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Review Article

Internet of Everything in the Teaching-Learning Approach: An Integrative Review

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ABSTRACT

Introduction: The fourth industrial revolution or industry 4.0 has brought a variety of technologies to different societies. One of these technologies is the Internet of Things (IoT), primarily conceptualized in engineering fields and then found its way to the field of education. Internet of Everything (IoE) has been discussed in the evolution of the IoT concept. IoE mainly focuses on things, people, processes, and data. This paper aims to investigate different studies from the emergence of IoT concept and its development to IoE based teaching-learning process.

Methods: The integrative review was applied as the research method, Web of Science and Scopus databases were directly investigated and 139 articles were finalized as the result of this integrative review.

Results: Findings of this study demonstrated that the teaching-learning process with the focus on IoE could be categorized into logic models, including inputs, activities, outputs, outcomes, and external factors. Based on extracted components, the final model showed that the teaching learning approach with the focus on IoE is a process that mainly occurs through integration and connection of IoT-based infrastructures, stakeholder's interactions, teaching and learning activities. Eventually, this has brought personal and general outputs to achieve sustainability, Green IoT, and meeting the needs of industry. Simultaneously with the implementation or application of this system, several challenges can arise in the process, namely Security, Privacy, Financing, Reliable connectivity, and Cloud infrastructure.

Conclusion: Therefore, this model can help policymakers or educators to be aware of the different parts of an IoE-based education system.

Keywords: Internet of things (IoT), Internet of everything (IoE), Teaching, Learning, Education

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Introduction

One of the most important needs of today's industry is the digitalization of the production process (1). Today, digital activities with the focus on displaying are increasing and people use their mobile phones or other devices that are connected to the internet, known as the Internet of Things (IoT) (2). All homes and companies are using millions of electronic devices that are connected to the internet. Demands for increasing bandwidth are growing since a variety of new technologies, such as different video types and IoT, are emerging and the future of these technologies will be more complicated (3).

IoT as one of the most influential concepts in industry 4.0 has made the interactions between the cyberspace and the real-world faster and easier (2). IoT has several advantages in different areas, such as making cooperation and interactions faster to achieve different goals (4, 5).

Recent advances in information and communication technology, especially in the IoT area, has helped to make things smarter. As an extension, the concept of the internet of everything "IoE" has emerged a more general concept beyond the IoT (6). This will contribute to the vast connections of us and all the things around us to exchange all kinds of information through the Net, anytime and anywhere (7).

Therefore, IoE has considerable effects on people's lives and making different things smarter and more intelligent (8, 9). IoE is also considered as a pattern that gathers people, processes, data, and everything to make things better. By changing information to action, IoE also can bring new capabilities, unique experiences, and a variety of economical and commercial opportunities (10, 11). IoE helps automatic processes that are based on people through developing a connection of different things to the internet. IoE has a deeper perspective than IoT in different aspects specifically in term of connecting things, people, and services. Three conditions should be met to achieve this goal:

1) Scalability: it is defined as making a scalable net to cover everywhere.

2) Intelligence: it means to activate smart decisions and actions for all devices.

3) Diversity: support all kinds of programs and activities.

Therefore, IoE basically depends on actualizing all the three mentioned conditions (12). This technology can assist people to have new opportunities to achieve new approaches to creativity, productivity, and effective learning. Therefore, anything about traditional approaches should be reconsidered toward more advanced technology-based learning and teaching. There are numerous considerable signs of progress in IoE fields, such as efficacy improvement, effectiveness for various applications, but other important subjects, namely security and privacy, should also be taken into account (13).

IoE has exhibited great potential to make huge changes in different aspects of life. Unfortunately, learning and teaching have not changed in line with the new technologies. Redesigning educational systems with considerable support of technology along with increasing economic, cultural, and social consistency and networking seem quite essential (14). Though IoE can bring great advantages to teaching and learning, the teachers and learners could face some challenges in this regard (15). Indeed, obtaining the required skills to invoke IoE into education and reconsidering the pedagogical approaches and competencies need training and more practices (16). To make education intelligent and smart, all stakeholders should cooperate and participate in this revolution. For future education, IoE is essential to increase the student's performance, enhance creativity, and promote collaborative learning (14).

