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How IoT (Internet of Things) Can Shape Education

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Resumen

Este documento se centra en la investigación relacionada con varios beneficios del e-learning en el sistema educativo inteligente. Este artículo presenta un análisis teórico. La aplicación de la tecnología de Internet de las cosas (IoT) como un fenómeno prevalente está creciendo y desarrollándose rápidamente en el mundo de la computación ubicua y digital. Una de las aplicaciones más visibles del IoT como conceptos emergentes, es la educación y el sistema de aprendizaje. IoT debido a sus ramas exclusivas, como la conectividad permanente entre las cosas (receptores IP), está cambiando el esquema actual del e-learning y la versión anterior del sistema de aprendizaje. Se desarrolla un modelo teórico multidimensional del sistema de aprendizaje inteligente para analizar cómo el IoT puede actualizar radicalmente el sistema de aprendizaje mediante la participación del elemento de inteligencia en la estructura de aprendizaje electrónico. Este trabajo finalmente describe los mayores impactos del uso del IoT en la plataforma de e-learning. La inteligencia, la cadena conectada, el acceso ilimitado en línea al aula (plataforma) más grande del mundo, son elementos destacados entre otros componentes que están configurando los enfoques reales de aprendizaje electrónico en una forma novedosa, eficiente, de alto rendimiento, en tiempo real e inteligente. La conclusión se puede utilizar como tema central para el estudio futuro de los investigadores.

Palabras claves: Educación; IoT (Internet de las cosas); Internet; Aprendizaje Inteligente; E-learning; Aprendizaje Electrónico;

Abstract

This paper focuses on the research concerned the various benefits of the smart e-learning in the Educational learning system. A theoretical analysis is presented in this article. Application of internet of things (IoT) technology as a prevalent phenomenon is quickly growing & developing in the ubiquitous computing and digital world. One of the most visible applications of IoT as emergent concepts is education and learning system. IoT because of their exclusive features such as permanent connectivity between things (IP receivers) is changing the current scheme of e-learning and previous version of learning system. A smart learning system theoretical multi-dimensional model is developed in order to analyze how IoT can update radically the learning system through involvement the smartness element into the e-learning structure. This work finally outlined the most impacts of the using IoT in the e-learning

Tema: Educación científica, matemática y tecnológica.

Principal área: Informática

Bayani-Abbasy, M., Corrales-Ureña, M.A., León-Brenes, R. & Loaiza-Berrocal, M. (2019). How IoT (Internet of Things) Can Shape Education. En Y. Morales-López (Ed.), *Memorias del I Congreso Internacional de Ciencias Exactas y Naturales de la Universidad Nacional, Costa Rica, 2019* (e224, pp. 1-11). Heredia: Universidad Nacional. doi <http://dx.doi.org/10.15359/cicen.1.76>

platform. The smartness, connected chain, unlimited online access to the biggest classroom (platform) in the world, are outstanding elements amongst other components that are shaping the actual e-learning approaches in a novel efficient, high performance, real time and *smart form*. The conclusion can be used as the focal topics for the future study for the researchers.

Keywords: Education; IoT (Internet of things); Internet; Smart Learning; E-learning;

Introduction and Background

Internet of things or IoT that is considered as the internetworking of the smart physical devices in which can collect and exchange information through the Internet. It refers, as well, to the use of smartly connected electronic elements in order to administrate data obtained by embedded sensors in the physical-virtual objects. Based on the Global Standards Initiative on Internet of Things (IoT-GSI), IoT has been defined as the global structure for the information society which can make possible interconnecting all kinds of smart devices such as physical and/or virtual things based on the predefined protocols and technologies (IoT-GSI, 2011).

Internet society (ISOC) also defined IoT as the scenarios where network communication and ubiquitous computing ability, cover up to the smart sensors to produce, send, take delivery of the information and exchange data without human interference (ISOC,2015). The IoT objects such as the sensors, computers and any type of the elements which can receive an identifies (IP: Internet Protocol) are able to interact within the biggest existing architecture (Internet) in the world (Williams, 2014; Evans, 2015).

They also, can be put together by other objects with/without human intervention to collect and transfer data, and make a control choice (O'Brien, 2016). Based on the predictions, more than 50 billion devices will be connected by 2020 and the global IoT market solutions will get to \$7.1 trillion in four years with an impact close to 6% of the worldwide economy (Lund, Turner, MacGillivray & Morales, 2014).

IoT is in the premature ages and very little applications are currently implemented based on it. But it is expected in the future, there will be developed a large number of projects for smart e-systems based on the IoT philosophy and technologies that drive it such as Telecommunication, RFID (radio-frequency identification) and Sensor Networks (Vázquez Rodríguez, Mejía Lavalle, & Pinto Elías, 2015).

The scope of IoT implementation with its technologies which support it, is extended form the smart connected small system to the advanced surgical procedure systems. The smart cities, smart homes, smart security system, smart transportation & energy consumption are several examples under the domain of IoT implementations. Amongst, Education is one of the most visible applications of IoT in the human life because of advancing the communication technology in the last decades. Using the communication Technology which has been converted to the essential module in the modern educational models can help in order to increase knowledge and skills of the learners, as well as, increasing their abilities in the smart learning Society (Selinger , Sepulveda, and Buchan, 2013).

As the use of IoT implementation in the education area is in the early stages, there exists very limited papers that focused on the application of IoT on the smart e-education, its measurable influence and how to shape the form of smart learning. This paper presents a descriptive research and a theoretical analysis on the IoT smart learning and their components which will be outlined in the following section.



