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Internet of Things for Sustainable Smart Education: An Overview

Khaula Zeeshan *, Timo Hämäläinen and Pekka Neittaanmäki

Faculty of Information Technology, University of Jyvaskyla, Mattilanniemi 2, 40100 Jyvaskyla, Finland; timo.hamalainen@jyu.fi (T.H.); pekka.neittaanmaki@jyu.fi (P.N.)
* Correspondence: khaula.k.zeeshan@student.jyu.fi

Abstract: In the realm of fourth-generation industrialization, there will be great demand for a skilled workforceTo produce a skilled workforce, we need sustainable education with quality and equity. Conventional ways of delivering and managing education would not fulfil the demands of the fourth industrial revolution (4IR). Disruptive technologies, such as Internet of Things (IoT), have great potential in revolutionizing the current educational setup. Therefore, this research work aims to present an overview of the capabilities of IoT applications in educational settings. Our research article digs into recent research carried out referring to IoT applications in education and provides a detailed insight into the topic from three different perspectives, i.e., from the perspective of school management, teachers, and learners. The present research explains the ways in which IoT has been applied for the benefit of school managers, teachers, and learners, showcased in the recent literature. The paper also sheds light on bottlenecks for IoT applications and explains security, privacy, scalability, reliability, and dehumanization as main constraints in IoT applications in educational settings.

Keywords: Internet of Things for schools; sustainable education; web learning; school management

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1. Introduction

Conventional educational settings remain the Achilles heel of sustainable education. Newfangled technologies are infiltrating our daily lives in ways we never imagined. The world we live in has changed dramatically in the previous decade as a result of technological advancements and digitization. Abrupt advances in wireless technologies and digital devices have ushered in a technological revolution all around us. The fourth industrial revolution, in this scenario, is bringing automation to every aspect of life, including schooling. It is critical to consider inclusive, equitable, and high-quality education at this stage of development. The digital divide is widening in the sense that the developed part of the world has more resources than the developing world. The only thing which can narrow the gap is sustainable quality education, provided equally to the masses. We must consider how technological advancements can assist in upbringing the world's underprivileged population. To keep the pace with technological advancements and the digital revolution, we have to embark new ways of educational systems.

The initiation of education and workforce policies which develop superior talent is one of the five policies identified by the World Economic Forum [1]. One way of narrowing the bridge between developed and developing countries is to reform educational settings by harnessing new technologies to uplift educational systems, therefore providing quality education for sustainable development. Educators can use advanced technologies not only for educational system development but also for developing a skilled workforce for future digital economies.

IoT, as one of the disruptive technologies, can play a vital role in enhancing quality of learning experiences and the performance of the learners, supporting teachers' daily work, school building management, school transport systems, and distanced learning provision. The Internet of Things has the potential to provide sustainable quality education and provide solutions for the everyday challenges which education providers and managers

face. From our point of view, the Internet of Things can enable equitable, quality education and can play a role in sustainability. Data-driven smart systems will be the cornerstone of the fourth industrial revolution. Therefore, the IoT is the key driving technology for the data-driven smart systems in future. However, we also think that there will be challenges related to IoT applications. In our research work, we explore the role of the Internet of Things as an enabler for smart schools in data-driven smart societies. We see this topic as a new research direction.

This article provides an overview based on recent research carried out related to the application of IoT for education. The research work provides an introduction to IoT and then moves on to a discussion of IoT applications in education. We showcase how IoT can be applied in educational contexts from school manager's, teacher's, and a learner's perspectives, to create a sustainable smart school. Finally, the study discusses the constraints of using IoT solutions in educational contexts.

2. Research Questions and Methodology

2.1. Research Questions

In our research article, we are aiming to answer the following research questions:

Question 1: How can the Internet of Things be applied in educational settings from school manager, teacher, and learner perspectives to provide sustainable smart education.To seek answers for Question 1, we have delineated the three following parts

- What is smart education, and how can the smart school concept be explained
- What does sustainable education mean? How can a smart education can be a sustainable education?
- How can the Internet of things be applied in educational settings from school manager, teacher, and learner perspectives

Question 2: What are the main challenges in applying the Internet of Things in educational settings?

2.2. Methodology

To answer the above research questions, this study presents an overview by reviewing the scientific literature published in the last 10–11 years.

