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Internet Of Educational Things (IOET) For Developing Students' Achievement In Science & STEM: Rethinking Instruction And Design

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Abstract:
The Internet of Things (IoT) is quickly gaining traction as the next generation of communication infrastructure, combining a wide range of multi-scale sensors and seamlessly blended devices for ubiquitous computing and communication.The demand for experienced professionals in the field teaching Science, Technology, Engineering, and Mathematics (STEM) has increased due to the rapid growth of IoT applications. Because there are few if any, dedicated IoT courses currently available, most STEM students will have limited or no exposure to IoT development until after graduation, leaving them underprepared to enter the workforce.Furthermore, STEM learners are increasingly being served in general education classes, where teachers may be ill-equipped to meet their needs. To address the needs of students for an effective online teaching environment to develop students' achievement in STEM, Internet of Things (IoT) can be used. This paper seeks to provide a literature review of the possible uses of IoT in enhancing the quality of teaching and learning processes ofstudents learning STEM in the age of the Covid-19 pandemic.

Keywords:STEM students; Internet of Things (IoT); literature review

Introduction:

Ubiquitous Learning, Mobile Learning, and the Internet of Things (IoT) (UMI) technologies are a new technological paradigm that is sweeping the globe by enabling "everywhere" presence, Internet connectivity, and computation capabilities on devices other than traditional computers and smartphones. These technologies are becoming increasingly prevalent in human-related activities in many facets of daily life, paving the path for young people's inventiveness. Schoolchildren must be able to interact with, use, and understand modern technologies to actively engage in this new period in conformity with society's values, requirements, and expectations. This will increase their desire to pursue a technology career that corresponds to the new era's prestige. (Glaroudis, et al., 2019)
The Internet of Things (IoT) and Cyber-Physical Systems (CPS) (e.g., smart products and services) have become increasingly popular. Medical services, smart shopping, customer service, smart homes, environmental monitoring, and industrial Internet are just a few of the areas where IoT applications are already being used. As a result, spending on the design and development of IoT applications and analytics will rise significantly (DeFranco & Kassab, 2019).
In 1999, Kevin Ashton coined the term "internet of things",many researchers have attempted to define the Internet of Things (IoT) in many ways since its inception, including Internet of Everything, Internet of Anything, Internet of People, Internet of Signs, Internet of Services, Internet of Data, and Internet of Processes(Cornel, 2015). The Internet of Things is therefore defined as "anything at all, depending on requirements (Oriwoh& Conrad,2015). The Internet of Things (IoT) is defined by Cisco as a network of interconnected physical items,including both real and virtual items as part of the Internet of Everything. IoE brings people, processes, data, and things together to make networked connections more relevant and valuable than ever before, turning information into actions that create new capabilities, richer experiences, and unprecedented economic opportunities for businesses, individuals, and countries." (Barakat, 2016).

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In educational contexts, as revealed in the recent literature,several research attempts bring IoT technologies into science education in general and specifically STEM. Stankovic, Sturges &Eisenberg (2017) looked at ways to prepare graduates for a highly cyber-physical environment, and how educational institutions should invest in developing, recruiting, and maintaining the faculty needed to provide current STEM education. Delistavrou& Kameas (2017) presents and analyses a comparison of computer science-related STEM curriculum from several countries. Bojic and Arratia (2015) provide methods for teaching STEM and IoT topics to primary and secondary students, focusing on IoT technology as a tool for increasing the appeal of STEM disciplines rather than as a means of education.
In this context, this study examines how IoT technologies are developing as educational tools and learning outcomes, as well as a support mechanism for STEM teaching and the enrichment of mainstream school students in the state of Kuwait.

1.1 Internet of Things (IoT)
The Internet of Things [IoT] was largely motivated by the needs of large companies, who stand to gain a lot from the foresight and predictability generated by the ability to monitor all items through the commodity chains in which they are embedded (Lianos & Douglas,2000). Through the IoT, organizations have been able to become more effective, speed up processes, minimize error, avoid fraud, and implement complex and scalable organizational structures (Ferguson, 2002).IoT is a technological development that reflects the future of computing and communications, and its growth is based on rapid technological advancement in a variety of fields, ranging from wireless sensors to nanotechnology (Madakam & Ramaswamy, 2015).
The Internet of Things is maturing and remains the newest and most hyped IT term. The word Internet of Things has gained prominence over the last decade by projecting a vision of a global web of networked physical objects that enables anytime, anywhere communication for anything and not just anyone (Kosmatos, Tselikas,and Boucouvalas, 2011).IoT is a global network that enables contact between human-to-human, human-to-things, and things-to-things, which can be anything in the world, by giving each object a unique identity (Aggarwal and Lal Das, 2012).

1.2IoT: Possible Definitions
The notion that the first version of the Internet was about data generated by individuals, and the next version is about data created by objects is shared by all of the meanings. “An open and comprehensive network of intelligent objects that have the capacity to auto-organize, exchange information, data, and resources, reacting and acting in the face of situations and changes in the environment,” is the best description for the Internet of Things.

According to Aggarwal and Lal Das(2012), IoT is a global network that enables contact between human-to-human, human-to-things, and things-to-things, which can be anything in the world, by giving each object a unique identity.IoT defines a world in which almost everything can be linked and interacts more intelligently than ever before. The majority of us associate "link" with electronic devices such as servers, computers, laptops, phones, and mobile phones. Sensors and actuators embedded in physical objects—from roadways to pacemakers—are linked through wired and wireless networks in what's known as the Internet of Things, which also uses the same Internet IP that connects the Internet (Madakam, Ramaswamy & Tripathi, 2015). These networks produce vast quantities of data, which are then sent to computers for analysis. When objects can sense and interact with each other, they become tools for comprehending and reacting to complexity. The fact that these physical information systems are now being implemented, and that some of them operate entirely without human interference, is groundbreaking. The "Internet of Things" is the coding and networking of ordinary items and things to make them independently machine-readable and traceable on the Internet (Biddlecombe,2009).

