Vokasi Unesa Bulletin of Engineering, Technology and Applied Science (VUBETA)
https://journal.unesa.ac.id/index.php/vubeta
Vol. 1, No. 2, 2024, pp. 91~102 DOI: 10.26740/vubeta.v1i2.35886
ISSN: 3064-0768

Internet of Educational Things (IoET): An Overview

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Article Info

Article history:

Received September 1, 2024
Revised October 15, 2024
Accepted November 14, 2024

Keywords:

Internet of Educational Things
Internet of Things
Digital Learning
Internet for Education
Education

ABSTRACT

The internet has caused a paradigm shift in education towards digitalization, so that students who experience it are now referred to as digital natives. This technology has changed the orientation of learning and teaching from teacher-centered to student-centered. Specific discussion is needed regarding the use of the internet modified in such a way in learning. Internet of Educational Things (IoET) becomes an interesting discussion in this article to support the paradigm shift. This article discusses using a narrative review approach. This means that this preparation tends to be reflective and in accordance with the author's understanding. The discussion includes (1) the paradigm shift from conventional to internet-assisted digital, (2) IoET as a digital-based instructional system approach and (3) related findings. Future recommendations will be presented, especially regarding the use of IoET in the education system.

1. INTRODUCTION

The advent of computer-mediated technologies, particularly the Internet, has significantly enhanced our capacity for information dissemination and interaction. These technologies are subject to extensive public discourse, scrutiny, and regulatory measures. Given their pervasive utilization, there is an imperative need to deepen our understanding of the individual and societal factors that influence the use of computer-mediated communication (CMC) and the resultant behaviors associated with it [1]. CMC is characterized as communication that is facilitated through computer technologies, encompassing both synchronous and asynchronous forms such as electronic mail and computer conferencin. It is defined as the process by which senders encode messages in text format, which are subsequently transmitted from the sender's computer to the recipient's [2].

Functions that were once performed exclusively through cognitive processes are now facilitated by technological advancement. The necessity to retain information such as phone numbers, directions, birthdays, or medical details has diminished significantly, leading to a reduced emphasis on the accumulation of extensive knowledge for the purpose of accessing specific information. The information we seek is frequently accessible with a simple Google search, a shift that has begun to significantly transform our cognitive processes related to thinking and memory. Consequently, examining memory in isolation from the Internet would yield an incomplete understanding of how knowledge is stored, accessed, and utilized in contemporary society [3]. For a significant portion of Internet users, the World Wide Web serves as a substantial source of opportunities that contributes positively to their overall well-being [4]. According to the data, over 221 million individuals in Indonesia have accessed the internet, representing approximately 79.5% of the nation's population. The annual growth in the number of internet users in Indonesia persists, demonstrating a consistent upward trend [5]. This highlights the need for better internet service infrastructure to support the vitality of people's lives.

Currently, the predominant mode of communication on the Internet is human-to-human interactioN. However, it is anticipated that in the near future, every object will possess a distinct identifier, enabling it to be addressed and connected. This evolution will transform the Internet into the Internet of Things (IoT). Consequently, communication modalities will broaden to encompass human-to-human, human-to-object, and

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object-to-object interactions, also referred to as machine-to-machine (M2M) communication. This shift is expected to usher in a new era of ubiquitous computing and communication, significantly altering the fabric of daily life [6].

Pretz (2013) has characterized the Internet of Things (IoT) as a network of interconnected devices that communicate wirelessly through smart sensors, enabling interaction without the need for human involvement. Initial applications of IoT technology have already been implemented in various sectors, including healthcare, transportation, and the automotive industry [7]-[9]. Although IoT technologies are still in their nascent stages, significant advancements have been made in the integration of objects equipped with sensors within the cloud-based Internet [10]-[12]. The progression of IoT encompasses numerous challenges, including those related to infrastructure, communication systems, interfaces, protocols, and standards [13][14].

Within the realm of education, the notion of the Internet of Things (IoT) is specifically termed the Internet of Educational Things (IoET). It can be contended that this concept remains relatively underexplored in scholarly discourse. The author has identified only a limited number of publications that explicitly address IoET. Consequently, the author intends to undertake a comprehensive overview of IoET to enhance the understanding of the internet's role within the educational context [15]-[17].

2. METHOD

This review adopts a narrative methodology to elucidate the concept of the Internet of Educational Things (IoET) and its application within the educational sector. The author compiles a diverse array of literature pertaining to the subject and synthesizes it into a cohesive interpretation that underscores the principal issues, trends, complexities, and controversies surrounding the topic [18][19]. Such a review is significant for ongoing education, as it equips readers with current insights regarding a specific topic or theme.