Figure 1 illustrates several aspects of these connections and collaborations. The link between machine to machine (M2M) and the Internet of Things is recognized once a connection is made between the sent and the received data to machines and things and vice versa. In this regard, the word "machine" does not include only computers but sensors, robots, motors, unmanned

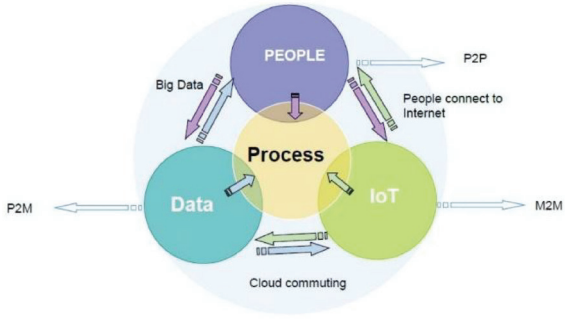

Figure 1: Different parts of Internet of Everything.

aircraft, electricity lamps, television, wind turbines, trains, mobile phones, and public vehicles that were previously not connected. In machine-to-person (M2P) connections, information is transferred from a machine to a person and vice versa. This does not consist of the traditional currents of the internet, such as downloading from a webpage only. If the person retrieves information from a database or a huge data reservoir, what we name data and its analysis falls into this category. Ultimately, person-to-person (P2P) connections work in tandem with it. P2P connections always occur virtually, similar to personal connections. This cooperation means that people's connection with each other on the internet is an integral part of IoE.

The four elements of IoE call for an educational system that allows a novel generation of digital citizens to grasp and comprehend IoE-based technologies and extensive social influences of correct reception and use of information that is provided. Higher education programs should make sure that the next generation of engineers will be able to understand the way of designing and constructing technological systems that mirror our technological expectations from participation and comprehensiveness (17).

IoT technology has significant capabilities and benefits, including providing services in a wider geographical area for learners, greater accessibility, and collaboration (18). IoT also provides opportunities for learners with disabilities. Observing behavior for real-time marketing, increasing situational awareness, Sensor-driven decision analytics, Process optimization, Optimized resource consumption, Instantaneous control and response in complex autonomous systems are the most benefits of IoT in education for disabled learners (19, 20).

Although (10) emphasizes the importance of education as one of the most important areas in which IoE can play a major role, most studies focus on industrial and commercial aspects. Nevertheless, the consequences of employing technology in different areas can be unpredictable and even disastrous until clear principles on the matter are made. Education organizations should concentrate on applying new technologies for the teaching-learning process in order to plan for the next generations. IoE can increase the effectiveness and interactions of the teaching-learning process through its four components; people, things, data, and processes. This review therefore aimed to fill this gap in the literature by designing a conceptual logic process model of the teaching-learning approach based on IoE technology.

Methods

The integrated review method was applied in this research and the results are illustrated in the logic model. This method comprises the definition of concepts, review of different theories, and analysis of different methods (21, 22). Figure 2 demonstrates the six steps of an integrative review.

A. Formulating Inclusion and Exclusion Criteria

Criteriashouldnotbetoobroadornarrow(21).

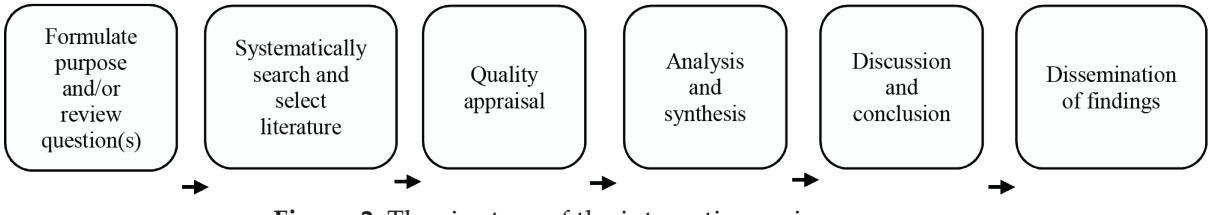

Figure 2: The six steps of the integrative review process.