We carried out our literature review using search engines such as Google Scholar, IEEE, and ERIC, using selected keywords: Internet of Things, smart school, Internet of Things and education, web learning, virtual learning, smart sustainable education, and educational management and Internet of Things. These are the main keywords used for the search, and we collected most of the literature addressed in this paper by using these keywords. Google Scholar, IEEE, and ERIC were used for the literature search because we found more recent work related to our search from these sources. These sources provided us with numerous recent studies. We retrieved almost 65 articles using the above-mentioned keywords. The total number of references included in the manuscript is 58. Out of which, 47 references refer to the included articles, and the remaining 11 refer to official websites and other authentic sources of information. The criteria for the articles to be included was partly based on the year of publication, because we are focusing on articles published in last 10-11 years. Two articles included were published before 2011. The reason for adding those articles is that they explained sustainability in a significant way, and in the authors' opinions, it was valuable to include those articles in the manuscript. Secondly, the articles were selected on the bases of their contribution on the topic of the Internet of Things in the field of education. We excluded some articles because some of them were published more than 11 years ago, and some articles had overlaps in discussion—for example, there were overlaps in reviews on IoT, challenges in IoT applications, and sustainable education. It is also noted that most of the work carried out on the topic has been published in recent years. Out of all the available papers, we selected the most relevant papers.The information related to research articles search and collection is summed up in Table 1.

Table 1. Information related to research articles search and collection.

Total Number of References	Total Number of Article-Based References	Total Number Official-Website-Based/Other-Information-Based References	Publication Period of Included Articles	Search Engines Used for Article Collection	Keywords for the Article Search
58	47	11	2011–2021	Google Scholar, IEEE, and ERIC	IoT, smart school, IoT and education, web learning, virtual learning, smart sustainable education, educational management and IoT

The study also analysed related information available on the internet from reliable resources, such as the official websites of the United Nations Educational, Scientific, and Cultural organization (UNESCO), United Nations (UN), and United Nations Development Program (UNDP). It is also noted that this topic is new, as application of IoT in education is in its infancy stage and is a new direction of research; therefore, there is not much work that has been carried out and published.

We divided the searched articles in three categories: (1) Internet of Things applied for solving school management problems; (2) Internet of Things applied for facilitating teachers in their daily work; (3) Internet of Things for facilitating learners. Furthermore, we looked for the bottlenecks in IoT applications from an educational perspective. The authors carried out a content analysis [2] of the collected research articles and present a detailed overview of the topic in discussion.

3. Smart and Sustainable Education

The Internet of Things has the capability to revolutionize the current conventional education system. Recent research has identified that IoT application in educational settings could prove to be a paradigm shift. Current research has pointed out that IoT has diverse services to offer for school managers, teachers, and learners. This section of the paper presents an overview of IoT applications for schools presented in recent research work. Although information and communications technology (ICT)-driven smart schools are not a new concept, there has not been much work carried out in that direction.

3.1. What Is a Smart School?

A smart school is a technology-driven physical or virtual learning environment equipped with modern technologies, devices, tools, and applications for interactive learning, engagement, collaboration, teaching, and management [3]. The term "smart" refers to intelligence, wisdom, efficiency, and effectiveness. So, smart education refers to a medium of learning which enables learners to think intelligently, act efficiently, and solve problems effectively. Therefore, a smart school aims to provide an intelligent learning environment, based on student-centric, personalized, and adaptive learning services, with interactive and collaborative tools characterized by unhindered access [3].

Worldwide, we can see various examples of smart schools. Malaysian smart schools focus on nurturing 21st century skills in learners by developing creativity, thinking, and fostering technology-driven, personalised learning [4]. Schools in Singapore have embraced technology-based education to enrich their learners with advanced learning experiences. Schools in Singapore have developed a national education and learning architecture for lifelong learning. Schools in Australia have introduced the smart school concept by developing a multidisciplinary, learner-centric education system, providing digital learning platforms,

smart monitoring systems, adaptive curriculums, and interactive technologies for students and teachers [5].

Schools in Finland have been leading the world by implementing user-driven, motivational learning solutions, incorporating technology in daily school work, focusing on student-centred, project-based pedagogical approaches [6]. Schools in New York have already started smart school ventures, focusing on 21st century skill development. Schools in New York have developed technologically integrated class rooms, focusing on student performances and collaborative interactions [7]. Schools in the United Arab Emirates (UAE) started developing a smart learning program—the Mohammed Bin Rashid Smart Learning Program (MBRSLP)—in 2012, which aims to reshape the learning environment and school culture into technology-based, interactive, and collaborative smart classes [8]. Schools in China have developed smart systems, focusing on the ICT infrastructure, digital resources, ICT applications, information literacy, and safeguard mechanisms [9].