The primary objective of this review is to explore the potential of digital learning in enhancing learners' competencies, contingent upon the adaptation of its implementation to the prevailing circumstances and contexts [20]. Consequently, the methodology employed in this review is derived from the framework established by Berdanier et al (2020), which encompasses the following steps: (1) the aggregation of written materials into digital documents, (2) the incorporation of supporting evidence into the outline, (3) the filtration of the assembled literature to identify content directly pertinent to the project, (4) the collection and organization of the selected literature, (5) the expansion of the literature review outline, and (6) the systematic arrangement of articles by thematic paragraphs.

3. RESULTS AND DISCUSSION

3.1. From Conventional to Digital Education

Traditional or conventional education is characterized by the presence of an instructor, a physical educational institution (commonly a school), and a cohort of students who convene at this location during designated times to receive instruction from the educator(s). This mode of learning often encompasses paper-based assignments and exams. In this context, both teachers and students occupy the same physical space, adhering to a timetable established by the educational institution. Throughout the educational experience, the educator exerts comprehensive control over the classroom activities [21]. This pedagogical approach, often termed face-to-face classroom education, allows learners to pose questions while navigating challenging tasks, potentially enhancing student motivation when responses are provided. A critical aspect of this method is the encouragement offered by educators, which significantly contributes to the elevation of student motivation [22][23]. Consequently, teacher-centered learning emerges as the predominant methodology employed by educators within traditional educational frameworks.

Teacher-centered instruction is characterized by the transmission of knowledge from the teacher to students within a learning environment where the teacher assumes primary responsibility [24]. In this model, lectures serve exclusively as a method for conveying information to students, resulting in a dynamic where teachers are actively engaged while students remain passive participants [25]. Fullan & Langworthy (2013) assert that, in the absence of the emergence of a new pedagogical framework, students are likely to experience heightened levels of boredom and disengagement, while educators may face escalating stress. They argue that the development of innovative pedagogies necessitates a transformation in the dynamics of teacher-student interactions, the methodologies employed in teaching and learning, and the approaches utilized for assessing learning outcomes. This is particularly pertinent given that the competencies required in the 21st century may not be effectively evaluated through traditional paper-and-pencil assessments [26].

Over the past two decades, the educational landscape has undergone significant transformation. Specifically, the proliferation of modern information and communication technologies (ICTs) has presented educators, including teachers and professors, with various challenges, thereby intensifying the pressure to adopt digitally enhanced teaching methodologies [27]. This situation may be attributed to insufficient technical skills and inadequate resources for online instruction. The digital education revolution emphasizes the enhancement of competencies in standardized testing, numeracy, and literacy. Additionally, this revolution encompasses the establishment of national professional accreditation standards and the development of national curricula. Such advancements within the educational framework have the potential to bolster a nation's productivity and competitiveness [28]. Consequently, it can be posited that the digitalization of education is becoming essential for cultivating the skills and knowledge necessary to generate market value, thereby effectively enhancing the country's competitive edge [29].

The advent of the digital revolution has given rise to a cohort commonly known as digital natives, a term initially introduced by Marc Prensky. Prensky posited that this demographic encompasses individuals born after the year 1980 [30]. Specifically, the cohorts identified as Generation Y, encompassing individuals born between 1981 to 1999; Generation Z, comprising those born from 2000 to 2010; and Generation Alpha, which includes individuals born from 2011 to 2024 [31]. Digital natives refer to the contemporary youth who have been born into the digital age and are continuously exposed to a vast array of digital information. This demographic represents a generation that has grown up in an environment saturated with digital technologies, where computers and the Internet are intrinsic elements of their daily existence. Unlike previous generations, digital natives do not require a comparative framework to understand technology; rather, they innovate and propose novel approaches to the effective utilization of technological resources. Their perception of the world is distinct; what may be considered a novelty by digital immigrants is regarded as commonplace by digital natives, ultimately becoming an essential aspect of their lives. nitroAdditionally, there exists a subset of individuals who occupy a transitional space; although they were not born into a digital milieu, they have successfully adapted to and integrated within this digital landscape. These individuals also influence contemporary organizational practices through their adeptness with available technologies [32].

In recent years, student-centered learning has experienced substantial transformations due to the implementation of a competency-based approach within the digital learning environment. This novel approach positions the educator as a central figure in the educational process, emphasizing the importance of professional competencies and personal interests of teachers. This focus aims to enhance the methodological, organizational, and technological support for personalized learning [33]. The student-centered approach represents a pedagogical framework that prioritizes the needs and interests of learners within the educational process. This methodology underscores the importance of engagement, collaboration, and student autonomy, with the objective of fostering a learning environment that is supportive, challenging, and congruent with the aspirations and objectives of students [34]. Khoury (2022) posits that this approach significantly enhances student motivation, promotes active engagement, and leads to improved learning outcomes, particularly in online and distance learning contexts. Contemporary educational practices advocate for active learning, wherein students assume a central role in the educational process, thereby cultivating their skills and competencies [35].

