Contents lists available at https://digitalcommons.aaru.edu.jo/huj_nas/.

Hadhramout University Journal of Natural & Applied Science

Article

Digital Object Identifier:
Received 19 August 2025
Accepted 2 December 2025
Available online 25 January 2026

Exploring Perspectives on Opportunities and Challenges: An Investigation into the Integration of the Internet of Things (IoT) in Educational Environments

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Abstract: The rapid integration of Internet of Things (IoT) technologies in educational settings has sparked considerable interest due to its potential to revolutionize traditional teaching methods. This paper presents a comprehensive survey, exploring the opportunities and challenges connected with the incorporation of IoT in education. By analyzing existing literature, this study aims to shed light on the transformative impact of IoT on learning environments and pedagogical practices. The IoT represents one of the most formidable platforms that signifies the interconnection of physical objects in the foreseeable future. A multitude of comprehensive evaluation studies have been undertaken to examine and consolidate the utilization of IoT and its applications across various domains. Thus far, the research landscape has overlooked the provision of a holistic review study concerning the implementation of IoT in the realm of education. Hence, the principal objective of this study is to elucidate the recent advancements in the integration of IoT applications in the field of education and delineate numerous opportunities and challenges for future endeavours. In a more focused context, this study review succinctly encapsulates the potential of IoT adoption in education, encompassing training in medical education and, vocational education, Green IoT in education, and wearable technologies in educational settings.

Keywords:Internet of Things (IoT); Education; Opportunities; Challenges

1. Introduction

"Internet of Things (IoT)" the term was originally devised by Kevin Ashton in 1999. He introduced IoT as a thought wherein pervasive sensors are employed to establish a connection between the physical world and the Internet [1]. IoT is widely regarded as the pivotal evolution towards a digital society. It plays a crucial role in enhancing the efficacy and bolstering the competitive edge of both commercial and academic institutions [2]. The ongoing digital alteration, the prevalent tendency of mechanization, and the seamless data among diverse exchange retailers all align with the principles of "Industry 4.0," which have IoT at their core [3]. In a current study directed by Assante et al. [4], the significance of IoT in European Small and Medium-sized Enterprises (SMEs) is underscored, as it becomes pivotal for their survival and competitiveness, even in comparison to non-European enterprises. The study underscores the vital need for training and providing to employees to effectively harness IoT technologies. In today's world, numerous cities globally are embarking on a transformative journey to become smart cities.

Simultaneously, academic institutions worldwide are integrating IoT into their curricula.

Consequently, there is a growing demand for educating engineers in IoT technology. Many higher education institutions are responding to this need by introducing elective courses related to IoT for undergraduate students majoring in Computer Science and Engineering [5]. These courses aim to equip students with the knowledge and skills necessary to contribute to the development of smart cities. Smart cities encompass a wide array of innovations, such as smart waste management, intelligent parking solutions, advanced traffic management, efficient lighting systems, environmental monitoring, intelligent irrigation techniques, and sophisticated intrusion detection systems for homes and financial institutions.

Moreover, social networks have emerged as one of the most rapidly adopted technologies, making their mark across various sectors [6,7]. They integrate seamlessly with numerous technologies, and the IoT is no exception. The context of social networks, IoT, and the three realms of the internet are harmoniously amalgamated to transform the physical world into a virtual one [8]. The "Social Internet of Things (SIoT)" represents a transformative paradigm that exhibits the potential to enable the efficient and effective facilitation of novel applications and networking services within the realm of the Internet of Things (IoT). SIoT, as a paradigm, strives to incorporate social interactions and relationships to enhance the functionalities and capabilities of IoT systems [9]. Consequently, By integrating social elements into the design and implementation of IoT technologies, SIoT enables the creation of innovative applications and services with miscellaneous needs and preferences of users. This paradigm emphasizes the significance of connectivity, collaboration, and communication among IoT devices, users, and the surrounding social environment [10]. Higher education institutions worldwide have embarked on the adoption of IoT technologies, aiming to usher in significant transformations in various facets of their operations, including teaching, learning, management, training, and infrastructure [11]. IoT's reach spans multiple disciplines, encompassing engineering, information science, computer science, social sciences, and mathematical sciences [12]. Consequently, the major purpose of this research work is to fill this void by providing a detailed examination of the opportunities and challenges presented by IoT in educational contexts.