In addition, IoT is defined, according to European research clusters, as a dynamic global network infrastructure with self-training capabilities, dependent on standard and interoperable communication protocols, where physical and virtual things have identities, physical attributes, and virtual personalities, and

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use smart interfaces, and are seamlessly integrated into the information network, and often coordinated. GSMA defines IoT as "Connected Life" because modern connectivity is achieved through smartly connected devices (Abdel-Basset, Manogaran & Rushdy, 2018).
Accordingly,IoT is a technological revolution that represents the future of computing and communications, and its development depends on dynamic technological innovation in several important fields, from wireless sensors to nanotechnology. The concept of IoT was first made very popular by the Auto-ID Center in 2003 and by related market analysts. Right from the start of the evolution of the IoT, there have been many things or objects connected to the Internet for different applications, using a variety of technologies, depending on the type of object for human comfort (Madakam, Ramaswamy & Tripathi, 2015).

1.3 IoT: Requirements

There are certain prerequisites for the successful implementation of the IoT, these perquisites include the following: a) dynamic resource demand (b) real-time needs, c) exponential increase in demand, d) availability of applications, e) data protection and user privacy, f)efficient power consumption of applications, g) applications near end users, h) access to an open, interoperable cloud system. Besides, there are three other main components required for seamless Internet of Things computing that include: a) hardware—composed of sensors, actuators, IP cameras, CCTV and embedded communication hardware, b) Middleware—on-demand storage and computing tools for cloud data analysis and Big Data Analytics, and c) Presentation—easy-to-understand visualization and interpretation tools (Madakam, Ramaswamy & Tripathi, 2015).

Schools and universities need a cost-effective network infrastructure that handles large data flows securely, but is also simple to manage and operate IoT systems, (ALE International, 2018).

1. Provide a simple, automated onboard process for IoT devices.Large IoT systems can contain thousands of devices or sensors, and providing and managing all of these endpoints manually is complex and error-prone. Automated onboarding enables the network infrastructure to dynamically recognize and assign devices to an appropriately secured network.
2. Provide the correct network resources for the IoT system to run properly and efficiently. Many devices in the IoT system provide mission-critical information requiring a specific level of QoS.For example, some cases of educational use require proper bandwidth reservations on a high-performance network infrastructure to ensure service delivery and reliability.
3. Provide a secure environment against cyber-attacks and data loss:Because many of the IoT's networked devices and sensors lead to a corresponding abundance of potential attack vectors, security is critical to the mitigation of cybercrime risks. Security is needed at multiple levels, including the containment of the IoT networks themselves.

1.4 IoT: Architecture& Models

IoT architecture consists of a collection of physical objects, sensors, cloud services, developers, actuators, communication layers, users, business layers, and IoT protocols (Chowdhury, Kuhikar&Dhawan, 2015; Rose,Eldridge, Chapin, 2015). Due to the wide domain of internet objects, there is no single consensus on the IoT architecture that is universally agreed upon. Various architectures have been proposed by different researchers. According to most researchers, conventional IoT architecture is considered to be three layers, which are:1) layer of perception, 2) layer of a network, and 3) layer of the application. The layer of perception is also known as the layer of recognition (Rose& Eldridge, 2015). The layer of perception is the lowest in the conventional IoT architecture. This layer is primarily responsible for collecting and converting useful information/data from objects or the environmentsuch as WSN, heterogeneous devices, real object type, and humidity and temperature sensors), RFID, Bluetooth, Near-Field Communication (NFC), and 6LoWPAN (Low Power Personal Area Network) (Silva, Khan, 2018).
The standard architecture of the Internet of Things consists of an EEG SENSOR, an amplifier, a microcontroller, a GSM IOT module, and an application. The EEG sensor will feel the children's brain signals. It's usually going to be in the changes in health. The day-to-day monitoring system creates a comfort zone so

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that there is no need for any hard copies of the medical report to be carried out so that the readings are stored in the cloud so that they can access and check the previous record of the action that has taken place over a specific period. Work begins with the EEG sensors, the EEG sensors that are attached to children sense brain waves that are in an analog format. The output of the EEG sensors is sent as input to the microcontroller. Converts analog waves to readable decimal format. The amplifier is used to amplify the signals – the signals are amplified to volts in microvolts.Micro volt format that cannot be processed so that it is given to the signal conditioning system that is the amplifier. The amplifier will be sent to the microcontroller to convert it to decimal values. From there, an antenna present in the IoT module with GSM will be sent to the cloud. The application will display the values that have been processed.The architecture diagram proposed for this system is shown in Figure 1.