We can infer that smart school concepts build on teacher training, reliable information, communications technology (ICT) infrastructures, modern curriculum designs, application of interactive and collaborative technologies, tools and devices, user-friendly, personalized learning environments, and intelligent school management systems. Therefore, the main objectives of a smart school—which characterize the advantages of a smart school over conventional schools—include the following:

- To achieve digital literacy and an ICT-literate future workforce.
- To achieve an interactive, collaborative learning experience and an enhanced quality of education
- To achieve inclusive education by providing virtual education to far-removed areas without setting up physical school infrastructures.
- To equip teachers with modern teaching tools and applications to harness ease of work and quality of delivery in their daily work routine.
- To achieve sustainable management of resources in providing quality education.
- To achieve sustainable development goals by supporting and building sustainable communities [10].

3.2. What Does Sustainable Education Mean?

Sustainability refers to persistence, sustenance, or endurance. It can also refer to preservation of environments, facilities, or cultures. Sustainability can also be defined as the maintenance of a certain system at a certain level without depleting the available resources and avoiding the fear of system breakage. We can also explain sustainability in terms of the reliability and continuity of a system.

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

The University of California, Los Angeles (UCLA), Sustainability Committee Charter defined sustainability as the following: "the integration of environmental health, social equity and economic vitality in order to create thriving, healthy, diverse and resilient communities for this generation and generations to come. The practice of sustainability recognizes how these issues are interconnected and requires a systems approach and an acknowledgement of complexity" [12].

In the scenario of sustainable development, sustainable education (SE) is explained in many ways. Australian researcher, Reynolds, in 2009 [13], introduced sustainable education in terms of "sustainability quotients" that can be applied to many forms of sustainability, and which point to the balance between the availability of resources and consumption. According to Reynolds, education as a social institution has the responsibility to make a meaningful contribution to ensuring sustainability at local, societal, and international levels. According to another study, sustainable education (SE) comprises four descriptors [14], as follows: Sustaining: It helps to sustain people, communities, and ecosystems; Tenable: It

provides equity, integrity, justice, and inclusiveness; Healthy: It nurtures systems, leading to healthy life styles; Durable: It is lasting and affordable so that the systems are not interrupted and are available to all.

Sustainable education plays an important role in society by empowering learners with responsible social and economical thinking. The 2018 UNESCO report emphasized the importance of education for sustainable development, and called for reforms in educational systems for all countries to transform education systems, focusing on innovative pedagogies, characterized by technology-driven, efficient, and intelligent learning environments, available to all with equity, justice, and equality. UNESCO has asserted sustainable education for sustainable development (environmental, social, and economical) as a key target to achieve before 2030 [15].

3.3. Main Features of a Sustainable Smart School

What features characterize a sustainable smart school? This is an important question, and so far, no perfect definition or benchmark has been set. However, on the basis of recent research, we can say that a very basic smart school can be a school which offers its learners computers, tablets, multimedia screens, projectors, and a free internet availability, in a reliable and sustainable way [10]. Reliability here suggests that applications should be secure and available without any service breakdown, and sustainability can be achieved when the application is secure, easily available, cost effective, and environmentally friendly.

A school can enhance its smart features by embracing advanced devices and technologies, such as sensors, cameras, smart and interactive white boards, virtual reality, augmented reality tools and applications, interactive learning games and learning environments, and technology-based assessment and feedback tools in sustainable ways. Therefore, a school which comprises secure and reliable ICT infrastructure, technology-driven physical and virtual classrooms, sustainable resource management systems, and advanced pedagogies, with personalized learning management systems (LMS), can be termed as a smart school [10].

Similarly, when we talk about e-learning, a virtual classroom set up comes in our mind, which utilizes distance learning. E-schools provide learning online, offline, or in virtual classrooms, where the student can learn at home without going into campus. This kind of virtual or distance learning education has so many advantages in terms of providing education to far-removed areas as well. In a COVID-19—and post-COVID-19—era, the world has experienced the power and convenience of distance learning. Therefore, a school capable of providing education online to those students who live in far-away places is a smart school. Distance learning is cheaper and more convenient than travelling every day, or building a physical school setup in far-removed areas.

We suggest that a smart school concept, driven by ICT and modern technologies, would help in achieving the United Nation's goals for sustainable development. United Nation has 17 goals for sustainable development as shown in Figure 1 [4]. By applying a small school concept, the goal for quality education (Goal 4), the goal for reducing discrimination (Goal 10), and the goal for sustainable societies (Goal 11) can be achieved on a wider spectrum [4]. Sustainable development Goal 4 [4], as explained by the United Nations, is to bring inclusion and provide quality education for all without any inequality. Sustainability garners the idea of developing the masses, not only for facing present challenges, but also for nurturing the ability of future generations to address future challenges and meet their own needs. Educational progress, enabled by advanced technologies, seems to pave the way to sustainability. We need a quality of education which would make our present better and our future brighter. Therefore, smart schools, enabled with advanced technologies, utilizing information and communication technology, will produce a skilled future workforce and a quality education for sustainable development. We summed up main features of Smart and Sustainable School at Figure 2.