Given that the concepts of the Internet of Things and the Internet of Everything has been introduced in the last two decades, article extraction criteria and search strategy are limited to the years from 2000 (Table 1).

B. Searching Systematically and Comprehensively

The selection of databases and how to search for them were supervised and guided by a librarian expert. The utilized databases and the search strategy are summarized in Table 2. In addition to the databases in Table 2, the Cisco website was explored as a gray literature due to its precedent in introducing these concepts.

C. Searching considerations to Increase rigor

According to the steps mentioned by researchers, we took into account several points to complete the search (23, 24). The process and criteria are illustrated in Figure 3.

We analysed the selected articles in the previous steps in detail in this stage and this process includes analysing and reviewing abstracts, introductions, methods, findings, and discussions by three experts. For the next stage, all the extracted keywords were categorized into the logic model process, including inputs, activities, outputs, outcomes, and external factors

Results

Results of the review are demonstrated based on program logic model (PLM) shown in Figure 4. This type of logic model has some main parts, including inputs, activities, output, and outcome (25). Researchers can also consider assumptions and external factors along with the main components (26). These components are elaborated as follows:

A. Inputs

1) Infrastructures

1-1) Political infrastructure

Educational policies for IoT technology are considered along with the IR4.0 needs at national and international levels. Specifically,

Table 1: Inclusion and Exclusion Criteria

Phenomenon/variable	Teaching and learning
Specification of domain	Internet of everything
Language	English
Time period	2000-2020

Table 2: Search string

Database	Search strategy
SCOPUS	TITLE (iot OR "internet of thing*" OR ioe OR "internet of everything*" OR "internet of" AND edu* OR teach* OR learn* OR train* OR student* OR universit* OR school* AND NOT "machine learning" OR "deep learning") AND (LIMIT-TO (EXACTKEYWORD, "Internet Of Things") OR LIMIT-TO (EXACTKEYWORD, "Internet Of Things (IOT)") OR LIMIT-TO (EXACTKEYWORD, "IoT") OR LIMIT-TO (EXACTKEYWORD, "Students") OR LIMIT-TO (EXACTKEYWORD, "Internet Of Thing (IOT)") OR LIMIT-TO (EXACTKEYWORD, "Education") OR LIMIT-TO (EXACTKEYWORD, "E-learning") OR LIMIT-TO (EXACTKEYWORD, "Teaching") OR LIMIT-TO (EXACTKEYWORD, "Curricula") OR LIMIT-TO (EXACTKEYWORD, "Higher Education") OR LIMIT-TO (EXACTKEYWORD, "Learning Environments") OR LIMIT-TO (EXACTKEYWORD, "Learning Process") OR LIMIT-TO (EXACTKEYWORD, "Human") OR LIMIT-TO (EXACTKEYWORD, "Distance Education") OR LIMIT-TO (EXACTKEYWORD, "Learning Outcome"))
Web of Science	TITLE: ("INTERNET OF EVERYTHING") OR TITLE: (IoE) OR TITLE: ("internet of things") OR TITLE: ("internet of thing") OR TITLE: (IoT) Fust Management, multidisciplinary sciences, education educational research, social sciences interdisciplinary, education scientific disciplines categories).