This study aims to provide a comprehensive analysis of IoT in education, cracking bright on its potential benefits and challenges, and paving the way for further research in this important and evolving field. The proliferation of IoT devices and applications has permeated various sectors, including education. The emergence of smart classrooms, wearable devices, and interactive learning systems has opened new avenues for enhancing the educational experience. This survey delves into the myriad opportunities offered by IoT technology, as well as the challenges faced in its implementation within educational contexts.

This survey encompasses the following key areas: Literature review in Section 2 which includes an overview of review studies on IoT-based, the general utilization of IoT in educational settings, the impact of IoT on medical training and education, IoT's role in vocational training and education, the development of Green IoT in educational applications, exploring the integration of IoT and, wearable technologies in educational settings. A thorough discussion of findings and implications (Section 3), A conclusive summary, and directions for future research (Sections 4&5).

2. Literature Review

2.1 IoT Review Studies

Numerous studies have been conducted to comprehensively investigate the IoT concept within various domains. In particular, the following studies have made valuable contributions. Ammar et al. [13] undertook an extensive analysis focusing on IoT framework security. This study offers an in-depth evaluation of the hardware, smart applications, architecture, and security features of the frameworks under scrutiny. Colakovi and Hadžiali [14] conducted a review study that provides a meticulous overview of pending issues and challenges in IoT research. This work places significant emphasis on the technological dimension. Bertin et al. [15] presented a comprehensive review study highlighting various access control models, architectures, and protocols designed for IoT systems. Cui et al. [16] performed a study to assess the application of machine learning in the IoT domain. This research reports recent advancements in machine learning methods across various IoT applications. Carcary et al. [17] carried out a systematic review study aimed at understanding IoT adoption. This was achieved by examining factors based on the Unified Theory of Acceptance and Use of Technology (UTAUT) at the organizational level. Wang et al. [18] executed a study focusing on Blockchain technologies, with a particular emphasis on their applications within the IoT framework. These studies collectively contribute to a broader comprehension of IoT's multidisciplinary applications and its ever-evolving landscape. In the realm of education, a study by Zhamanov et al. [19] centered on reviewing the IoT smart campus model and its practical applications. This examination encompassed a range of applications deployed within the university campus, including IoT-based flipped classrooms, the IoT-based entrance system, student feedback mechanisms, IoT-based orangery initiatives, and IoT heating systems. Concurrently, Dominguez and Ochoa [20] conducted a comprehensive survey addressing the utilization of IoT and smart objects within educational contexts. The primary objective of their study was to investigate the potential advantages of integrating IoT in education, while also probing into the principal challenges hindering its widespread adoption. While a substantial body of review studies has been dedicated to IoT applications across diverse domains, the relationship between IoT applications and the field of education remains relatively unclear.

2.2 IoT Through an Educational Lens

The landscape of education has undergone a significant transformation, shifting from the traditional model to one rooted in digital technologies, driven by the influence of information and communication technologies [37,13,27]. In this context, the IoT stands out as a pivotal paradigm that

contributes to this evolution. This section is dedicated to reviewing studies that delve into the general applications of IoT within the educational sphere. Jasim et al. [23], for instance, conducted an in-depth study of the advantages of employing advanced educational IoT-based applications. The study takes a granular approach, elucidating the merits and demerits of mobile education. Within this examination, an innovative mobile education architecture is proposed, leveraging cloud technology to confer adaptability and scalability to the educational process. In parallel, a distinct endeavor saw the creation and development of a mobile learning tool on IoT-based education, primarily designed for employment in northern primary schools of Thailand [24]. This initiative aimed to provide an effective teaching platform, making judicious use of a considerable number of tablet computers. Furthermore, Sarıtaş [25] an examination of the intricate relationships between IoT, cloud computing, and the emerging learning theory called "connectivity" reveals the necessity for educational institutions to develop a holistic strategy. This strategy should encompass various aspects such as curricula, professional development of teaching staff, philosophy-based educational staff, legal and political considerations, and data security, as well as infrastructure and resources transformation. The purpose of such a strategy is to efficiently discourse the multifaceted tests present in the field of teaching. To tackle the challenge of integrating numerous IoT-related courses into STEM education, He et al. [26] propose a transformative approach. They recommend the blending of IoT-based learning frameworks with corresponding laboratory projects within STEM core courses. Figure 1 below provides a visual representation of the comprehensive three-dimensional architecture of IoT, highlighting its versatile and interconnected nature.