Figure 1. UN sustainable development goals.

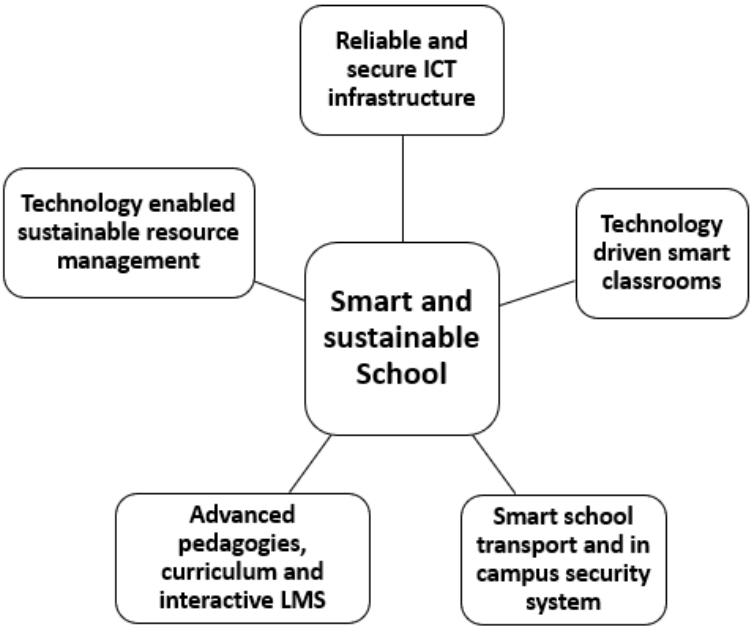

Figure 2. Smart and sustainable school.

4. Internet of Things: A Brief Introduction

Kevin Ashton, the co-founder of the Auto-ID Center, first introduced the term Internet of Things (IoT) in 1999 [16]. Later, International Telecommunications Union defined IoT as the following: "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 Internet of Things is a technology which gathers information in the form of data and transmits it to other devices, connected through internet. In this way, IoT interacts with its environment in close connection with other connected devices. A "thing" in IoT refers to a thing that should be capable of gathering and transmitting data to other connected devices. Multiple advanced technologies work as enablers of Internet of Things. For example, wireless communication and artificial intelligence are the key enablers technologies for the Internet of Things. In order to deliver IoT services, IoT works through the combination of different advanced technologies. Things in the Internet of Things do not include only electronic equipment, but also includes things such as art items, eatables, craft items, sports items, costumes, and garments [18]. IoT assures fast communication by collecting and transferring data, interacting with other devices, and receiving and transmitting information.

IoT Architecture

The architecture of IoT comprises of four layers, as shown in Figure 3. The first layer works as the physical layer. Sensors, wearable devices, actuators, and radio frequency identification tags (RFID) make up the physical layer. Therefore, we can say that the physical layer is made up of data collecting devices. Actuators are devices converting energy into motion. Basically, actuators are the motion producers. Motion can be linear, rotatory, or oscillatory [19].

Next to the physical layer is the network layer. The network layer acts as the backbone layer, which may constitute of wireless networks (3G, 4G, 5G), satellite networks, optical fibre networks, an ethernet network, or a cloud network. The network layer enables various functions, such as mobility management, accounting for IoT terminals, and the authentication and authorization of IoT applications [20].

After the network layer comes the software layer, commonly known as the data processing layer. The software layer behaves as a data processing engine. This layer consists of databases, data processing units, and high-power data processing servers to process the collected data. Therefore, the software layer enables the working by ensuring communication protocol for the data communication and management.

The last layer of an IoT architecture is the application layer. The application layer utilizes smart devices to make machine-to-machine (M-M) and machine-to-human (M-H) interactions possible. The application layer acts as an interface between the infrastructure and third party applications.

An Internet of Things system is characterized by three main features: (1) comprehensive perception, (2) reliable transmission, and (3) intelligent processing.

The Internet of Things has a vast range of applications, from smart industry to smart city concepts, which encapsulate smart health, smart commerce, smart education, and smart transport systems [20].