The conventional model of education, characterized by the simultaneous physical presence of instructors and students, is often regarded as the most effective due to the extensive opportunities for communication and interaction that such proximity facilitates. However, evolving lifestyles and increasingly demanding schedules are compelling a growing number of students to pursue the advantages of remote academic instruction, resulting in a significant rise in the demand for distance education. Furthermore, the advent of advanced communication and information technologies has paved the way for the enhancement of both traditional and distance learning methodologies through the utilization of synchronous and asynchronous tools, including the digitalization of the internet [36].

3.2. From IoT to IoET

The integration of physical objects with the Internet facilitates the remote access of sensor data and enables the control of the physical environment from afar. The amalgamation of collected data with information sourced from various platforms, such as that available on the Web, leads to the development of innovative synergistic services that surpass the capabilities of standalone embedded systems. This concept underpins the framework of the Internet of Things [37].

The term ‘Internet of Things’ (IoT) was invented by Kevin Ashton in a presentation in 1998. The Internet of Things (IoT) represents a developing global information framework that operates on the Internet, enabling the exchange of goods and services [38]. Its primary objective is to establish an information technology infrastructure that supports the secure and reliable exchange of "things," thereby bridging the divide between physical objects and their digital representations within information system. Furthermore, the IoT is anticipated to improve transparency and augment the efficiency of global supply chain networks [39].

The IoT represents a highly intricate framework for the interconnection of various entities, which involves the tagging of objects for identification purposes, as well as the integration of sensors, actuators, and other technological components [60]. IoT refers to a paradigm in which a vast array of objects can be interconnected and engage in intelligent communication to an unprecedented degree. Typically, the concept of "connectivity" is associated with electronic devices such as servers, computers, tablets, telephones, and smartphones. However, within the framework of the IoT, sensors and actuators integrated into various physical entities—ranging from infrastructure like roadways to medical devices such as pacemakers—are interconnected via both wired and wireless networks, frequently utilizing the same Internet Protocol (IP) that underpins the broader Internet. These networks generate substantial volumes of data that are subsequently transmitted to computers for analytical purposes. The ability of objects to both perceive their surroundings and communicate effectively transforms them into instruments for comprehending and swiftly addressing complex situations. A significant aspect of this development is the deployment of these physical information systems, many of which are capable of functioning with minimal human oversight [40][41].

IoT applications are currently being utilized across various sectors, including healthcare, smart retail, customer service, smart home technology, environmental monitoring, and the industrial internet. Given their pervasive characteristics, educational institutions are increasingly seeking to integrate IoT technologies into their pedagogical practices to enhance the experiences of students, educators, and the educational system as a whole. Proposals for IoT applications in the education sector aim to address a wide array of modalities, objectives, subjects, and perspectives [42]. In order to establish an intelligent educational environment, it is essential to implement an Internet of Things (IoT) infrastructure, which consists of sensing devices, communication networks, and user applications, often leveraging cloud computing [63], [64]. A significant advantage of this infrastructure is its capacity for incremental implementation, allowing for the gradual enhancement of smart capabilities without necessitating substantial initial capital investment. Organizations can develop the intelligence of the system progressively, evaluating its performance and effectiveness as it evolves [43]. The Internet of Things (IoT) has significantly transformed traditional educational methodologies, while simultaneously instigating modifications in the infrastructure of education institutions. The notion of the Internet of Educational Things (IoET) is perceived as the application of IoT technologies to improve the infrastructure of educational institution, including their school/campuses, classrooms, and the overall academic and instructional processes [44].

The Internet of Educational Things (IoET) signifies the incorporation of technology and connectivity within educational environments, fundamentally transforming conventional learning paradigms. IoET includes the utilization of intelligent devices, such as interactive whiteboards, tablets, and wearable technology, to enhance educational experiences. These interconnected devices facilitate educators in developing personalized and interactive instructional materials, monitoring student progress, providing immediate feedback, and granting access to a vast array of educational resources and online libraries. Through IoET, the learning process becomes collaborative, accessible, and customized to meet individual needs, thereby empowering students to take an active role in their educational journey. The integration of technology in education via IoET holds the potential to revolutionize traditional classrooms, promoting a more engaging and effective learning experience for students across all age groups [45].