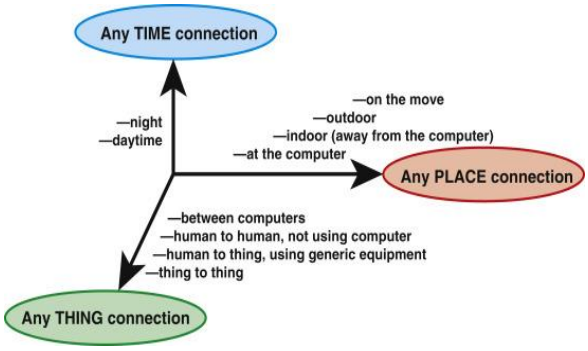

Figure 1. IoT Any THING 3-Dimensions Architecture

The design of this framework is outlined in their study, along with the provision of effective learning methods to address the associated challenges. Furthermore, the study by Tsaramirsis et al. [27] conducted a case study involving the implementation of this IoT-based learning framework in a software engineering course focusing on system analysis and design. The results of the study indicate that students generally perceive this framework positively. The IoT exhibits a high level of adaptability and applicability across various academic disciplines, thus revolutionizing the approach to research and learning.

2.3 IoT Through a Medical Education and Training Lens

Ahmad et al. [28] have introduced a system aimed at enhancing the learning experiences of students by enabling interactions with physical objects pertinent to specific academic subjects. Mechanical engineering, computer engineering, and medicine are the academic programs that need to necessitate student engagement with tangible objects [28, 29]. Testing on the operational prototype demonstrated the system's efficacy in assisting instructors during the teaching process and in improving students' academic performance. Over the past two decades, the use of case-based learning (CBL) in medical education has been somewhat limited. However, CBL has recently garnered recognition as an effective teaching method, especially when integrated with flipped learning and the Internet of Things (IoT) [31]. IoT applications demonstrate their suitability for educational purposes, as depicted in figure 2, by providing innovative solutions tailored to enhance the learning experience through a lens perspective focused on education. The integration of these three approaches—CBL, IoT, and flipped learning—has been shown to significantly enhance the educational outcomes of medical students [32].

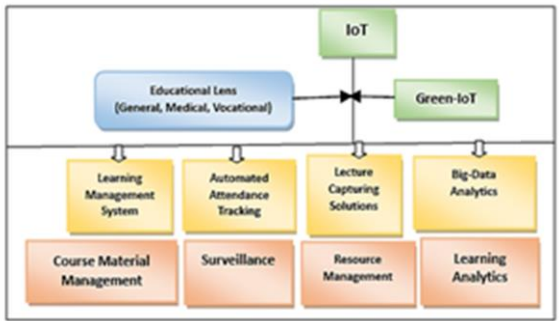

Figure 2. IoT Application for Educational Lens Perspective

2.4 IoT Through a Vocational Education and Training Lens

In vocational institutions, the assemblage of instruments within IoT proves advantageous for both students and educators. There is a compelling argument in favor of the incorporation of IoT into vocational education and training to improve the teaching and learning processes. The integration of IoT into vocational training offers various benefits, including the production of well-qualified students, the creation of safer educational environments, the promotion of self-directed learning, the efficient utilization of educational resources, and the enhancement of the learning experience [33].