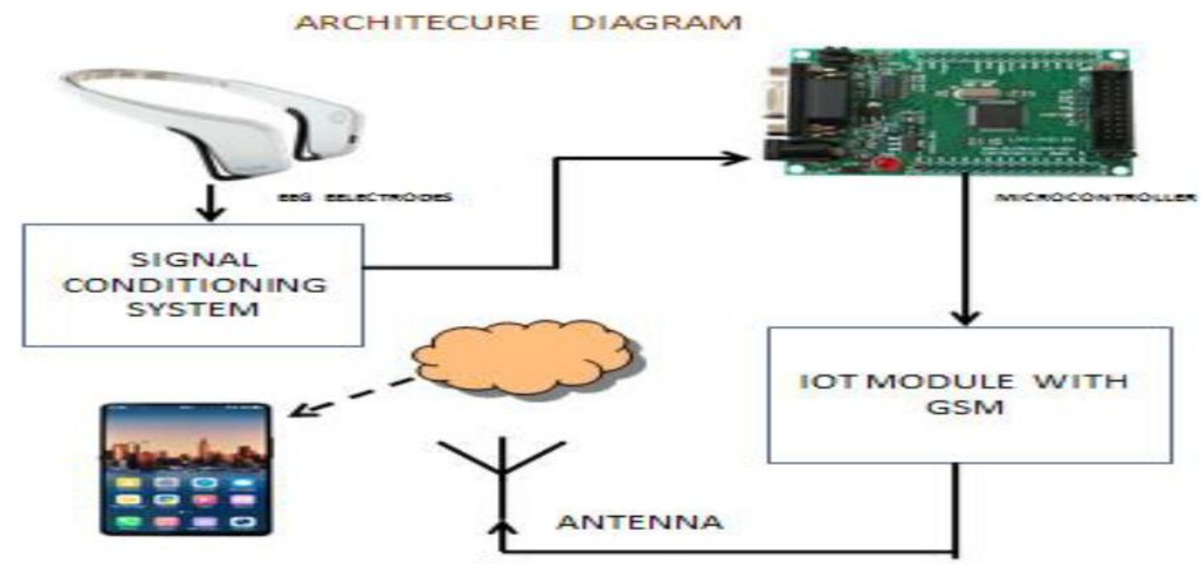

Fig 1. IoT system architecture (Gayathri, et al. 2019)

In a related context, Tin (2019) proposed an IoT system architecture that includes using wearables and portables in the students' surroundings. The proposed IoT system consists of sensors, machine augmented intelligence, and of course networks.

Fig 2. IoT system architecture (Tin, 2019)

In addition, Abdel-Basset,Manogaran, & Rushdy, (2018)proposed a model for IoT, in their viewpoint, the IoT interconnects physical and virtual things that rely on interoperable information and communication technologies to enable advanced services in the information society. GSMA defines IoT as "Connected Life" because modern connectivity is achieved through smartly connected devices. This Connected Life has a major impact on our lives and work; it also improves health care, transport, education, and energy use as shown in Figure 3. The link between the billion number of devices is an IOT pointer; this contact is just an enabler. The real value of IoT is data, as IoT is considered to be a huge data producer.

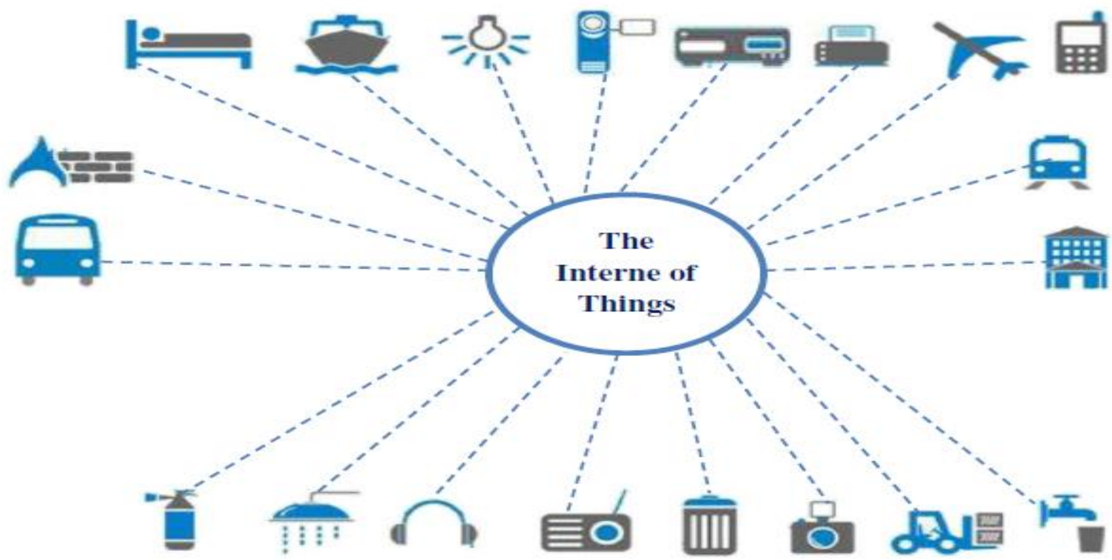

Fig 3. IoT proposed model (Abdel-Basset, Manogaran & Rushdy, 2018)

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An additional model has been proposed by Kun Han, Shurong Liu, Dacheng Zhang, and Ying Han's Architecture (2012), in the "Initial Research for the Development of SSME under the IoT Background" section, the model is as follows:

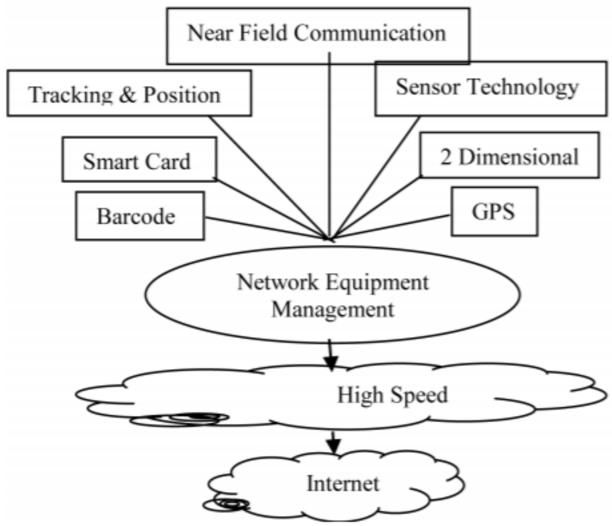

Fig 4. IoT architecture (Kun Han, Shurong Liu, Dacheng Zhang, and Ying Han, 2012)