The Internet of Things (IoT) enhances the educational experience and facilitates improvements in the physical and structural environment of educational institutions. A smart school is characterized by facilities that function seamlessly to deliver a higher degree of personalized learning. The smart devices employed within these educational settings utilize Wi-Fi networks to transmit data and receive instructions, thereby enabling the development of more effective lesson plans. This connectivity ensures the efficient management of essential resources and enhances access to information, fostering rapid communication between students and educators both within and outside the classroom at any time. Consequently, numerous educational institutions have begun to acknowledge the significance of incorporating technology, particularly the Internet of Things, into their daily pedagogical practices. Several rationales and justifications support this initiative, with the most compelling reasons for integrating IoT in education [46].

First, the education sector consistently leads in the adoption of modern technologies, serving as a fundamental pillar for the development of the knowledge economy, which is anticipated to be a significant focus for major economies in the forthcoming years. Second, the implementation of Internet of Things (IoT) technology within educational contexts has provided, and will continue to provide, numerous advantages for teachers, students, and educational institutions. This technology enhances the clarity and effectiveness of the educational process, thereby improving the quality of education and producing the qualified human resources that are essential for national development [46].

Thirdly, the integration of the Internet of Things (IoT) within the educational sector aligns the operational realities of educational institutions across all levels with contemporary advancements in technology as implemented in various countries worldwide. Fourth, experts predict that the IoT will fundamentally transform the operational dynamics of schools, universities, and other educational entities, heralding a significant revolution across all facets of educational processes. This transformation encompasses teaching, guidance, learning, management, monitoring, and communication among all stakeholders involved in the educational framework, extending to self-managed customer services. Additionally, the IoT has the potential to interconnect all participants within a digital network, facilitating remote monitoring even after the completion of studies and graduation [46].

Fifth, Internet of Things (IoT) represents a transformative technology that is anticipated across various sectors, including educational institutions. Prominent organizations and technology firms are actively engaged in exploring the potential of IoT and harnessing its benefits. It is evident that IoT is poised to emerge as a significant global force, having established an unparalleled connectivity within the digital network that encompasses individuals, machines, tools, and various objects. This interconnectedness enables organizations to monitor a wide array of operations occurring in their environments. Sixth, IoT facilitates the automation of mundane and repetitive tasks, thereby allowing individuals to concentrate on more critical activities while delegating routine functions to machines [46].

Seventh, the implementation of Internet of Things (IoT) technology facilitates the automation and adherence to increasingly rigorous international industrial regulations, codes, and standards. This is achieved by enhancing the movement of goods within facilities and enabling the tracking of hazardous materials, components, and various products. Additionally, it aids in the management of critical contact points, particularly within the food processing sector. Nevertheless, the current cost of this technology poses challenges to overall cost efficiency. Eighth, this technology offers a comprehensive and adaptable framework for students, educators, administrators, and other stakeholders to engage with, learn from, and navigate the educational system within a highly advanced environment [46].

Ninth, the integration of advanced technology facilitates the acquisition of knowledge among students by enhancing educational objectives. It enables both students and educators to collaboratively share and modify documents in real-time, assists instructors in organizing educational resources for students, and allows for the direct recording of lessons on digital platforms. Furthermore, it provides students with streamlined access to a vast array of information through a singular search on various search engines. Tenth, the integration of technology facilitates diverse communication channels between students and educators, enabling teachers to monitor student progress, assign homework through various online platforms, and assess performance effectively. This continuous connectivity fosters a reduction in communication barriers, ensuring that teachers remain accessible to students. Furthermore, the utilization of technological tools empowers students to assume multiple roles and take ownership of their learning, while also providing them with opportunities for self-expression within a contemporary and secure educational environment [46].

The eleventh point emphasizes the importance of contributing to education in a flexible manner, accessible at any time and from any location. This is particularly significant in the context of societal development, as various online platforms play a crucial role in this process. Advanced technology facilitates educators in monitoring students' academic progress, thereby enabling learners to acquire knowledge irrespective of their geographical location or time constraints. Furthermore, it fosters communication between students and teachers through multiple channels, allows for the exploration of upcoming media and events beyond the traditional classroom setting, and even provides opportunities for job applications. This application is notable for its provision of a secure network and comprehensive privacy, which safeguards unique ideas and ensures confidentiality [47].

3.3. The IoET Models

As previously discussed, the Internet of Educational Things (IoET) represents a modification of the Internet of Things (IoT) within the educational sector. Consequently, the frameworks utilized in IoET are analogous to those employed in IoT. According to Rose et al (2015), the models associated with IoT are delineated as follows.

3.3.1 Device-to-Device Model

The device-to-device communication model constitutes a framework wherein two or more devices establish direct connections for the purpose of communication, thereby eliminating the necessity for an intermediary application server. This form of communication can transpire across diverse network types, including Internet Protocol (IP) networks or the Internet. Typically, these devices employ protocols such as Bluetooth to enable direct communication between them [48].