2.5 Green IoT Through an Education Lens

In the contemporary landscape, Green Information Technology (Green-IT) is increasing interest. The primary aim of Green-IT is to decrease the consumption of various computing devices electrical power, computer peripherals, and equipment, thereby achieving both economic and environmental benefits. As discussed by Singh and Hota [34], Green IT encompasses environmentally responsible IT practices. This involves the scrutiny of servers of computers, and their associated sub-type of systems—such as displays, imprinters, storing diplomacies, and schmoozing and announcement structures—with a focus on improving efficiency while minimizing or eliminating their

environmental impact. Singh and Hota detail several strategies fundamental to the transition towards Green IT. These strategies include the implementation of eco-friendly design, screensaver, management features of power system, system shutdowns during inactivity, the development of data centers with green-tech features, and virtualization vigor preservation measures. They argue that adopting Green IT practices results in reduced power consumption, cost savings, lower carbon emissions, enhanced system performance, more efficient resource utilization, and the conservation of physical space. In the realm of education, Raimundo and Rosário [35] showed a comprehensive study assessment to assess Green-tec IoT from the practitioners of perspectives and academicians from an educational fact of view, revealing a substantial convergence of views. The implementation of Green IT has gained significant traction as a powerful and meaningful approach. Both practitioner and academic communities have recognized the pivotal role of Green IT in fostering environmental sustainability. Almufarreh and Arshad [36] investigated the critical factors influencing the successful implementation of Green Information and Communication Technology (ICT) in educational institutions. Their research identified several essential factors, including the optimal utilization of resources, stakeholder involvement, the integration of energy renewable sources, energy preservation practices, official strategy considerations, the role of Green ICT committees, and the impact of relevant legislation. Moreover, Bayani et al. [37] examined the potential applications of the Green IoT in engineering instruction, focusing on the assistances and challenges associated with integrating Green IoT into smart classrooms. Their model leverages green communication technology, computing technology Green IoT, Green-smart grid systems, and various applications, positioning it as a sustainable and innovative enhancement to engineering education.

2.6 IoT Through Wearable Technologies in Education Lens

A subset of the broader Internet of Things (IoT) Wearable technologies, are rapidly acquiring admiration and are predicted to become progressively integral to our daily lives shortly. These pieces of knowledge are defined as "technological devices worn on a user's body" and include a wide range of items such as eyeglasses, wristwatches, wristbands, shoes, and even clothing. The literature identifies wearable health technologies, wearable textile technologies, and wearable consumer electronics as three main categories of wearable technologies [18, 20]. Smart glasses are leading a paradigm shift in our everyday activities among these devices. Google Glass is a notable example, which features a central processing unit, an integrated display screen, a high-definition camera, a microphone, and wireless connectivity [37]. For instructors, Google Glass clutches the probable to offer "heightened suppleness in accessing information, occasions for seamless association, and the ability to share and enrich learning experiences [39]. An example of smart glasses is Google Glass, prepared with a central processing unit, a high-definition camera, a combined demonstration screen, a microphone, and wireless connectivity [15, 18]. For educators, Google Glass offers the potential to introduce "enhanced flexibility in accessing information, opportunities for seamless collaboration, and the ability to share and enhance learning experiences [39]. In the medical domain, Google Glass technology has found applications as a teaching tool. For instance, Guia et al. [40] live-streamed surgical procedures to mobile devices through Google Glass, allowing others to observe. Furthermore, some studies have reported on telemonitoring scenarios in which instructors employed Google Glass to guide trainees wearing similar devices during medical procedures [36]. Ali and Nihad [41] highlighted the pivotal role of Google Glass's recording feature in facilitating teaching and learning. Students can use this feature to record their interactions with peers or document their activities during field trips, later leveraging this recorded material for self-evaluation and peer assessment. Educators, in turn, can record their lectures and incorporate these resources into flipped learning initiatives.