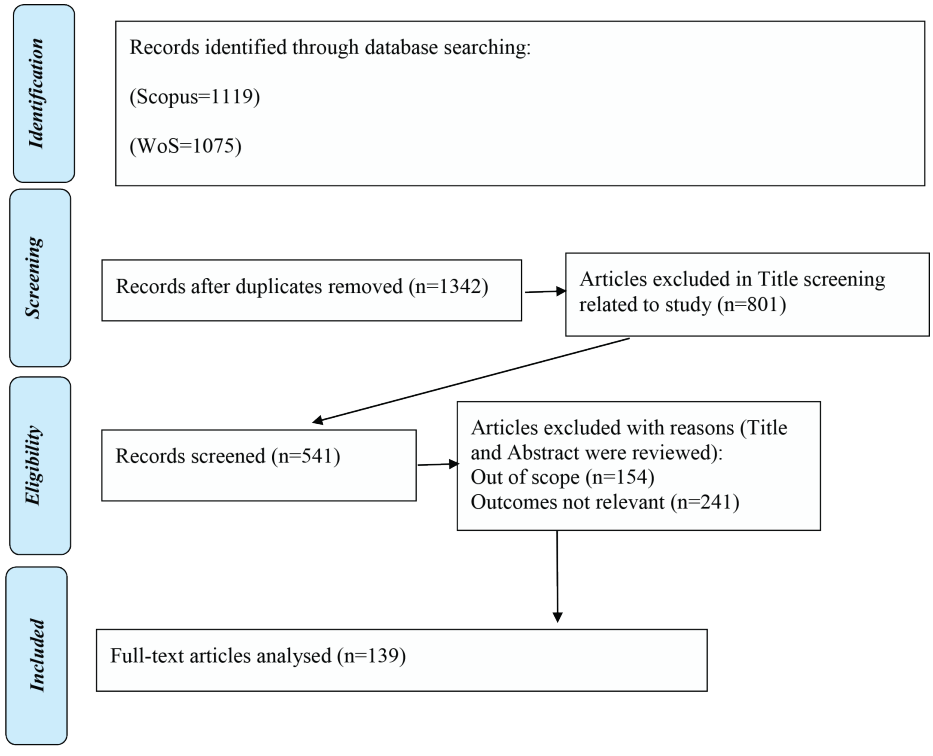

Figure 3: PRISMA tool search process.