Figure 1 Example of Device-to-Device Model

Figure 1 illustrates the basic concept of device connectivity over a wireless network. There are two devices connected by a network, where the connection is bidirectional, allowing both devices to send and receive data. This diagram reflects wireless technologies such as Wi-Fi or Bluetooth, which allow communication without the use of physical wires. With a wireless network at the hub, devices can interact efficiently and flexibly in a variety of environments to share data, media, and other services. This diagram provides a simple yet basic overview of the functions and architecture of a wireless network. Device-to-device enable communication and message exchange among devices adhering to a specific communication protocol, thereby allowing them to execute their intended functions. This communication model is commonly utilized in applications such as home automation systems, which typically rely on small data packets to facilitate interactions between devices with relatively low data rate requirements [48].

The use of device-to-device communication in educational settings can greatly improve interaction among the devices used in learning, especially in collaborative environments with both students and teachers. In Augmented Reality (AR)-enhanced learning, student devices like tablets or smartphones can connect directly with other devices in the classroom via Bluetooth or Wi-Fi. For example, during lessons on historical topics, students might point their devices at specific objects, which would then interact with signal-emitting devices to display relevant AR content. Additionally, in science classes, students can use sensors—such as those for measuring temperature, humidity, or light—that are directly linked to their devices to support hands-on experiments. The data gathered from these sensors is sent in real-time to the students' devices, allowing for instant analysis or graphical representation, so students can track experimental results as they happen.

3.3.2 Device-to-Cloud Model

In a device-to-cloud communication architecture, Internet of Things (IoT) devices directly interface with cloud services, such as those offered by application service providers, to enable the transmission of data and control messages. This framework typically employs established communication technologies, including conventional wired Ethernet and Wi-Fi, to establish a connection between the device and the Internet Protocol (IP) network, which in turn links to the cloud service [70].

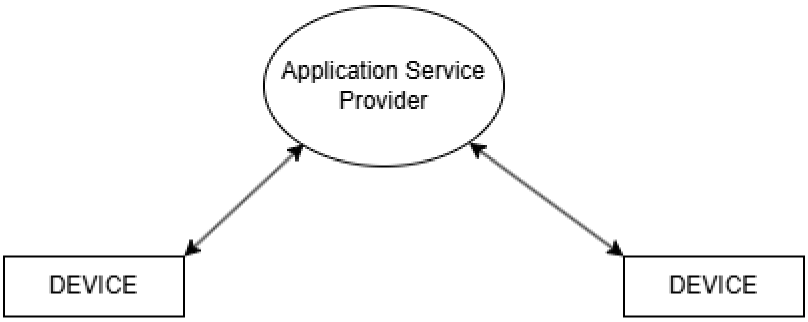

Figure 2 Example of Device-to-Cloud Model

Figure 2 illustrates a device communication scheme that involves an application service provider as the main hub. Two devices are connected to an Application Service Provider (ASP), which serves as a hub to facilitate the sending and receiving of data between the devices. The bidirectional arrows indicate reciprocal communication between the devices and the ASP, where the ASP becomes an intermediary that handles processes, such as authentication, data management, or provisioning of application-based services. This architecture is often used in cloud-based service models or online applications, where user devices do not communicate directly but through a platform operated by an ASP to ensure security and efficiency. This communication framework is illustrated by various popular consumer Internet of Things (IoT) devices, such as the Nest Labs Learning Thermostat and the Samsung SmartTV. This can be seen from the use of Nest Learning Thermostat transmits data to a cloud-based database, which facilitates the analysis of energy consumption patterns in residential settings. Furthermore, this cloud connectivity enables users to remotely control their thermostat via a smartphone application or web interface, while also allowing for software updates to be implemented on the device. In a similar vein, the Samsung SmartTV utilizes its Internet connection to relay user viewing data to Samsung for analytical purposes and to enhance its interactive voice recognition functionalities [48].

For example, devices like tablets or laptops that connect to the cloud can significantly enhance students' access to current learning materials from school servers or educational content providers. With this cloud connectivity, teachers can effortlessly upload assignments, resources, or exam questions, allowing students to access and complete them online instantly. The ability to synchronize and store assignments in the cloud also facilitates real-time evaluation by teachers. Moreover, student tablets or smart devices linked to the cloud enable both teachers and parents to monitor learning activities as they happen. Information such as the time spent on learning apps, accomplishments in assignments, and results from practice questions can be stored in the cloud for teachers to review and analyze student progress. This data allows teachers to offer tailored learning support or recommendations.

3.3.3 Device-to-Gateway Model

In the device-to-gateway architecture, often termed the device-to-application-layer gateway (ALG) model, Internet of Things (IoT) devices connect through an ALG service that acts as a conduit to cloud services. This model involves the deployment of application software on a local gateway device, which functions as an intermediary between the IoT device and the cloud service. The gateway not only enables connectivity but also bolsters security and provides supplementary functionalities, such as data and protocol translation [48].

