, events, school news, and attendance. Wearable IoT technology also facilitates the creation of seamless learning. IoT wearable devices may customize the learning environment for each student by integrating social media engagement, fitness logs, and location data. The IoT-ready platform from the MaTHiSiS H2020 EU project [52] is a prime example. The impact of students interacting with game-based learning materials is recorded using Internet of Things (IoT) sensor devices. Robots and mobile devices, including tablets and smartphones, were used for engagement on this Internet of Things platform [52]. Wearable Internet of Things (IoT) devices collect data from students and then analyze it to assist in customizing the learning environment to each student's requirements.

- **School and home management:** Parents and children may utilize IoT as a tool for administration. One example

of home and school management is the IoT-enabled brilliant school backpack. A study in [53] suggested an IoT-enabled bright bag for kids. It quickly gives students access to a schedule management tool and notifies parents of any books or other school-related supplies missing from the bag.

5. Obstacles in Adapting IoT to Education

IoT adoption in education presents several challenges despite its enormous advantages [54]. This section discusses obstacles to IoT applications in education.

5.1. Privacy and Security

We are all aware that having systems linked to the internet increases the risk of cyberattacks. If outsiders or students attack any of the school system's systems, the whole system may be in danger. Such efforts might render the institutions nonfunctional. An internet outage can cause the educational system as a whole to stand at a standstill. Data theft is yet another major worry. IoT devices would gather a great deal of data; therefore, if that data were stolen, there would be a severe security risk. Integrity-related problems, end-to-end security, authentication, and data confidentiality are a few more security and privacy obstacles [55]. Only when dependable and safe can IoT applications be used in educational settings. Massive amounts of data are collected by IoT tools and apps using NFC, 4G, and 5G technologies, as well as gadgets like RIFD. Data security is thus quite complex. We must consider the solutions to the problems in this situation, such as who will gain from the data and who owns it. Thus, data management, control, and security are most important. Authenticity and confidentiality of data are additional crucial considerations. The information gathered must be secure and restricted to authorized users, whether computer systems or people. Data should be handled securely, and to prevent data breaches, manipulation, or theft during data collecting and processing, a dependable and secure system is needed.

5.2. Efficiency and Dependability

IoT solutions in the education industry need to be scalable.

Because IoT gathers vast amounts of data, data analysis is essential to gaining meaningful insight from the data. For this reason, data scalability is one of the challenges in using IoT in educational contexts. Scalability was covered in research work [56], which also suggested a social recommender system based on Hadoop and parallel computing that offers students personalized learning materials based on extensive data analysis. Research suggested a secret sharing plan for scalable and safe Internet of Things systems [57]. This study also covered how dispersed IoT infrastructure deployment might improve the scalability and dependability of IoT applications. IoT-based solutions have to be universally accessible and sustainable.

Consequently, it must be immediately available and accessible to its users. For their systems to function sustainably, schools and other educational institutions must have access to sufficient funding to purchase these services and apps.

5.3. Concerns about Dehumanization and Ethics

In this sense, dehumanization is downplaying the significance of people. When we have autonomous systems that need little to no human involvement, dehumanization occurs. One major problem that will arise when systems operate autonomously and involve fewer humans is dehumanization, which will give service providers more control and authority [58]. Modern technology plays a significant part in our everyday lives, yet ethical and dehumanization considerations must be considered. IoT-based services and apps must adhere to an operational protocol.

User awareness is essential when using sophisticated technology, tools, and gadgets. Consumers and users must be informed about safe internet technology usage practices and self-defense strategies against various cyber threats. Before implementing new technology, international governments must arrange public awareness campaigns and educational initiatives about such technologies. This way, consumers may make the most informed use of those tools, knowing their features.

6. Talk

Technological breakthroughs have significantly changed the world and will continue to change. These developments have equal advantages and disadvantages. One industry that is constantly evolving and transforming is education. Digital tools have replaced traditional instructional methods in the COVID-19 era.

Like the last industrial revolution, the fourth is moving toward more sophisticated digital technology requiring a specialized workforce. The future workforce must possess 21st-century skills to handle upcoming problems. Countries will need such a competent labor force for economic progress. As a result, we need educational institutions that can generate a trained labor force. We contend that a wise, sustainable education system may develop this future workforce. We need an education that considers sustainable development's environmental, social, and economic aspects. We believe that a technology-driven education system that improves sustainability in justice, fairness, equality, and sustenance is a sustainable, intelligent education that can produce the future workforce.

New and developing technologies are essential to the education sector. Our research effort was centered on the Internet of Things. We outlined the key issues and provided an overview of how the Internet of Things can support sustainable, intelligent schools. We stress how helpful technology can be when it comes to sustainability. A technology is no longer sustainable if it is costly, harmful, or unfavorable to the environment. We make the case for the use of technology that prioritizes sustainability.

We demonstrated in our study work that the Internet of Things is a state-of-the-art technology for learning environments. We discussed how school administrators, instructors, and students may all benefit from using the Internet of Things in the classroom. IoT sensor technology contributes to the resolution of several issues. Energy management, transportation management, student health management, on-campus security, and student monitoring systems are services that school administration may get via the Internet of

Things. IoT uses sensors, cameras, cloud computing, machine learning, and data-gathering devices in these applications. IoT may be very helpful for instructors in several areas, including STEM classrooms, intelligent learning environments, student attendance management, feedback and evaluation systems, and interactive teaching tools. Innovative learning environments, customized learning management systems, intelligent gadgets for students with specific needs, and interactive and collaborative tools for immersive learning—both on and off campus—can all be made possible by IoT, according to students' perspectives. Further study is required to fully explore the potential of IoT applications in schools. Likewise, additional research is needed to identify sustainable technology integration strategies.

This article offers educators and readers an overview of how IoT might facilitate intelligent teaching and learning. IoT applications are not without difficulties. IoT applications in educational contexts have three primary challenges: dehumanization, scalability and dependability, and security and privacy. By conquering these obstacles, we can make IoT solutions more environmentally friendly.

Similarly, further research is required to identify sustainable technology integration techniques. One of the UN's Sustainable Development Goals is to provide equitable and inclusive quality education for everyone. Research on integrating sustainability with technological applications is thus desperately needed. Technology-driven, intelligent education may be sustainable if accessible, inexpensive, healthful, and good for the environment.

In conclusion

Our research goal was to comprehensively understand how the Internet of Things may be used to implement intelligent school features in learning environments. The objective of digitalization is to provide a high-quality, sustainable education. There are, nonetheless, a lot of limitations in this area. We've outlined the main points of the most current study on IoT's role in facilitating the idea of "smart schools." IoT provides a chance to use crucial smart

Table 2 summarizes school characteristics and centers on instructors, students, and school administration. Thus, traditional methods must be replaced with cutting-edge technology for a sustainable, high-quality education. The World Economic Forum [4] lists five policies for education and the workforce that produce exceptional talent.

We conclude that the Internet of Things has the potential to revolutionize the way sustainable, innovative schools are implemented. We prioritize eco-friendly teaching strategies that support intelligent learning environments. IoT is essential to meeting the demands of learning environments. We comprehensively demonstrated how IoT may be used for intelligent school learning, teaching, and administration. We also discussed the difficulties in using IoT in education and its security and privacy concerns. Significant constraints in IoT applications include security, privacy, scalability, dependability, dehumanization, and ethical difficulties. Further study is required to find out how to make the Internet of Things safer and more secure. In subsequent studies, we will use the Internet of Things in STEM (science, technology, engineering, and mathematics) classrooms to foster students' critical and analytical thinking.

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