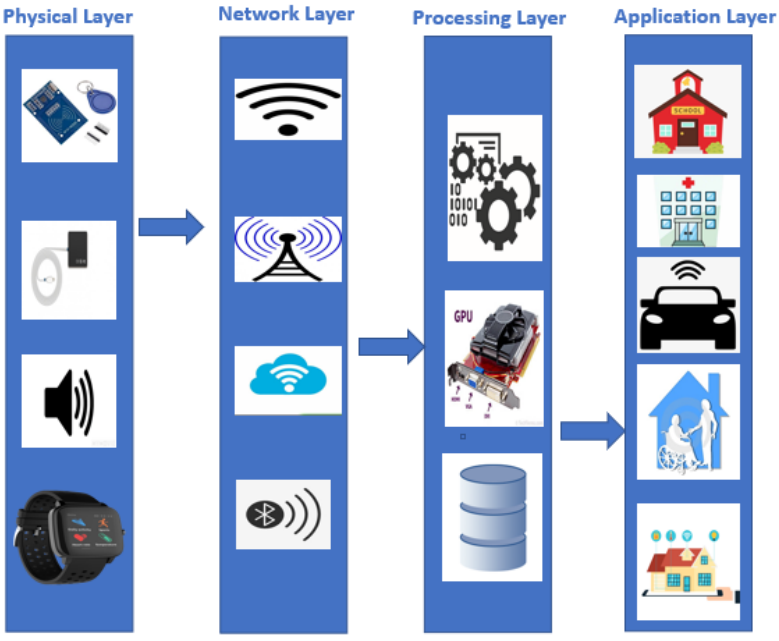

Figure 3. IoT architecture.

5. IoT as an Enabler for Sustainable and Smart Education

In this section, we explain the application of IoT from three different perspectives, i.e., from the school management perspective, from the teacher perspective, and from the learner perspective. The conceptualized IoT-driven Samrt School is shown in the Figure 4.

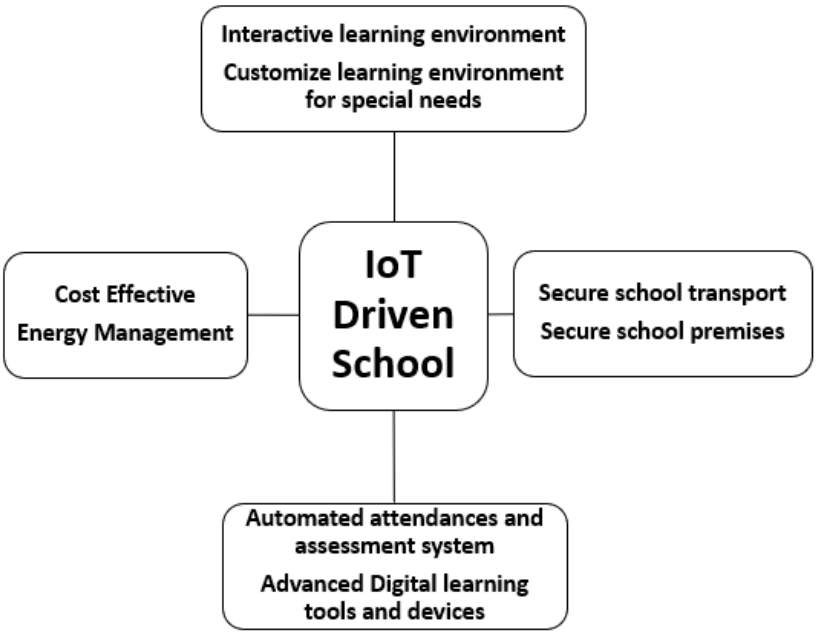

Figure 4. IoT-driven smart school.

5.1. IoT for Smart School Management

- Energy management: In the interests of sustainability, energy management demands interconnectivity and interoperability. Educational organizations could save millions of dollars using smart energy management. IoT sensors in school premises allow utility of only on demand energy and avoid unnecessary use of energy as in case of electricity. In this way, educational organizations can not only minimize their cost per unit of electricity but also their carbon footprint. An IoT-based communication framework can thus provide energy consumption information to the management system. An IoT-based energy-management platform has been developed to provide smart energy management for schools [21]; therefore, it provides a system based on demand resource energy management (DR). Another noteworthy solution for smart school building management is presented in [22], where a low-cost solution is designed for implementing energy consumption and environmental monitoring using an open-source IoT infrastructure. The solution is installed in many school buildings in Germany.
- On-campus security: School premises security is a challenge, especially in cases of large institutions. Most school buildings have insufficiently secured infrastructure. Therefore, it is almost impossible to detect incidents, such as physical abuse, fire, theft, or sexual abuse, on campuses. School management can enhance their in campus security by using real-time cameras in combination with devices. In this way, school management can reach the place of the incident quickly and initiate an action plan immediately. IoT-based security systems comprise sensing technologies, sensitive cameras, advanced cellular technologies, wireless communication, and cloud-based networks [23].
- Student monitoring system: In another work, researchers developed an IoT-based student monitoring system which utilizes Bluetooth low-energy technology (BLE) cards along with IP-based, closed-circuit television (CCTV) system. Here, the beacon chips are used for fingerprinting technology to determine the position of the object and face recognition is used to identify the student. In this way, it would be easier to monitor and identify the students carrying the BLE cards [24].
- Management of students requiring extra support: Facilitating learners with special needs is a challenge for education providers. Learners with physical and mental disabilities require holistic solutions to help them in learning. IoT has the ability to develop learner-