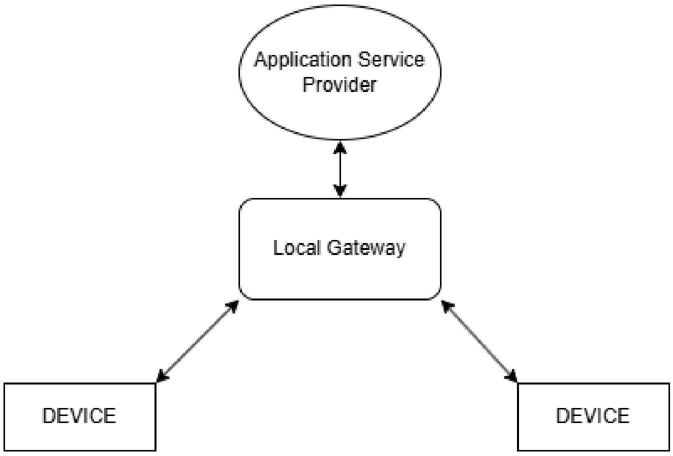

Figure 3 Example of Device-to-Gateway model

Figure 3 illustrates the process of device communication through the Local Gateway as a local intermediary before connecting to the ASP. Two devices connect to the local gateway in a two-way communication. The Local Gateway serves as a local hub that handles data traffic, such as routing, buffering, or local network settings. This gateway is then connected to the ASP, which acts as the central provider of application-based services. This model is often used in systems that require local management before sending data to the cloud, such as in the Internet of Things (IoT), enterprise networks, or applications that require local data processing for efficiency or security. This diagram shows the communication hierarchy, from the device to the local gateway, to the broader application service. Multiple versions of this model are evident in the realm of consumer electronics. Often, the local gateway device is a smartphone that utilizes an application to enable communication with a peripheral device and to relay data to a cloud service. This methodology is frequently employed in popular consumer products, such as personal fitness trackers. These devices generally do not possess the intrinsic ability to connect directly to a cloud service; consequently, they rely on smartphone application software to serve as an intermediary gateway, facilitating the connection between the fitness device and the cloud [48].

In education, the device-to-gateway communication model plays a crucial role in improving the learning experience and managing the devices used by students and teachers. Each student typically uses a tablet or laptop that connects to a local gateway application, which is usually hosted on the school's internal network. This connection allows student devices to interact with cloud-based learning management systems like Google Classroom or Microsoft Teams. The gateway enhances security, controls access to educational content, and helps automatically sync assignments and materials with the cloud. For STEM projects, students often use basic Internet of Things (IoT) devices, such as microcontrollers like Arduino or Raspberry Pi, which do not connect directly to the cloud. Instead, these microcontrollers can link to the cloud via a gateway application on a laptop or tablet. As a result, data generated by the microcontroller can be accessed by students in the cloud for monitoring or analysis, giving them hands-on experience in data collection and processing for their projects.

3.3.4 Back-End Data-Sharing

The back-end data-sharing model serves as a communication framework that enables users to export and analyze data produced by smart objects from a cloud service, alongside data obtained from various other sources. This architecture responds to users' preferences for granting third-party access to the uploaded sensor data. It signifies a progression beyond the traditional single device-to-cloud communication model, which frequently leads to the formation of data silos, where Internet of Things (IoT) devices transmit data solely to a single application service provider. The back-end sharing architecture promotes the aggregation and analysis of data gathered from the individual data streams of IoT devices [48].

