Application of Internet Of Things Technology in Inclusive Education: A Systematic Review

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ABSTRACT
The emergence of the Internet of Things technologies (IoT) today has not been fully incorporated in inclusive education to improve methodologies to benefit students and the entire education system. Internet of Things technologies is implemented in many areas outside education such as health, customer service, environmental monitoring, and smart retail. Inclusive education could address students' diversity in their learning through the provided learning environment. It is for this reason that the Internet of Things should be fully incorporated to enhance the learning process. This article reviews the application of Internet of Things technology in achieving Inclusive Education. Further, it sought to identify factors that hinder effective Inclusive Education and to explain how the Internet of Things Technology can help to foster the achievement of Inclusive Education. To achieve this, documents on IoT were analysed and it has been established that IoT enables the carrying out of remote experiments, e-learning, and smart classrooms. The challenges to the application of IoT in the provision of Inclusive Education include traditional modes of teaching and security threats.

KEYWORDS: Inclusive Education, Internet of Things, E-learning, Smart classroom

1. INTRODUCTION

The term “Internet of things” (IoT) has recently become popular to emphasise the vision of a global infrastructure that connects physical objects/things, using the Internet Protocol to allow them to communicate and share information. The term ''IoT'' was coined by Kevin Ashton in 1999 to refer to ''uniquely identifiable objects/things and their virtual representations in an internet-like structure.'' According to analyst firm Gartner, 8.4 billion ''things'' were connected to the Internet in 2017, excluding laptops, computers, tablets, and mobile phones. Because of its continuous growth, it is useful to discuss a purpose-built system within the IoT, referred to as a network of things (Kassab et al., 2020).

Internet of Things is the transformation process in numerous aspects of our daily life. IoT technologies differ from previous innovations as they are ubiquitous, and encourage solutions to be intelligent and autonomous. Advances in the IoT are a major strategic technology trend. Ubiquitous sensors and the ability to bridge the gap between the physical world and the machine world were perceived as the conceptual framework for the new learning model. The thinking behind this great paradigm shift is to embed sensors into any object and use Machine-to-

Machine (M2M) communication to connect billions of objects/devices to the current internet infrastructure (Aldowah et al., 2017).

Although IoT brings significant advantages over traditional communication technologies for ubiquitous learning, its implementation is still not widespread (Sayassatov & Cho, 2019).

With the advance of modern technology, society has been transformed into a 'mobile society. Mobile learning technologies have influenced many aspects of education, and provide a new method for instructors to deliver knowledge and motivate students to engage in various learning activities (Chung et al., 2015).

A major defining characteristic of inclusive education is response to student diversity through the deployment of learning environments and learning opportunities for all. This ensures that all learners have the potential to be an integral part of the school community and to engage actively in all facets of school life (Panesi et al., 2020).

The European Digital Strategy recently announced by the European Commission highlights digital inclusion among the key priorities for the coming years (European Commission, 2020). The Commission's efforts to ensure that everybody can contribute to and benefit from the digital economy and society reflects an inclusion-driven approach through digital technologies that centers around four main pillars: (i) advancing accessible ICT solutions (design for all), (ii) developing assistive technologies enabling people with disabilities to interact, (iii) empowering citizens' skills and digital skills to fight marginalization and social exclusion, and (iv) fostering social inclusion and participation of disadvantaged people in public, social, and economic activities (Panesi et al., 2020).

2. LITERATURE REVIEW

The Internet of Things applications are already being leveraged in diverse domains such as the medical services field, smart retail, customer service, smart homes, environmental monitoring, and industrial internet (Kassab et al., 2020). Because of their ubiquitous nature, schools and academic institutions are looking to incorporate IoT into educational activities to benefit students, instructors, and the entire educational system. IoT applications are being proposed to address a diverse range of modes, objectives, subjects, and perceptions in the education sector (Kassab et al., 2020).

IoT and Cloud computing technologies can provide solutions for smart and a sustainable campus to improve the learning methods of the students and improve the efficiency of everyday activities in the Institution. IoT in education enables students to learn new technologies that help to create new ideas and logic for social problems (J et al., 2020).

The Internet of Things provides a link to the Internet for every object with computation and communications. It is a new paradigm that provides a range of interactions and cooperation between objects or things through the internet. The rollout of things over the current Internet infrastructure promises to extend the interaction by offering applications and services that allow the interaction of the human/computer to integrate daily customization (Che et al., 2021).

The IoT is the connection of devices, other than standard ones such as computers and smartphones, to the Internet. The transformational journey of IoT has the power to change the world in such a way that people will get closer to their fully integrated and smart surroundings for better management of energy, health, transportation, and life resources. The education sector is also likely to become more impacted as schools and universities make greater use of connected devices. For example, Quick Response (QR) codes have made their way into educational textbooks. Feedback, assignments, and additional knowledge resources become easily available to students when they scan the QR codes with their smartphones. Another example is the radio-frequency identification (RFID) chips that are being used by students to tag and track physical objects to study them. In addition, IoT devices are being used by university administration and instructors to take automatic attendance using student ID cards, track equipment, and monitor lighting and security systems (Mershad & Wakim, 2018).