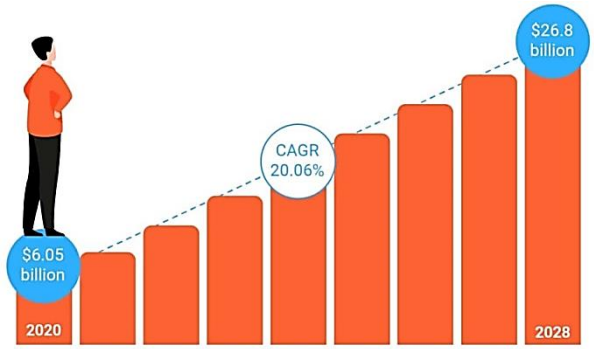

Figure 3. Global IoT in the Educational Market

3. Discussion

This study examination highlights the transformative credible education in IoT, emphasizing its numerous benefits for students and institutions. IoT enables access to educational content from any internet-connected device, enhancing learning flexibility and accessibility [42]. Moreover, educational institutions can utilize IoT to monitor and assess Educational institutions can utilize IoT to monitor and assess student progress through data from sensors and wearable devices, providing valuable insights into learning behaviors. IoT also streamlines administrative tasks, such as automatic attendance recording via RFID tags or facial recognition, and assists in identifying available study spaces and providing on-demand supplementary lessons [43]. In specialized fields like medical and vocational education, IoT enhances decision-making skills and collaborative learning, while wearable technology improves interactive learning experiences [44]. From a discussion standpoint, figure 3 sheds light on the global presence of IoT within the educational market, offering insights into its widespread adoption and impact on educational institutions worldwide.

Curriculum enhancements are necessary to include IoT courses, ensuring graduates are equipped to manage IoT projects. Institutions must also integrate IoT into their curricula, provide staff orientation sessions, offer professional development for instructors, and educate students on IoT applications [13]. Technological issues like

coverage of wireless technology, sensor battery life, and costs, need resolution to facilitate adoption. Additionally, security and privacy concerns must be addressed to ensure effective utilization. By overcoming these challenges, the sector of education can generate a technologically enriched inclusive erudition atmosphere, fully harnessing the benefits of IoT to shape the future of education [45]. Furthermore, habiliment technology enables undergraduates to monitor and document their education behaviors, thereby enhancing their collaborating learning experiences [40]. Several changes are depending on the integration of IoT in the education sector. Initially, departments of computer science and engineering must update their syllabuses to embrace IoT developments, certifying that alumnae obtain the essential assistance to accomplish numerous projects of IoT. Furthermore, educational institutions prerequisite IoT into their curricula to refine their strategies by participating, as long staff with direction conferences on the reimbursements of IoT, for instructors offering professional development plans, and refining scholars on countless applications of IoT. Third base, as IoT is immobile in its premature phases, many matters remain unsettled, such as wireless attention, costs of high sensors, and batteries with limited life. [46]. Therefore, to facilitate the adoption of IoT applications, IoT locomotive engineers and designers must discourse these encounters. Fourth, despite frequent deliberations and studies on mobile learning applications like augmented reality and learning analytics in IoT-related research, their adoption remains limited and requires further investigation [65, 50]. Fifthly, significant challenges are security and privacy concerns that hinder IoT education integration. Therefore, future exertions in emergent applications of IoT for education should arrange these influences to overwhelm barricades acknowledged in previous investigations and guarantee effective application. [48].

3.1 Challenges

Mounting concerns surrounding the security and privacy of IoT ecosystems, coupled with the challenges related to funding IT infrastructure and services, are imposing limitations on the IoT market within the education sector [49]. Some educational institutions are displaying hesitancy in incorporating IoT technologies into their classrooms due to the increasing vulnerability of the IoT ecosystem to security and privacy threats, alongside financial constraints concerning information technology services and infrastructure [50]. Market growth is also hindered by constraints associated with business operations, regulatory compliance, and legal considerations. The absence of robust IT infrastructure and, in certain instances, the lack of awareness among educational institutions about the advantages of IoT in the education sector, particularly in some developing countries, may somewhat restrain the growth of the IoT market in education [51]. This lack of awareness can lead to suboptimal use, consequently impeding market growth.