1.5 IoT: Technology

IoT has emerged as one of the most important technologies of the twenty-first century in recent years. Now that we can connect everyday objects to the internet via embedded devices, including kitchen appliances, vehicles, thermostats, and baby monitors, seamless communication between people, processes, and things is conceivable. Physical things can share and collect data with minimal human interaction thanks to low-cost computers, the cloud, big data, analytics, and mobile technologies. Digital systems can record, monitor, and alter each interaction between connected things in today's hyperconnected environment. The physical and digital worlds collide, but they work together.

While the concept of the Internet of Things has been around for a long time, recent advances in a variety of technologies have made it a reality. The following are some technologies that have enabled the Internet of Things.

1. Low-cost, low-power sensor technology is available. IoT technology is becoming more accessible to more manufacturers thanks to the availability of low-cost, high-reliability sensors.

2. Connectivity. A variety of internet network protocols have made it simple to connect sensors to the cloud and other "things" for efficient data transfer.

3. Platforms for cloud computing Cloud platforms are becoming more widely available, allowing businesses and consumers to gain access to the infrastructure they need to scale up without having to manage it all themselves.

- Analytics and machine learning: Businesses can gather insights faster and more easily thanks to advances in machine learning and analytics, as well as access to diverse and vast amounts of data stored in the cloud. The emergence of these allied technologies continues to push the boundaries of IoT, and IoT data feeds these technologies as well.
- Artificial intelligence that converses (AI): Natural-language processing (NLP) has been brought to IoT devices (such as digital personal assistants Alexa, Cortana, and Siri) thanks to advances in neural networks, making them more appealing, affordable, and viable for home use.(Patel & Patel, 2016).

According to Vermesan & Friess (2013), the enabling technologies for the Internet of Things (IoT) are divided into three categories: (1) technologies that allow "things" to acquire contextual information, (2) technologies

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that allow "things" to process contextual information, and (3) technologies that improve security and privacy. The first two categories can be viewed as functional building blocks for embedding "intelligence" into "things," which are the characteristics that distinguish the IoT from the traditional Internet. The third category is not a functional need, but rather a de facto one, without which IoT penetration would be severely limited (Vermesan & Friess, 2013).
It is required in IoT applications to send data generated by devices or sources to the internet. For IoT applications, proving connectivity and coverage is a difficult task. Users and suppliers alike have long desired to collect data and analyze it for further processing to improve their devices. It is critical to correctly implement new technologies for data communication and processing. A better-privileged network, specifically for its applications, would be a better alternative than going to another network. In today's world, industries are working hard to build wired and wireless communication channels and protocols. However, pricing and infrastructure development are critical factors in the growth of IoT technology. Figure 5 depicts the technology that is embedded in IoT. The following is a brief description of each of these products.

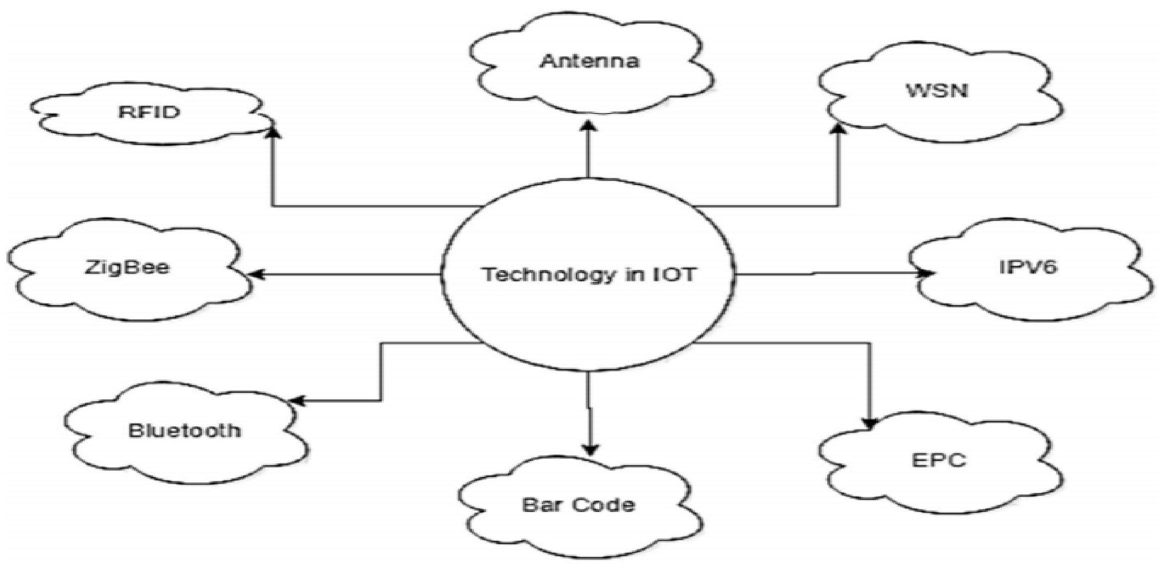

Fig. 5 Technology embedded in IoT (Balaji, Nathani & Santhakumar, 2019**)**

The Internet of Things is a collection of distinct hardware and software technologies, rather than a single technology. The Internet of Things (IoT) offers solutions that combine information technology (hardware and software used to store, retrieve, and process data) with communications technology (electronic systems used to communicate between individuals or organizations).