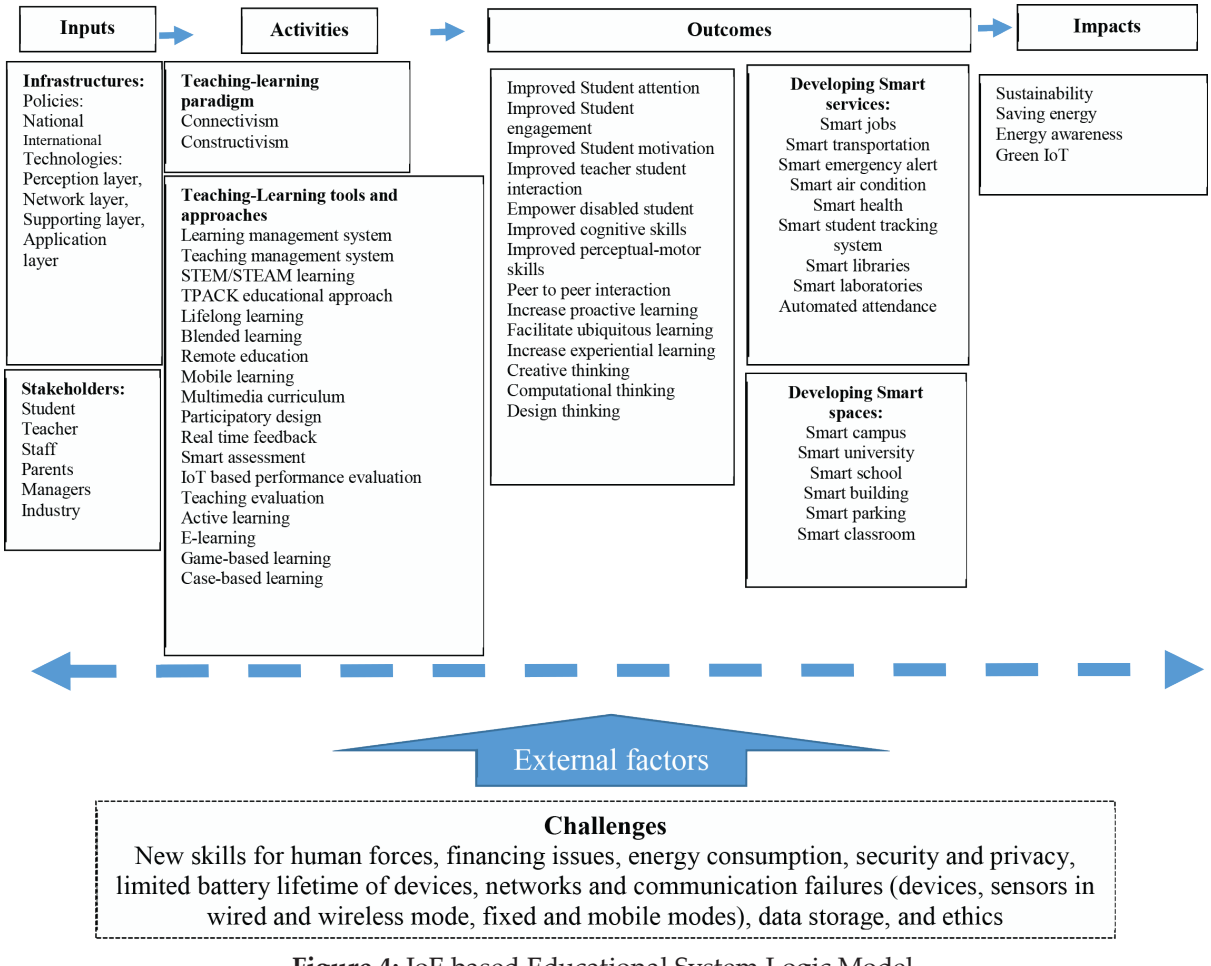

Figure 4: IoE based Educational System Logic Model.

VET institutions and SMEs (small and medium enterprises) have received more attention in the literature (27, 28, 29).

1-2) Technological infrastructure

The review of scientific literature has revealed that there are several concepts to explain the infrastructure. Infrastructure can be defined as items involved in the education process, such as classrooms, labs, conference rooms, libraries, ICT, and other places, devices, or tools that take part in the education process. Infrastructures are important to produce custom-made hardware since it helps students to achieve what they want with fair prices (27). Another infrastructure's definition is a piece of software that receives, analyzes, and stores all the sensor's data (28).

Technically, IoT architects, as a new technology, are demonstrated in four layers which can also be applied in educational context, Perception layer, Network layer, Supporting layer, and Application layer (29).

The definition of instructional technology based on the infrastructure and facilities in any context, is mainly influenced by technology and its advances and changes over time. In the first decade of 1900, instructional technologies were considered to be "media", but during that time and in the 1960s, they were considered as "processes" and nowadays known as instructional and non-instructional processes (30). Universities should access a variety of technologies to educate their students since they will work in different industries and ought to know about the process of technology in the industry; for example, research labs should access new technologies to confirm and validate new concepts (31). The learning management system (LMS) is a software that can help learners to manage and share online content. Most LMSs are web-based and can therefore achieve information easily and fast anytime and anywhere (32). LMS is also conceptualized as a software application or web-based technology to plan and run a specific learning process (33).

2)Stakeholders

Students, teachers, parents (34), and educational organizations and industries (35) are the most important stakeholders who will directly benefit from the use of IoT in the education at different contexts, such as schools, TVET systems, universities, and kindergartens.

B. Activities

1) Teaching-learning Paradigm

The most important didactic paradigm in IoT-based education is constructivism (36) and the most influential learning theory is connectivism (37, 38). It is worth mentioning that IoT could be applied in the theoretical and practical dimensions as a didactic resource to promote interdisciplinary learnings in educational contexts (39). Smart pedagogies along with smart environments strengthen the development of smart learners (35).