4. Conclusion

The education sector emerges as a hopeful domain for the employment of applications of the Internet of Things (IoT). This review study aims to provide a comprehensive exploration of IoT educational applications, clarifying both the challenges and prospects linked through this attempt. Numerous studies have anticipated and demonstrated the efficacy of learning frameworks based on IoT platforms, heralding a new learning paradigm that substantially enhances teaching and learning processes. Therefore, this study significantly enhances the understanding of IoT's transformative impact on education by reviewing current research on its applications and challenges, highlighting opportunities such as enhanced learning environments and improved educational management. Positive contributions include the facilitation of efficient learning processes, real-time student assessment through data collection, and effective energy management in educational settings. However, the study identifies several deficiencies, including a scarcity of empirical research on IoT's impact on student performance, insufficient integration of IoT courses in computer science curricula, and substantial security and privacy concerns. To address these issues, future efforts should prioritize conducting thorough empirical research to evaluate the educational outcomes of IoT applications, revising academic programs to incorporate relevant IoT training, and developing robust security measures to safeguard educational data.

5. Future Implications

5.1 Opportunities

Building on the conclusion, the opportunities presented by IoT in education are vast and multifaceted. IoT integration results in substantial reductions in the time and effort required to accomplish various tasks, optimizing the daily operations of educational institutions [42]. Key opportunities include the development of smart classrooms, which enhance teaching efficiency and resource management, and the use of IoT devices for real-time monitoring of energy consumption, contributing to significant cost savings [21]. Additionally, IoT enhances administrative tasks such as fee submissions and attendance recording, making these processes more streamlined and efficient. The deployment of Learning Management Systems (LMS) through IoT allows instructors to manage course syllabi and monitor student progress effectively, offering students the convenience of accessing essential information from any location at any time [49]. This capability aligns with the increasing demand for advanced technology in e-learning, further propelling the IoT market in education, which is estimated to be worth $19.0 billion by 2027 with a CAGR of 17.74 % from 2020 to 2028 [52]. Future implications involve addressing challenges such as integrating IoT training into educational curricula, developing robust security measures to protect sensitive educational data, and conducting empirical research to evaluate IoT's impact on student learning outcomes. By harnessing these opportunities and addressing identified gaps, educational institutions can significantly enhance the quality and inclusivity of education, paving the way for innovative and effective educational practices with IoT at the forefront.

Acknowledgment: The authors would like to express their gratitude to Hadhramout University for its invaluable support in facilitating this research.

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استكشاف وجهات النظر حول الفرص والتحديات: دراسة حول دمج إنترنت الأشياء في البيئات التعليمية

الملخص : أثار التكامل المتسارع لتقنيات إنترنت الأشياء (IoT) في البيئات التعليمية اهتمامًا واسعًا نظرًا لقدرته على إحداث تحول جذري في أساليب التعليم التقليدية. يقدم هذا البحث مسحًا شاملاً يستكشف الفرص والتحديات المرتبطة بإدماج إنترنت الأشياء في التعليم. ومن خلال تحليل الأدبيات الحالية، يهدف هذا البحث إلى تسليط الضوء على الأثر التحولي لإنترنت الأشياء على بيئات التعلّم والممارسات التربوية. يُعد إنترنت الأشياء واحدًا من أقوى المنصات التي تمثل ترابط الأشياء المادية في المستقبل القريب. وقد أُجريت العديد من الدراسات التقييمية الشاملة لفحص وتوثيق استخدام إنترنت الأشياء وتطبيقاته في مختلف المجالات. ومع ذلك، لا يزال المشهد البحثي يفتقر إلى دراسة مراجعة شاملة تتناول تطبيق إنترنت الأشياء في مجال التعليم. بناءً على ذلك، يتمثل الهدف الرئيس لهذه الدراسة في توضيح أحدث التطورات المتعلقة بدمج تطبيقات إنترنت الأشياء في قطاع التعليم، بالإضافة إلى تحديد الفرص والتحديات المتعددة التي يمكن أن تشكّل توجّهات الأبحاث المستقبلية. وفي سياق أكثر تحديدًا، تستعرض هذه الدراسة بإيجاز إمكانات تبنّي إنترنت الأشياء في التعليم، بما يشمل التدريب في التعليم الطبي، والتعليم المهني، وإنترنت الأشياء الأخضر في التعليم، وتقنيات الأجهزة القابلة للارتداء في البيئات التعليمية.