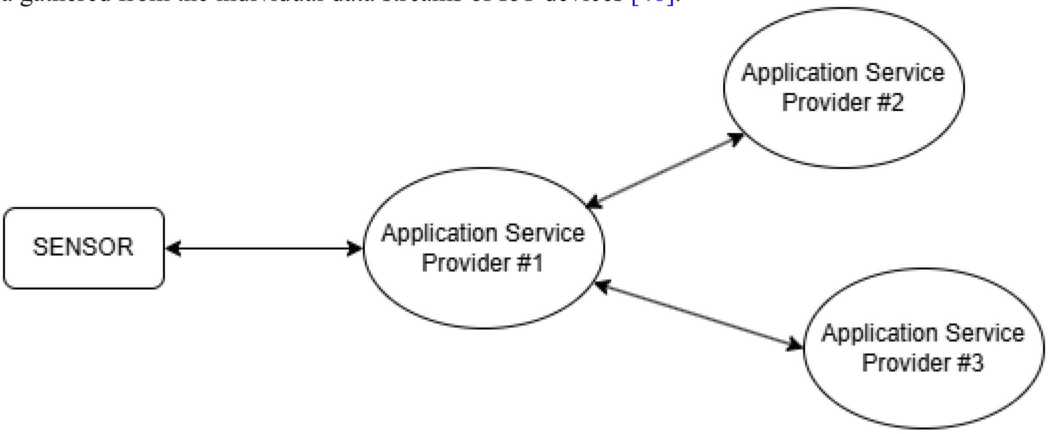

Figure 4 Example of Back-End Data-Sharing Model

Figure 4 illustrates the data communication flow between the sensor and several application service providers. The sensor acts as an input device that sends data to ASP 1 via a two-way connection. The data received by ASP 1 is then distributed to ASP 2 and ASP 3 via a one-way connection. In this system, ASP 1 acts as the center of data management, while ASP 2 and 3 only function as data receivers without any communication back as depicted in the diagram. This flow is relevant for Internet of Things (IoT) based systems, where data from sensors is used for various purposes, such as further analysis or control by integrated applications. For example, a corporate administrator overseeing an office complex may aim to consolidate and analyze energy consumption and utility data generated by all Internet of Things (IoT) sensors and Internet-enabled utility systems within the facility. In the conventional single device-to-cloud model, the data produced by each IoT sensor or system is typically restricted to a separate data silo. A robust back-end data-sharing architecture would facilitate the organization's ability to efficiently access and analyze the comprehensive data generated by the entire array of devices within the building. Additionally, this architecture addresses the necessity for data portability, enabling users to transfer their data seamlessly when transitioning between IoT services, thereby eliminating the traditional barriers associated with data silos [48].

In education, using a back-end data-sharing model can significantly improve how data from various Internet of Things (IoT) sources is analyzed and integrated within schools. Educational institutions can gather information on student learning activities from multiple devices, such as tablets, laptops, and wearables. By implementing a back-end data-sharing model, this information can be brought together on a single platform for thorough analysis. This integration helps educators gain a complete view of students' learning behaviors, engagement levels, and academic progress, allowing for personalized support that meets each student's unique needs. Additionally, data on student engagement can also be collected from educational platforms like Learning Management Systems (LMS), e-assessment tools, and daily assignment applications. The back-end data-sharing model facilitates the combination of these varied data sets into a cohesive analytical platform, producing detailed reports on students' academic performance. As a result, schools can evaluate student engagement across different subjects, help educators identify areas that require targeted intervention, and improve learning outcomes through strategies based on integrated data analysis.

3.4. The Application of IoET: Findings of Study

There are several studies that have specifically revealed their findings regarding the application of IoET. The study conducted by Ahmed et al (2024) reports on special education research supported by IoT technology, considering dimensions such as learning tools, strategies, domains, research problems, subjects, disability levels, and learning environments. Recent research results show a diversity in learning tools and applications. Data collected from UN-recognised countries, categorised by economic conditions, as well as information on the disabled population, show disparities in opportunities for higher education. Developed countries, which have more resources and technology, tend to have more inclusive education systems. In contrast, there is a lack of data on students with disabilities in poorer countries and their educational conditions.

Research by Shaqrah & Almars (2022) highlights that social support, facilitating conditions, innovativeness, and effort expectations—based on the Unified Theory of Acceptance and Use of Technology (UTAUT2)—have the most substantial impact on the acceptance and use of IoET applications. In contrast, performance expectations and perceived usefulness show a relatively weaker effect on IoET adoption. The study also revealed no significant link between perceived ease of use and behavioral intention towards IoET, indicating that this factor does not play a role in the acceptance of these applications. These findings could help universities pinpoint the key factors that influence student acceptance and use of IoET applications, thus aiding in the integration of Internet of Things (IoT) concepts into educational practices.

Then Thaariq et al (2024) highlights the importance of integrating technology in education to empower educators and improve learning outcomes. There are main findings of the study on the Internet of Educational Things (IoET) and its impact on teachers at Wahid Hasyim Junior High School. First, the implementation of IoET significantly improved the digital capabilities of teachers, enabling them to integrate technology more effectively into their teaching practices. This empowerment was facilitated through training sessions that included workshops, discussions, and hands-on activities related to IoET applications. Second, the study emphasized the importance of authentic assessment as a means to evaluate teachers' understanding and ability to apply IoET concepts in real-world teaching scenarios. This approach allowed for a deeper measurement of teachers' skills in designing relevant tasks and assessing student progress meaningfully. Third, the research outlined a framework for the sustainability of the IoET program, which includes ongoing evaluations of the program's outcomes, updates to learning materials, and further training for teachers. This continuous improvement process is aimed at ensuring that teachers can effectively address learning challenges using IoET. Last, the integration of IoET applications was found to foster a more interactive and personalized learning environment, enhancing both teaching efficiency and student comprehension. This shift is particularly relevant in the context of the challenges posed by the COVID-19 pandemic, which necessitated a move towards online learning