1.6 IoT: Characteristics

The fundamental characteristics of the IoT are as follows: (Vermesan, Friess, Guillemin& Gusmeroli, 2011; Serrano,2015).

1. **Interconnectivity:** Anything can be networked with the global information and communication infrastructure when it comes to the Internet of Things.
2. **Things-related services:** Within the restrictions of things, the IoT is capable of offering thing-related services, such as privacy protection and semantic consistency between real and virtual things. Both physical and information world technologies will alter to provide thing-related services within the restrictions of things.

3. **Heterogeneity:**The IoT devices are heterogeneous, as they are based on many hardware platforms and networks. Through various networks, they can communicate with other devices or service platforms.
4. **Dynamic changes:**Sleeping and waking up, being connected and/or disconnected, as well as the context of devices, such as location and speed, all affect the status of devices dynamically. In addition, the number of devices can fluctuate.
5. **Enormous scale:**The number of devices that will need to be managed and communicate with one another will be at least an order of magnitude greater than the number of devices currently linked to the Internet. The management of the data collected and its interpretation for application purposes will be even more crucial. This has to do with data semantics and efficient data management.
6. **Safety:**We must not forget about safety as we reap the benefits of the Internet of Things. We must plan for safety as both makers and recipients of the Internet of Things. This encompasses the security of our personal information as well as our bodily safety. Securing endpoints, networks, and the data that moves between them all necessitates the development of a scalable security paradigm.
7. **Connectivity**:Network accessibility and compatibility are made possible via connectivity. Accessibility is the ability to connect to a network, whereas compatibility is the capacity to consume and typically output data.

Therefore, the IoT is an outstanding technology that is characterized by several prominent features including the interconnectivity privacy protection, semantic consistency between real and virtual, the heterogeneous nature of IoT, IoT is dynamic, the interconnection of physical devices, and the Internet with controlled management, IoT also provides an utmost degree of safety, and finally the connectivity of the network. All these characteristics make IoT a challenging technology for use in various fields of our life.

1.7 IoT in educational settings

Educational technology has played a significant role in connecting and educating students. IoT technology has an important impact on the field of education. IoT not only changed traditional teaching practices but also brought about changes in the infrastructure of educational institutions. (Mohanapriya, 2016).IoT technology plays an important role in improving education at all levels, including school, college, and university. From student to teacher, from classroom to campus, this IoT-based technology in the education society can make the most of everything. (Tin, 2019). the growth of IoT in education also brings with it an explosion of cybersecurity threats, as the proliferation of sensors and connected devices greatly expands the network attack surface. IoT is particularly vulnerable because many IoT devices are manufactured without security in mind or built by companies that do not understand current security requirements. As a result, IoT systems are increasingly a weak link to network security in educational institutions (ALE International, 2018).

IoT, directly and indirectly, affects the education sector. It mainly facilitates overall work and improves the quality of education. It has a broad impact on the teaching and learning process. The education assessment area needs real treatment and IoT is well suited for real implementation in this sector. Once key areas such as teaching, learning, assessment are taken into account, the main aspect will be improved. According to Sari,Ciptadi& Hardyanto (2017), IoT is a subcategory of Internet technology that supports education in many ways. IoT solutions make it easier for educational institutions to collect a large amount of data from sensors and wearable devices and to carry out meaningful actions based on these data. These systems allow students to explore the environment using embedded sensors, QR codes, and other technologies. They can have access to learning materials and other information from anywhere at any time. Teachers can also use wearable devices and smartphones in classrooms to improve teaching and learning.

1.8 IoT: Applications

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Different technical communications models are used in IoT deployments, each with its unique set of features. Device-to-Device, Device-to-Cloud, Device-to-Gateway, and Back-End Data-Sharing are four popular communication methods (Vermesan & Friess, 2013).