friendly personalized learning environments. Recent research work has presented the scope of IoT for students with special needs [25–27]. A useful example is that of gloves connected with sensors and a tablet for generating speech, which can help a deaf and mute learner for in class communication and interaction. Screen readers are one of the learning technologies which help in text-to-speech recognition for visually impaired students. Other features of screen readers include the following: on-screen keyboards, which help learners with mobility impairments to type; screen magnifiers, which enlarge screen content; and on-screen alerts, which send visual messages to assist deaf or hearing-impaired learners [28]. The research in [29] presents a wearable IoT device for early-stage detection of autism and management of related data.

- Smart transport for schools: School management can leverage IoT for the provision of secure transport for its learners. An IoT-based vehicle-monitoring system is presented in [30]. The presented idea explains a mechanism comprising a cellular device application and a microcontroller. Global positioning system (GPS) is used to find the position of the school transport using a cellular device. The mechanism uses an alcohol sensor and a panic switch for the security of the students. The real-time status of the vehicle can be observed by parents and school managers. Another proposed IoT-based bus-tracking system introduces a tracking website and an android application for the school administration, parents, and drivers of the buses to track the school transport [31].
- Student health monitoring system: A learner's health influences their educational performance. If a student is suffering from health-related problems, it would be extremely hard for them to focus on their studies, and thus their academic performance will decline. IoT in this case plays a vital role. IoT sensors gather health-related data through wearable devices. The collected data is then processed and gives precise measurements of student's health parameters. Research in [32] proposed a students health monitoring system presents an ambient intelligence-assisted health monitoring system (AmIHMS) based on IoT devices. Researchers in [33] suggested a cloud-centric IoT-based health monitoring framework. Research work in [34] presents an emotion detection system using long short-term memory (LSTM) and physiological signals. Researchers focused on distance learning in the pandemic era have presented an IoT-based framework for healthcare. A data-driven air quality prediction system in learning institutions is proposed in [35].

5.2. IoT for Teachers

- Autonomous attendance system: Taking attendance of each student is a strenuous daily task for educators. The main task of teachers is to teach and facilitate learners in learning. Biometric attendance system provides an automatic attendance system where each student has an ID card with a barcode to identify the student. This system is connected to face recognition, so that each student is recognised as well. Both teachers and parents will be aware of the presence or absence of the student [36–38].
- Advanced pedagogies: Learning spaces are not limited to physical classrooms these days. Now, learning is happening in physical modes, online modes, and hybrid modes. Classrooms can be real or virtual. Mobile learning, e-learning, online learning, digital learning, and distance learning are different names for the same concept. In that scenario, teachers need new pedagogies that support digital learning environments. For teachers, its vital to meaningfully use the advanced concepts and pedagogies for learning facilitation and teaching. The flipped classroom is a good example, where the teacher facilitates the students. Here, the flipped classroom worked as an IoT element during a computer network course [39].
- Assessment, evaluation, and feedback system: IoT can be used as an embedded technology to assess, evaluate, and provide feedback to students. Teachers can use such automated assessment tools for quick and easy working with in-depth insight into student performances. Research work presented in [40] proposed a framework for student interactions using attention scoring assessment in e-learning. Another

study proposed a real-time data mining approach based on IoT for students assessment [41]. Research work in [42] proposed student's engagement assessment based on IoT designed with Raspberry pie.

- IoT-based STEM education: IoT devices can be used in STEM (Science, technology, engineering, and mathematics) classes to have hands-on experiments and learning experience. Moreover, the learners can analyse the data collected through sensors or devices. Students can use IoT kits for design-based learning and can develop design thinking, which is one of the STEM skills [43]. IoT tools can be used in physics education and performing laboratory experiments [44]. A research study in [45] proposed methods to integrate IoT in STEM learning. Multimodal data collected through IoT devices can be used for developing analytical skills [46]. Research work in [47] shows IoT-based smart learning environments help learners to develop critical thinking and problem solving skills.