Research by Wang (2022) explores how IoT technology, combined with sensor technology, can enhance physical education systems. It presents a multi-sensor data fusion model tailored for environmental parameter collection and outlines a framework specifically designed for physical education. The research demonstrates that this innovative system significantly supports college students' physical education through comparative experiments and statistical analysis. The main findings from the comparative experiments conducted in the research indicate that the physical education system based on the framework of the Internet of Things (IoT) plays a significant auxiliary role in enhancing the physical education of college students. The experimental results showed that the system effectively improves the monitoring of student status and the overall teaching effect in physical education. Specifically, the statistical evaluations demonstrated positive outcomes in both body monitoring effects and teaching effect evaluations, suggesting that the integration of IoT technology can lead to better engagement and performance in physical education settings

Lastly, research by Han et al (2024) introduces a game-theoretic enhanced learning model that optimizes student management through innovative resource scheduling strategies and a robust student management system. Key findings indicate that the fog computing-based hierarchical Q-learning model achieves faster convergence in 80 training rounds, lower average workload delays of 0.5 ms, and maintains fog node latency below 1 ms, demonstrating improved efficiency and responsiveness. The model is also cost-effective, minimizing service costs while supporting up to 3000 concurrent users and handling 20 parallel tasks per second without errors. Additionally, it facilitates comprehensive real-time monitoring of student behavior through IoT devices, enabling dynamic resource allocation and personalized learning experiences, thus significantly advancing educational management practices.

Various studies have shown that the implementation of IoET (Internet of Educational Things) has great potential in improving the quality of education by supporting inclusion, effectiveness, and personalisation of learning. Research by Ahmed et al. (2024) highlighted the disparity in access to inclusive education for people with disabilities between developed and developing countries, while Shaqrah & Almars (2022) found that social and innovation factors were more significant in influencing IoET acceptance than ease of use. Thaariq et al. (2024) emphasised the importance of improving teachers' digital competencies through IoET training as well as authentic assessment in creating an interactive learning environment. Meanwhile, Wang (2022) showed that IoT sensor technology can support physical education through more accurate monitoring of student conditions. Research by Han et al. (2024) proposed a high-efficiency fog computing-based learning model that enables dynamic and real-time student management. Overall, IoET plays an important role in improving engagement, learning outcomes, and education management through innovative technologies and integrated systems.

4. CONCLUSION AND LIMITATION

IoET has transformed into a modern digital learning approach, primarily due to its focus on integrating digital technology into online learning environments. The models include (1) device-to-device, (2) device-to-cloud, (3) device-to-gateway, and (4) back-end data-sharing. Device-to-device refers to the connections between devices, while device-to-cloud involves linking devices to the cloud. Device-to-gateway pertains to connecting devices to the network, and back-end data-sharing emphasizes the unification of individual devices within a cohesive architecture. Numerous studies have demonstrated the effective use of IoET in education, yet it faces several limitations. Firstly, unequal access to technology in developing nations, particularly for students with disabilities, hampers IoET's potential to foster inclusive education. Infrastructure challenges and insufficient funding hinder the adoption and development of IoET technologies in schools located in economically disadvantaged areas. Secondly, the acceptance and use of IoETs are still shaped by various psychological and social factors, such as social support and expectations of convenience, which can impact their effective implementation. Thirdly, teachers' proficiency in utilizing IoET is a significant barrier, as it necessitates extensive and ongoing training for educators to successfully integrate this technology into their teaching. Fourth, the requirement for adequate sensor devices and IoT infrastructure to support IoET applications, particularly in physical education, may restrict the implementation of IoET in schools with tight budgets. Lastly, the technological complexity of real-time management and monitoring through fog computing poses a challenge for schools lacking the expertise to ensure the reliability and sustainability of such systems. These challenges underscore the necessity for targeted strategies and continuous support to ensure the effective and equitable deployment of IoET.

Future research on IoET (Internet of Educational Things) should focus on addressing the challenges of equitable access, teacher training, and technological simplification to enhance its integration into digital learning environments. This includes developing cost-effective IoET solutions and inclusive frameworks to support economically disadvantaged schools and students with disabilities, as well as investigating scalable, low-budget infrastructure models. Research should also explore effective training programs to improve teacher proficiency and strategies to address psychological and social factors influencing IoET adoption, such as perceived convenience and social support. Additionally, studies on simplifying complex IoET systems, like fog computing, and optimizing sensor applications for specific contexts, such as physical education or STEM learning, can enhance their usability and reliability. Policy analysis and strategies to promote public-private partnerships and equitable IoET deployment across diverse educational settings are also crucial to maximizing its potential for inclusive, modern education.

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