Fig. 6 Device to Device connection

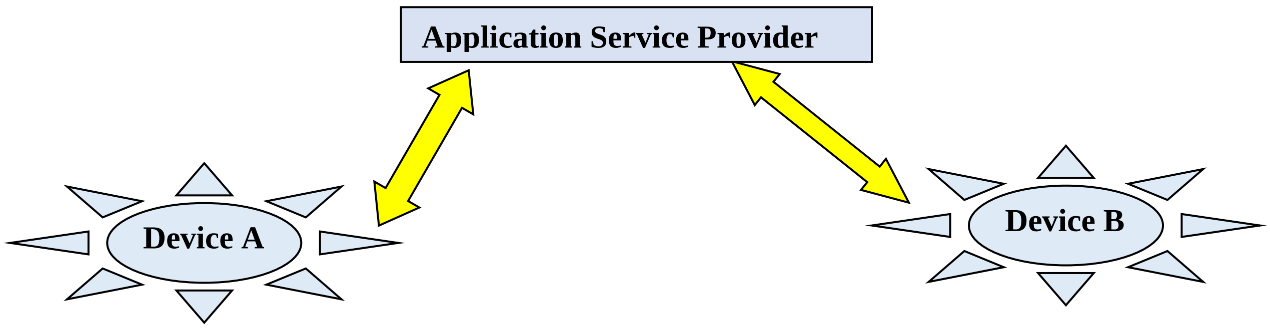

Fig. 7 Device to cloud communication

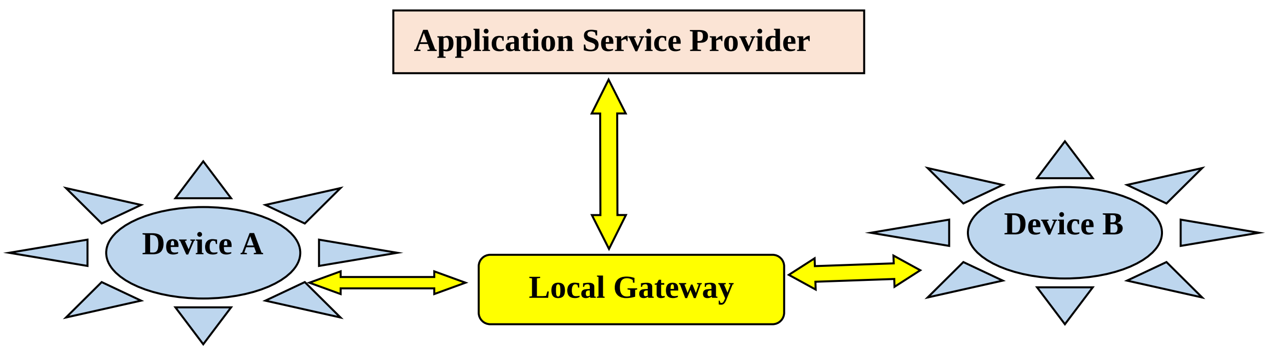

Fig. 8 Device to gateway communication model

Fig. 9 Back-end data sharing model

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These models show how IoT devices may interact and deliver value to users in a variety of ways. Furthermore, three essential components are necessary for the IoT to function: devices, communication networks, and computing and storage units. IoT systems link sensors and data networks, connecting with back-end applications to provide insight into massive amounts of data. When a device with a specific sensor detects something wrong with the person using it, for example, healthcare with IoT networks can instantly trigger an alarm.The Internet of Things (IoT) is a relatively fragmented application scenario that spans a wide range of applications, some of which are listed below: (Anwar, 2017)

1. Smart Homes:The development of smart houses has ushered in a new era in home design. Energy, time, and money would be saved by using smart home technologies. The owner of a Smart Home would be able to control household tasks from a remote place. Switching on the air conditioner or heaters minutes before arriving home, turning on/off the lights, operating the washing machine, and so on are examples. Even though smart houses have been adopted, the expense of building such homes remains a key barrier to their use (Lueth, 2016).
2. Wearable Devices:Wristwatches and glasses with sensors and software that collect and analyze data are examples of wearable gadgets. Google and Samsung, for example, have made significant investments in the development of such gadgets. These gadgets address a wide range of exercise, health, and entertainment needs. A fundamental issue in building such systems is that they must be light in weight, tiny in size, and consume very little power. (Kashyap, 2016)
3. Traffic Monitoring: Vehicles should be able to optimize their performance, fuel consumption, pollution control, maintenance, and passenger comfort. If smart traffic can be established, it will be a game-changer because it will substantially cut road accident fatalities. Citizens can also identify free available parking places throughout the city by placing sensors and using web applications.

4. Industrial Internet:Industrial Internet, also known as the Industrial Internet of Things, is the latest buzz in the industrial sector (IIoT). Sensors, software, and big data analytics are enabling industrial engineering to design smart machines. The IIoT has a lot of potential in terms of quality control and long-term sustainability. The supply chain's efficiency will be improved via applications for tracking items, real-time inventory information interchange between suppliers and merchants, and automated delivery.

5. Smart Cities: Smart cities can better manage resources, become more resilient to momentary failures and disasters, and encourage efficient behavior thanks to the Internet of Things. Smart and weather-adaptive lighting, water/gas leakage monitoring, smart parking with dynamic pricing, and automatic parking guidance are just a few examples of how the Internet of Things can be used to address today's urban issues. Ubiquitous vision can deliver an unprecedented level of safety and security by identifying the possible threat and providing critical data on crowd behavior and citizen requirements. Vision in IoT enables physical augmentation to social media and human activity monitoring to produce a more dynamic match between demand and supply of services, in addition to providing ubiquitous and augmented surveillance. It may also be used to create real-time noise urban maps to reduce noise pollution at important times and to pinpoint noise events for safety purposes (Acharjya, & Geetha, 2017).

Sensors for detecting cars or human movement can be installed in street lights, which can then be dynamically switched on when there is an activity in the zone and turned off otherwise. It can help the city conserve electricity (and money) while maintaining security by preventing dark zones around people (Mavromoustakis, Mastorakis& Batalla, 2016).

6.Healthcare: In the healthcare industry, IoT technologies can be used in a variety of ways. On the one hand, they can be used to improve existing assisted living arrangements. Medical sensors will be worn by patients to continually measure body temperature, blood pressure, heartbeat, blood glucose level, and blood oxygen level (Patel & Patel, 2016).

7. Agriculture:The need for food is tremendously high as the world's population continues to grow. Governments are assisting farmers in increasing food production by assisting them with sophisticated technology and research. Smart farming is one of the most rapidly developing IoT fields. Farmers are gaining valuable insights from their data to increase their return on investment. Simple IoT applications include sensing soil moisture and nutrients, managing water usage for plant development, and deciding on bespoke fertilizer (Kashyap, 2016).

1.8 IoT in the context of Science & STEM education

One of the modern and extraordinary uses of IoT is in educational settings, it is coined as the Internet of Educational Things (IoET). In the educational contexts, the Internet of Things (IoT) connects a variety of devices, including desktop computers, laptop computers, tablets, smartphones, PDAs, and other hand-held embedded devices. Other devices include blood pressure monitors, heart rate monitors, biochip wristbands for pets or agricultural animals, emergency call devices, robots, autonomous vehicles, home appliances, and so on. These devices use a range of sensors and data gathering technology to capture meaningful information, which is subsequently transmitted to other processing equipment for interpretation and decision-making (Cornel, 2015).