5.3. IoT for Students

- Distance learning: Distance learning has emerged as a solution in the pandemic era, when contact learning was impossible. Distance learning or online learning can be enhanced effectively by IoT [48]. IoT tools can benefit distance learning and help in uplifting student performance and efficiency by up to 20 percent, as reported in [49]. IoT sensors measured the brain activity during learning sessions and recorded the feedback. In this research [49], IoT sensors measured level of tiredness and keep brain active by sending signals.
- Enhanced productivity and interaction: Smartphone-based online classes, virtual classes, or e-classes develop more interactivity in students. This interaction-based learning develops students' interest in being involved in different tasks and participating actively in the feedback and assessment processes. Therefore, IoT-based learning environments enhance students productivity and interaction. For example, e-books with barcodes help students to read in an interactive environment. Scanmaker is an IoT device which can quickly scan editable text from books, papers, and other documents directly into a phone, tablet, or computer. The device has the ability to translate text in 40 languages [50].
- Customized learning environments: Customized digital learning environments are targeted to personal needs of the learner. Blackboard [51] is a digital learning environment, which has emerged as a convenient online learning solution for teachers and students. Blackboard is a virtual classroom technology which facilitates learning with enhanced collaboration, using an interactive learning management system (LMS). Such customized digital learning environments keep parents and students updated with daily school schedule, student grades, events, school news, and the attendance of the student. Additionally, IoT wearable technology provides the development of seamless learning. IoT wearable technologies can integrate the user location information, exercise log, and social media interaction into the learning and tailor the learning environment person-to-person in a personalized way. A good example is the IoT-ready platform from the MaTHiSiS H2020 EU project [52]. IoT sensing devices are used to capture the affect of learners during their interaction with learning material, which is in the form of games. This IoT platform utilised mobile devices, such as smart mobile phones and tablets, and robots for interaction [52]. The wearable IoT devices gather data from the learners and then, after processing the data, help in customising the learning environment according to the needs of the learner.
- School and home management: IoT can be used as a school and home management tool for students and parents. IoT-enabled smart school bag is one of the examples for home and school management. The research in [53] proposed a smart bag designed with IoT for students, which provides them with a quick timetable management tool and provides alerts for parents with notifications about any missed books or other school-related items which should be in the bag.

6. Challenges in IoT Adaptation in Education

Although application of IoT in education has tremendous benefits, there are many challenges posed by IoT adaptation in education [54]. This section aims to discuss bottlenecks in way of IoT applications in education.

6.1. Security and Privacy

We all know that there is a greater threat of cyberattacks when we have systems connected to the internet. The school system can be under direct threat if any of its system attacked, either by students or outsiders. The institutions can be made nonfunctional by such attempts. There can be a case of internet failure, which can paralyse the whole school system. Another great concern is data theft. Because a large amount of data would be collected by IoT devices, if such data is been stolen, then this poses a huge security threat. Among other security and privacy challenges are integrity-related issues, end-to-end security, authentication, and data confidentiality [55]. The IoT application in educational settings can be applied only when they are secure and reliable. IoT tools and applications gather huge data through devices such as RIFD, and technologies, such as NFC, 4G, and 5G. Therefore, data security is a great challenge. We need to think of the answers for the questions which arise in this context; for example, the following: who owns the data and who will benefit from it? Therefore, data management, control, and security is of the utmost priority. Data confidentiality and authenticity is another important factor. Data collected should be safe and can only be available to authenticated users either machines or humans. Data should be managed safely, and a secure and reliable system is required, so that there should not be any data breach, tampering, or theft occurring during data collection and data processing.

6.2. Scalability and Reliability

In the education sector, scalability is required for IoT applications. IoT collects huge data, so data analysis is the key to seek deep insight into the collected data. That is why data scalability is a challenge in IoT adaptation in educational settings. Research work in [56] discussed scalability, and proposed a social recommender system based on parallel computing and Hadoop, which provides students with customized learning content on the basis of large data analysis. Research work [57] proposed a secret sharing scheme for secured and scalable IoT systems. This research also discussed that the reliability and scalability of IoT applications can be achieved by deploying distributed IoT infrastructure.

IoT-based solutions should be sustainable and should be provided equally to all. Therefore, it should be accessible and available to its users without any delay. Schools and educational institutions should have enough money to acquire these services/applications so that their systems would be running in a sustainable way.

6.3. Dehumanization and Ethical Concerns

Dehumanization, in this context, refers to minimizing the role of humans. Dehumanization arises when we have autonomous systems with minimal human intervention. Dehumanization is one main issue which would arise when systems will work on their own, and there will be less human involvement, thus shifting control and power to the service providers [58]. Advanced technologies have great role to play in our daily lives, but concerns related to dehumanization and ethics should be taken into account. There should be an operating protocol for services and applications based on IoT.