Another suggestion was that information written by a lecturer on a smartboard could be converted into text and provided to students on their device of choice via a Learning Management System (LMS), ensuring that students can quickly gain access to the content and assist remote learning students as well given most current video recordings of lectures. This solution demonstrates how connectivity, combined with the ability to obtain specific data, can generate a widely distributed benefit to students with disabilities (Hollier & Abou-Zahra, 2018).

A third idea discussed was the ability to use sensors to monitor the lecturer and the students to gauge interest in the class, providing feedback to the lecturer to adjust the presentation in real-time and likewise determine engagement from the students in response to the change in content delivery (Hollier & Abou-Zahra, 2018).

Regarding teachers, their roles should be more that of researcher and facilitator. This is an area for teachers to explore further as a researcher in information retrieval. To become an effective facilitator, a knowledge of lesson planning and the skills necessary to incorporate online elements into the teaching and learning process are deemed necessary (Ashraf et al., 2014).

The main recommendation is that instructional design must be customised to support student learning in specific domains. Instructional design that benefits novice students may not benefit advanced students. Novice students may experience greater difficulty

recalling prior knowledge as compared to advanced students. Design that is used to support novice students' cognitive processing may be unnecessary (and even counterproductive) for advanced students. An example is when students are provided with visual aids that include prior knowledge when learning the concepts of graphs and equations in mathematics lessons. The visual aids facilitate novice students' learning but may impede the learning of more advanced students (Chiu & Lim, 2020).

Twenty-one percent of the overall papers provided actual implementation for IoT systems, which were tested in actual educational settings. We further analyzed these systems and extracted the most common implemented scenarios, which aim to integrate IoT in education: Smart environment for supporting learning and improving the quality of education, e-learning and education management, virtual learning, teaching and management, remote laboratories, and distant E-labs, human motion capture, ubiquitous learning, distance e-teaching, and e-learning, augmented reality e-learning, wireless robotic educational platform, cyber security lab, attendance system based on IoT, and psychological health education service based on IoT (Kassab et al., 2020).

In the modern era, libraries confront significant service challenges. Some challenges are linked to information resource management which includes direct availability of information for immediate decision making. The Internet of Things (IoT) is a recent technological shift that library personnel should be aware of because it has the potential to enhance information resource management (Khan et al., 2021).

The suspension of institutions around the world in early 2020 due to the COVID-19 virus did not stop the learning process. E-learning concepts and digital technologies enable students to learn from a safe distance while continuing their educational pursuits. Currently, the Internet of Things (IoT) is one of the most rapidly increasing technologies in today's digital world; and e-learning is one of the most powerful learning methods available (Rahmani et al., 2021).

The gamification approach had the advantage of providing a playful and generalized introduction to energy awareness topics, while also allowing teachers customizing the content by uploading custom quizzes and creating their activities tailored to the actual students (education grade, interests, etc.). Nonetheless, some teachers of the high school in Prato, Italy, expressed the intention of raising the bar by asking for IoT-driven energy awareness activities that could be more easily integrated into their syllabus and more challenging for the students. We first describe the IoT Lab Kit and then we describe how it has been applied in the design of a hands-on IoT activity and the experience carried out in a high school in Italy (Mylonas et al., 2021).

IoT technologies have caused an increase in the utilisation of limited resources or raw materials where some of them have become rare or are

already rare (for instance, specific precious metals for electronics) (Nižetić et al., 2020).

2.1 Factors Hindering Effective Inclusive Education

Traditional modes of education focus largely on transmitting knowledge with very little importance given to the practical implementation in a complex socio-economic environment or questioning of knowledge by the students. Traditional education utilises a strict set of rules that identify clear differences between what is right and wrong. It imparts information but does not allow for much "out of the box" thinking. Overall, traditional education renders learning the primary mission verified by student assessments. Testing methods measure students' retention of transmitted knowledge but fail to ascertain their ability to understand and apply it. Moreover, this system of education is not adapted to individual learning, and focus is based on rigorous grading and assessment, competitive, and marked with the unequal access to quality education across the races, genders, and socioeconomic groups (Skowronek et al., 2022).

In addition to the above issues, students often come from different levels of resources and rigor that their high schools could offer, which could be overlooked without reaching out to students through special local "eco-systems" or programs to foster a connection and establish trust, to understand their hurdles and inform them of resources to succeed (Skowronek et al., 2022).

As documented in the Global Education Monitoring Report, many education systems are limited in their capacity to respond to diversity. The resulting integration of children with disabilities and children from other marginalised populations within existing systems leads to limited access to education, and only to those who can fit within its existing structures and mechanisms (Hunt, 2021).