In education, technology has played an important role in connecting and educating pupils. The Internet of Things (IoT) has a significant impact on the sector of education. The Internet of Things has altered not only traditional teaching methods, but also the architecture of educational institutions (Mohanapriya, 2016). Because of its use as a technology instrument to improve academic infrastructure and as a subject or course to teach essential principles of computer science, the phrase Internet of Things in Education has two meanings (Elyamany & Alkhairi,2015).

IoT technology has the potential to improve education at all levels, including school, college, and university instruction. Everything can benefit from this technology, from students to teachers, classrooms to campuses.The use of IoT in academia is like a new wave of change that has opened up new chances and possibilities for improving both the teaching-learning process and the infrastructure of educational institutions. The study of Gul, et al., (2017) discussed the relevance and uses of IoT in the sphere of education, the latest research findings, difficulties, and the impact of IoT on future education.

Furthermore, Putjorn et al. (2018) analyzed the impact of OBSY, a unique sensor-based Internet of Educational Things (IoET) platform that was iteratively planned, built, and evaluated to enhance education in Thailand's rural areas. A study of 244 pupils and eight teachers was conducted at four primary schools along the Thai northern border to analyze the usefulness of this platform. Participants were invited to complete three science-based learning activities and their learning outcomes and engagement were assessed. Overall, the results demonstrated that students in the IoET group who utilized OBSY to learn had considerably better learning outcomes and engagement than students in the control condition. Furthermore, there was no significant effect on learning results for those in the IoET group based on gender, home location (Urban or Rural), age, prior familiarity with technology, or ethnicity. Only age was found to affect learning engagement interest/enjoyment. The study used a co-design approach with teachers and students to demonstrate the potential of IoET technologies in underserved areas, taking into consideration local conditions.

IoT as a subject is a very interesting and intriguing topic for students to learn about, and it's an excellent platform for teaching computer science topics**(**Chin & Callaghan, 2013**)**.In a related context. the Open University in the United Kingdom launched a new course for undergraduate computer science students called My Digital Life, which is built on IoT concepts. My Digital Life teaches students how to utilize IoT as a tool to better understand and examine the world around them, as well as how to recognize their position in IoT **(**Barakat, 2016**)**.

IoT-based interactive models have been designed and used to improve students' academic achievement in servals disciplines; English language for correct the pronunciation and the shape of English learners' mouth (Wang, 2010),teaching fundamental concepts of Programming language to students (Chin & Callaghan, 2013), and for collecting data and analyze students' learning method using learning analytics techniques (Cheng & Liao, 2012).

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Smart objects are expected to become prevalent in the field of education soon, giving students access to rich and relevant learning content at their leisure.In such circumstances, the main benefits of IoT technology are that it makes learning more "real, local, and entertaining," helping students to grasp more difficult concepts by utilizing relevant data gathered through interactions with physical items in the real world(Selinger, Sepulveda & Buchan, 2013). It is feasible to turn everyday things into interactive learning opportunities using networked smart tags, sensors, and mobile computing devices, allowing students to gain authentic learning experiences from real-world data (Xue, Wang & Chen, 2011).
Many research on the application of IoET have been conducted in rich countries, which means that such technology could also be effective in improving education in developing and disadvantaged areas in the teaching and learning process (Putjorn, et al., 2018).Prior research (i.e., Traxler, 2007; Kumar, et al., 2012; Gedik, et al., 2012) has shown how similar technologies have been successfully employed to help empower learning in impoverished countries.According to Gómez, et al., (2013), an IoET-based learning environment's unique characteristics could make it particularly useful in assisting education in rural and impoverished areas. This type of technology has the potential to offer students with ubiquitous access to high-quality learning information, hence reducing learning inequity.
In science education, IoET can be used through using Mechatronic Educational IoT to assess wind, the temperature in the external fields.A wind vane, a cup anemometer, and a tipping bucket rain gauge are also included in the MEIoT Weather Station; see Figure 6 for more information. The connections to the MEIoT Weather Station board are indicated by circles 4 and 5 in Figure 5. These sensors don't have any active electronics; instead, they take measurements using sealed magnetic reed switches and magnets. To produce an output, each instrument requires a voltage. The rain gauge is a tipping bucket kind that self-empties. A digital counter or microcontroller interrupt input can be used to record each 0.2794mm of rain that triggers one temporary contact closure.