User awareness is a crucial factor when it comes to the use of advanced technologies, tools, and devices. Customers/users must be educated on how to use internet technologies safely and how they can protect themselves from different kinds of cyber threats. It is a great responsibility of global governments, before rolling out any new technology, to organise mass awareness and education about those technologies, so that the users are well aware of all the aspects of a certain technology and can benefit from it in the safest way.

7. Discussion

With the advancements in technology, the world around us has changed a lot and it will keep on changing. Along with these advancements, on the one hand we have benefits, and on the other hand we have challenges. Education is one of the fields which is continuously reforming and evolving. The COVID-19 era has turned conventional educational means into digital means.

Similarly, the fourth industrial revolution is heading towards more advanced and digital technologies, which will demand a skilled workforce. The future workforce needs 21st century skills to meet the challenges of the future. For economical development, countries will require such a skilled workforce. Therefore, educational systems which can produce a skilled workforce are required. We argue that a sustainable smart education system can develop this future workforce. We need education which takes into account the economic, social, and environmental factors of sustainable development. In our point of view, a technology-driven education system which enhances sustainability in terms sustenance, equity, equality, justice, and quality is a sustainable smart education, and can deliver the skilled workforce of the future.

Emerging technologies are playing a vital role in the educational field. We focused on the Internet of Things in our research work. We presented an overview of how the Internet of Things can enable sustainable smart schools and we identified the challenges. We emphasize the utility of technology with sustainability. If a technology is expensive, unhealthy, or environment unfriendly, then its no longer sustainable. We argue for the application of technology which holds sustainability as a priority.

In our research work, we showcased that the Internet of Things is cutting-edge technology for educational settings. We discussed the ways in which the Internet of Things can be used in educational settings from the perspectives of school managers, teachers, and learners. IoT sensor technology plays a role in solving many problems. The Internet of Things can provide school management with energy management solutions, school transport management, student health management, on-campus security, and student monitoring systems. In all such applications, IoT makes use of sensors, data collection devices, cameras, cloud computing, and machine learning. From the perspective of teachers, IoT can play a key role in managing student attendances, assessment and feedback systems, STEM classes, smart teaching environments, and interactive tools for teaching. From the perspective of students, IoT can enable smart learning environments, personalized learning management systems, smart devices for students with special needs, and interactive and collaborative tools for immersive learning, both on the campus and outside of the campus. There is more research needed to explore the capabilities of IoT applications in schools. Similarly, more work is needed to discover sustainable methods of technology integration.

The present paper presents a view for our readers and educators which presents ways in which IoT can enable smart education. IoT applications have challenges also. The main challenges in IoT applications in educational settings are security and privacy, scalability and reliability, and dehumanization. We can make IoT solutions more sustainable by overcoming these challenges.

Similarly, more work is needed to discover sustainable methods of technology integration. Quality education with equity and inclusion is one of the United Nations' sustainable development goals. Therefore, there is a dire need for research bringing sustainability into technology applications. Smart education driven by technology can be sustainable if it is affordable, available, environmentally friendly, and healthy.

8. Conclusions

In the present study, we aimed to present a holistic view of the capability of the Internet of Things to enable smart school features in educational settings. In the realm of digitization, the provision of a sustainable, high-quality education is the goal. However, there are many constraints in this regard. We have summarized the focus of the recent research work on IoT as an enabler of the smart school concept. IoT is an opportunity to implement key smart

school features focusing on school management, teachers, and learners as summarised in Table 2. Education and workforce policies which develop superior talent is one of the five policies identified by the World Economic Forum [4].Therefore, for a sustainable, high-quality education, the conventional ways need to be replaced with advanced technology.

Table 2. IoT enabling smart school features.

IoT for School Management	IoT for Teachers	IoT for Learners
Energy Management	Autonomous attendance system	Distance learning
School Premises security	New Pedagogies	Virtual classrooms, distance learning
Special need management	Feedback system	Enhanced productivity
Smart school transport	Assessment and evaluation system	Enhanced interaction, learning efficiency
Health management system	STEM education	Personalized learning environments

We conclude that the Internet of Things could prove to be a paradigm shift as an enabler of sustainable smart schools. We emphasize sustainable education methods promoting smart learning environments. IoT plays a vital role to optimize the needs of educational settings. We showcased in detail how IoT could be used for smart school management, smart school teaching, and smart school learning. We also discussed challenges in the application of IoT for education and addressed the security and privacy issues related to the Internet of Things. Security, privacy, scalability, reliability, dehumanisation, and ethical issues are the major bottlenecks in IoT applications. More research is needed to explore ways of making the Internet of Things more safe and secure. In our future research, we will focus on how we can use the Internet of Things in STEM (science, technology, engineering, and mathematics) education in secondary school settings to develop critical and analytical thinking in pupils.

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