While some of these barriers have been identified and are being addressed to varying extents, others are only partially recognised and addressed. For example, the barriers created by inflexible systems are being addressed by United Nations Educational, Scientific and Cultural Organization, International Institute for Educational Planning (UNESCO IIEP), the World Bank, United Nations Children's Fund (UNICEF), and the Global Partnership for Education (GPE) through their collective efforts to develop the Education Sector Analysis Methodological Guidelines (Hunt, 2021).

Security requirements have always been a crucial aspect of education. Given the increased communication and complexity of IoT technology, there is an increase in security-related concerns (Kassab et al., 2020).

More broadly, as more and more people especially the young ones rely upon the Internet and social media as a source of information and learning, the more important it has become that they evaluate the sources and credibility of the information they receive. This sort of

critical digital literacy is a growing educational imperative one that, we believe, is not receiving enough attention in schools (Burbules et al., 2020).

There are many challenges associated with the development and implementation of smart school systems such as cyber-attacks, user privacy, and security. Physical security of kids is one of the priority concerns starting from home to school and inside the schools. Schools have been always the main target of terrorists and other violent attacks. Most of the kidnappings have been observed during school hours. There is an alarming boost in terrorist attacks, violence, crime, and student kidnapping in schools. There are many incidents in the near past where students have been kidnapped during school hours. These are the security hazards that are linked to and motivated to design of new and smart security systems for schools. Cyber-attack is another security breach where a malicious intruder succeeds to access or control the entire school management and administration's computerised systems and compromises data used for terrorist attacks (Qureshi et al., 2021).

3. APPLICATION OF THE INTERNET OF THINGS IN INCLUSIVE EDUCATION

The table below shows the enhancement of inclusive education with the Internet of Things Technology.

Table 1: Main Categories and Features of Systems for Learning

Category	Features	Tools/Technology Used
E-Learning	Computer-based training	Internet and Intranet
M-learning	Flexibility of location	Mobile and portable
U-learning	Pervasive education	Mobile devices and stable PC
Smart learning	Personalized content and efficiency	Smart devices as SNS service
Smart classroom	Smart education environment and seamless	Internet, Camera, PDA, PC, and sensors
Computer-based learning	Recommendation for learners	Computer-based system

Source: Kassab et al., 2020

With the Internet of Things, it is possible to execute a remote experiment enhanced by learning management systems (LMS). Students can run a lab experiment at any time from any place, without missing any of the experience that is gained by being physically present at the experiment location (Kassab et al., 2020).

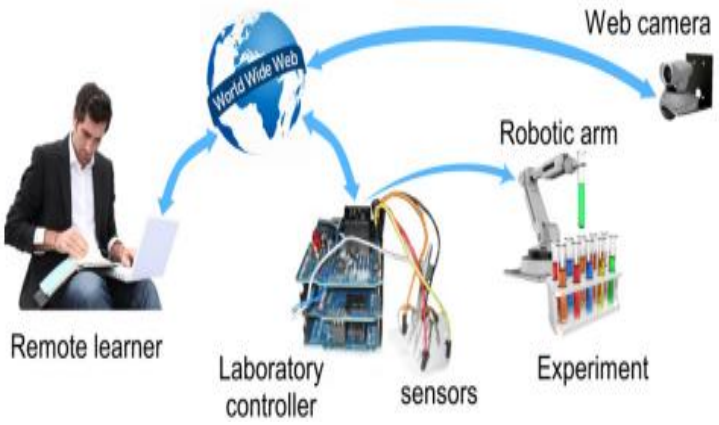

Figure 1: Components of Remote Experimentation System
Source: Kassab et al., 2020

Mobile devices such as laptops, personal digital assistants, and mobile phones have also become learning tools with great potential in both classrooms and outdoor learning. Although there have been qualitative analyses of the use of mobile devices in education, systematic quantitative analyses of the effects of mobile-integrated education are lacking (Sung et al., 2016).

As IoT continues to grow in its consumer acceptance, for people with disabilities, IoT offers far more than the sum of its parts. Given that IoT can provide aid based on human limitations, it can be argued that IoT is, in principle, a form of Assistive Technology (AT), providing support to information in a similar way to how a screen reader provides content to a person who is blind (Hollier & Abou-Zahra, 2018).

Much of the potential power of IoT for people with disabilities is concerning its always-on, real-time connectivity, which can ensure that people can quickly and easily obtain assistance and support. This can result in another avenue to achieving a good quality of life and facilitating participation, both socially and economically. With this in mind, it can be argued that the potential benefits of connected things are limitless, especially for persons with disabilities (Hollier & Abou-Zahra, 2018).

4. CONCLUSION

It is clear from the above explanations that the Internet of Things applies to Inclusive Education. This includes report experiments, e-learning, and having a smart classroom. IoT has also been seen as assistive technology for visually impaired persons. However, they are factors that hinder the application of IoT to achieve Inclusive Education which are traditional modes of teaching and security threats.

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