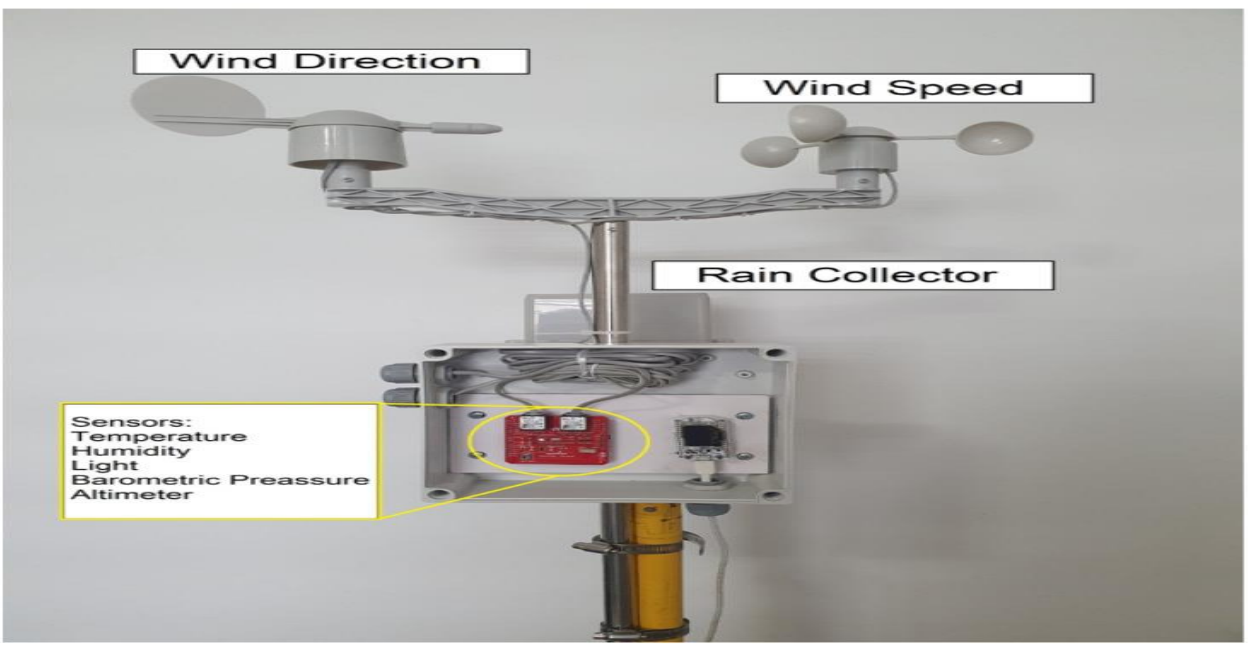

Fig. 10 Installed MEIoT Weather Station(Carlos-Mancilla, et al., 2020)

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Improving students' academic achievement in Science, Technology, Engineering, and Mathematics (STEM)through the use of IoET received increased interest nowadays. For the IoT maker course, Chen et al. (2020) designed a teaching methodology called Propose, Guide, Design, Comment, Implement, Display, and Evaluate (PGDCIDE). The PGDCIDE teaching model combines "theory, practice, and innovation" and is based on STEM teaching and Kolodner's design-based scientific inquiry learning cycle model. Finally, this study creates an IoT maker course to put the PGDCIDE paradigm into practice. Students' emotional, knowledge, and inventiveness levels all improved dramatically after taking the course, according to the practical outcomes. As a result, the PGDCIDE teaching model presented in this work can improve the effectiveness of IoT maker course teaching while also promoting the development of students' long-term engineering abilities. It is significant as a reference for the use of maker courses in engineering education.

Conclusions:

In education, the Internet of Things is being used as a teaching and research tool. According to Marquez, et al., (2016), using IoT as a new actor in educational contexts can facilitate the interaction of people (students and professors) and (physical and virtual) things in the academic environment.IoET Technology can be used effectively to make schools safer IoT networks through providing customized security strategies that incorporate connected devices such as colored lights, digital signage, door locks, and sensors. Some schools employ an IoT network to develop various programs in response to harsh weather, intruders, and other security threats. IoT technology also allows solutions in the classroom, such as integrated emergency alarm buttons. Teachers may use IoT security tools to take action and keep their pupils secure.

In addition, IoET applications to improve student outcomes. Fluorescent lighting, which is commonly seen in classrooms, has been proved to have a negative impact on student performance in studies. Installing programmable IoT-connected LED lighting in a classroom is just one method to improve the student experience. Also, IoET includes energy efficiency and cost savings. Lighting and other IoT-connected devices can be programmed and automated. Lights, for example, can be programmed to turn on and off on a timetable or be connected to occupancy sensors and turned off when a classroom is empty. IoT connectivity increases building efficiency and minimizes energy waste, which saves money.

IoT is widely used in each field in our daily life, yet using IoT in educational settings is of paramount importance, especially in both teaching science in general and STEM in particular. Educational institutions can benefit greatly from the Internet of Things. IoET technologies have a lot of potentials for educational institutions to benefit from. Smart cards with IOTs could be provided to students. Students can use these smart cards to gain entry to the grounds, laboratories, classrooms, libraries, and other areas. When a student arrives on campus, he/she will be reminded of the availability of reserved books in the library, his/ her daytime timetables, and other important information. Students in a choice-based program might acquire a personalized timetable and classroom location as soon as they arrive on campus (Mrabet&Moussa, 2017)

A student can choose his or her subjects or papers with a lot of freedom. A biometric attendance scheme might use this to track student attendance. It might be tied to scholarships, mobile phones for parents, and other things in the future. Fitness apps can be used to track the well-being of students and dormitory residents. Temperatures can be monitored automatically in laboratories and laboratory equipment. Interactive projectors, touch screens, and automatic reading capture are all possibilities. (Satu et al. 2019). Teachers can link touch boards to the internet and download content to the board right away. It connects instructors and students to worldwide educational resources, creating rich and hybrid learning environments. Pervez et al. (2018) suggested that the database of a student's research be saved and evaluated to provide tailored advice to students.Workers and suppliers will be notified via smart apps when equipment needs to be maintained before a problem emerges. In a variety of structures, smart doors, locks, and cameras can be utilized to track and manage movement. Customized learning, according to Mahmood et al. (2019), maybe done at one's own pace and intellectual capacity.

To sum up, the Internet of Educational Things (IoET) is extremely important in the realm of education since it makes the learning process smarter and easier for students. Furthermore, it has the potential to reshuffle a person's geographical position by allowing for more flexibility in the field of education. By correctly implementing IoET technology, the learning experience will be enhanced, and the learning environment will be healthier. The purpose is to evaluate the potential benefits of IoET, as well as how it can be used to leverage the sector while overcoming difficulties and lowering risks. Our future efforts should be focused on implementing IoET in other educational stages and learning disciplines.

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