2) Instructional Design Process

The Internet of Things paradigm when combined with Learning Enhanced Technology pushes instructional designers to rethink learning scenarios (40, 41). Internet of things (IoT) and digitalization of industries are modifying and updating the qualifications required from new university graduates. Embedding IoT projects in curriculum enhances these skills (42). Instructional strategies are defined as strategies applied in instruction and learning situations that help to achieve instruction goals through defining principles before presenting contents (43). Assessment is one of the educational processes to demonstrate the levels of learning in students. Meaningful assessments can provide useful information about learners' misunderstandings and correct them to improve educational processes (44). Teaching evaluation (45), student assessment (46, 47), and scenario-based evaluation (43) are some of the prominent evaluations in IoT-based educational context. The changes that are taking place in Education 4.0 will describe the prerequisite for the effectiveness of education used by educators in the classroom. The use of new technologies will make classrooms more attractive to the younger generation because it fits into their interests (48).

Regardless of inclusion of technology into learning activities, here are various active approaches and methods which are more general in teaching and learning. In the following, some of these active methods are addressed:

- Flipped learning (inverted learning) (49), Game-based learning (50), Serious games learning (41), Gamification (51), Active and Interactive learning (52), and Discovery based learning (53).
- Cooperative learning (54, 55), Problem-based learning (56), Cooperative problem-based learning (54), Inquiry-based learning (56), hybrid blended learning (57), Case based learning (58), Experiential learning (59).
- Self-paced learning: Methods that the user learns based on his / her ability using the guidance of a facilitator or educational materials designed in this field. Individual studies, guided studies, and virtualized and personalized learning activities are some of the activities that can be performed (60).
- Remote education (61, 62), Distance learning (63), Online learning (64), Lifelong learning (65), and Mobile learning (66, 67).

Internet of things (IoT) as along with various multimedia and smart technologies enables the implementation of more enhanced teaching approaches for all the categories stated previously (68), (69). For instance, there has been various research on the combination of IoT and learning in many contexts, including IoT in effective distance learning process (63), influencing IoT on e-learning (70), Smart E/electronic learning application (71), Generate E-Learning Quizzes (72), Teaching IoT in a Collaborative Laboratory Environment (73), Smart virtual interactive environment for work in universities (74), IoT-based Effective E-learning (75), using IoT for e-learning (76), Improving the E-learning System (77), applying open E-learning services as a tool (78), and IoT Smart Device for e-Learning Content Sharing (79).

C. Outputs

The current review revealed that many experts have developed smart spaces and services for education and shed light on the effectiveness of these elements in enhancing the learning outcomes. University library management (80), Distance lab (81, 82), Fabrication laboratories (62), Living lab (83, 84), I-campus (85), Smart campus (86), Smart classroom (87), Smart school (88), and Smart university (89) are examples. Furthermore, smart services, such as Smart parking (90), Smart health (91), Smart jobs (61), Smart transportation (92-94), Student tracking system (95), and IoT-school attendance system (96) are among the service-based outputs. Briefly, IoT in education has proven more effectiveness for Student motivation (97), Student engagement (98), Student attention (99), Student learning styles (70, 76, 100, 101), Student disabilities (102, 103), Perceptual motor skills (104), and Cognitive skills (105).

D. Outcomes and Impacts

The Internet of Things in education can provide financial savings by raising sustainable awareness and changing behaviors for energy savings (106). For example, some European schools have developed kits and tools to create and increase energy awareness (107). It has also been facilitated to increase energy savings in high schools by applying gamification-based experiences and IoT-based tools (51), and IoT-based platforms and in their buildings and architecture, which have been very effective in increasing productivity and reducing energy in some university campuses (108).

E. Challenges

Despite all the advantages that IoT could bring into the education system, it could also bring challenges. These challenges specifically in Education 4.0 may be expressed as:

New skills for human forces, financing issues, energy consumption, security and privacy, limited battery lifetime of devices, networks and communication failures, data storage, and ethics (109).

Discussion

This integrative review was conducted

to investigate different studies from the beginning of the IoT concept and its development to IoE-based teaching-learning process to achieve the current status of the literature since its beginning.

Findings have shown that "Thing" in IoE concept has obtained considerably more attention than other aspects in the IoE-based teaching-learning process. According to articles, research, and extracted components, the role of IoE has become much more crucial in different areas, including IoT-based infrastructures, stakeholder's interactions, teaching and learning activities, personal and general outputs, and outcomes, such as sustainability, Green IoT, and meeting the needs of industry. IoE is also one of the most fundamental factors to make smart spaces for education in future (Figure 4).

The following topics are seen more frequently in the literature: preparing educational context to meet the educational challenges, offering IoT courses, IoT for maintaining and transmitting social values to sustainable development, the impacts of intelligent educational management system, providing a model for implementing IoT training technologies, users' information and privacy in IoT training solutions, and others (110).

There are numerous new methods and instructional technologies that can improve the teaching-learning processes. With the emergence of learning management specified operating systems, scientists have been expecting to observe increases in usage of online media for learning goals. Technology innovations, such as remote communications, social media, social learning, mobile-based learning, virtual reality, and gamification, have demanded modifications in education systems (111). Teachers and trainers who are involved in remote education are enthusiastic to know how to integrate new technologies with teaching-learning processes in the remote education system (112). IoT-based instruction is a new conceptual pattern in the usage of mobile phones and other technologies in the education process. IoT-based instruction encourages cooperative instruction through personal computers and wireless devices to create new opportunities in this area for learning (18). Instructional technologies include different parts, namely teaching, learning, support, and grouping of learners. For example, running IoT-based technologies as an important part of a smart campus helps teachers and students to perform the education process automatically. Performing IoT-based flipped classes is a good example of this process (113).

The way IoT supports teachers and trainers in instructional environments can have different influences on cooperation, communications, and functionality (114). Teachers and learners are the main components in the classroom. The virtual labs help students and learners to learn faster, easier, and more flexible in term of time and location of learning. Remote access to expensive devices and tools, such as robots, is also interesting since they can make practices more attractive than a simulator (115). Libraries can play major roles in teaching electronic research skills to employ a variety of databases on the internet. Benefiting from up-to-date information databases helps educators to create a dynamic education system (116). For instance, a smart campus can be designed through a computational environment equipped with IoT to create infrastructures for users and provide services through a joint assessment of environmental units, including people, spaces, and machines. IoT platforms facilitate connections between different devices. This platform creates physical hardware that minimizes the need for understanding all the sensors and stimulators and provides mediators and frameworks for developers to design smart properties with minimum effort (117).

People involved in IoE-based instructional environments can have a variety of roles like motivating, teaching, supporting, and learning roles with the possibility of cooperation and joint participation. Education system authorities can apply IoE technologies and methods in different educational settings and environments to facilitate the teaching-

learning process in different institutions. To sum up the discussion, this study helps other researchers to further understand the IoE-based issues and investigate the related studies more precisely.

Conclusion

In this paper, a novel IoE-based educational system logic model was proposed, which considered inputs, activities, outcomes, and impacts via an integrative review methodology. Based on previous studies, the inputs consist of national and international policies and infrastructure at various levels. Moreover, on the human aspect, it addresses all the stakeholders of the educational system. In the activities step, the educational paradigms using different tools and approaches can be considered and then the effective outputs can be obtained in personal or in public situations. This logic model can have positive impacts on sustainability and responses to industrial needs and Green IoT. Simultaneously with the implementation or application of this system, several challenges can rise in the process, including Security, Privacy, Financing, Reliable connectivity, and Cloud infrastructure. Therefore, this model can help policymakers or educators to be aware of the different parts of an IoE-based education system.

Authors Contribution

All the authors had the same role in Conceptualization, Methodology, Software, Data curation, and writing-Original draft preparation.

Conflict of Interest: None declared.

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