Theoretical Framework

In the following sections, a concise explanation of IoT structure is detailed.

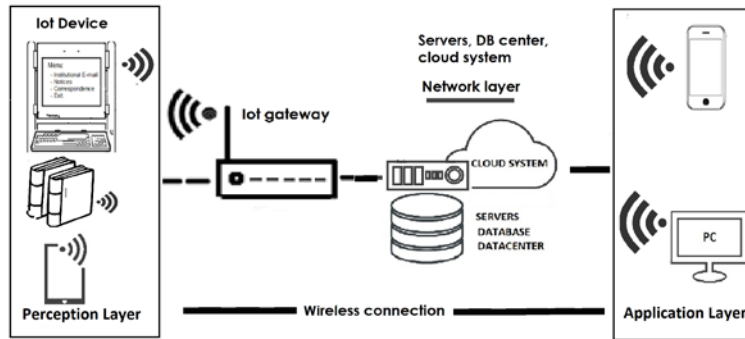


Figure 1. A Basic Architecture of IoT in Education

Basic IoT Structure

A Basic system Architecture of IoT is shown in Figure 1. Based on the figure, the basic IoT architecture includes three general layers: application, network and perception layers (Sethi and Sarangi, 2017).

The application layer is considered as an interface between the user and Network layer. The network layer provides connection between nodes and gateway point. The gateway point is an intermediary node between application and perception layers, in charging of gathering the data sensed from the nodes in the perception layer and, then send the sensory data to a private cloud system area. The perception layer can encompasses the physical devices or sensor nodes which can sense an event or action.

In a small IoT education system as Figure 2 shows IoT devices detect the events, or any data in the perception layer. The collected information will be sent to the gateway, stored in a private cloud for further processing and making decision by the users which can be teachers, learners or even developers.

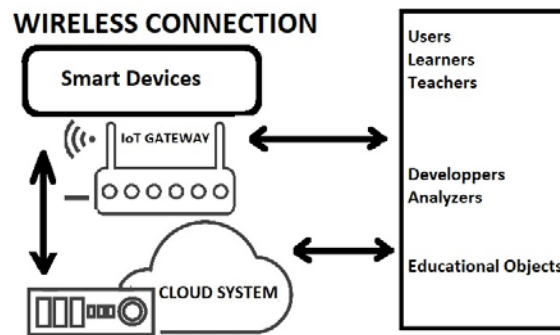


Figure 2. A Basic IoT Educational Structure

Methodology and Analysis

Despite the fact that a lot of investigations and endeavours related to the IoT development, there exists very limited implementations Networks (Vázquez Rodríguez, Mejía Lavalle, & Pinto Elías, 2015).



IoT can build a high capacity system providing almost an unlimited road and platform by using both virtual and physical world elements and projects, based on it (Pande and Padwalkar 2014). One of the most tangible applications of IoT is in the education systems. The education systems are coming from large routes.

At the beginning, for thousands of years before, people have been educated themselves through the self-directed experiences, observations and explorations (Gray, 2008). A chronological model of Education is developed in Figure 3.

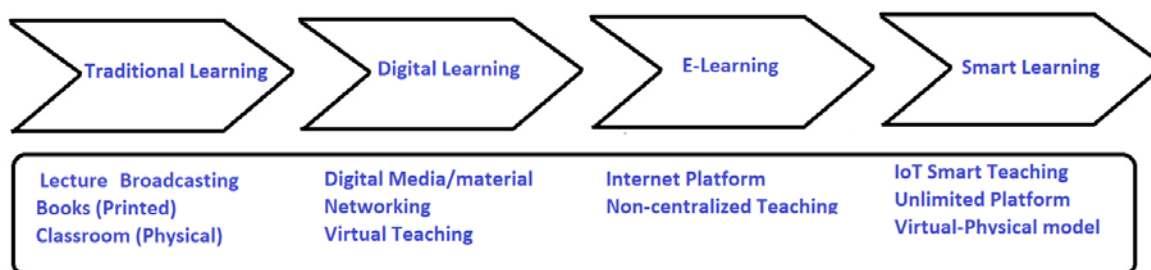


Figure 3. The chronological model of Education

One of the possible historical classifications could be defined as is shown in Figure 3. Four phases that construct the formal pathways of the learning are: traditional learning, digital learning, e-learning and finally smart learning based on the IoT.

Traditional learning: is the first formal approach employed by traditional, conventional or customary systems. It is defined as trainer-based delivery of instruction to classes of learners who obtain information directly from a face-to-face teacher (Huson, 2019; Dewey, (1938). A typical teacher-directed learning in a setting where course implementation takes place with in person interaction (Gaimaro and Lomellini, 2019; Nirupama, 2019). Traditional learning is the direct product of the face-to-face learning interactions that take place in the physical-traditional classrooms in different educational levels. Traditional schools generally focus on the basic educational labs, practices and follow the ability of academic learning in different areas of studies.

Traditional systems are the first form of formal education. Teacher broadcasting, printed books and text, and the physical classrooms are *shaping* a simple, conventional and habitual teaching and learning.

Digital learning: is any type of learning approach that is accompanied with the media technology, digital labs and instructional practices to make operational the use of digital and related, technologies. It covers a wide spectrum of applications and practices including blended adaptive learning, online classroom technologies and virtual learning (Teaching with Digital Technologies, 2017).

The exclusivity of digital learning characteristics in the education system, especially in higher education, allows forming a *novel shape model* to enhance the learning experience rather than replace traditional methods. But, at the same time it combines the technology with the education which be able to create various form of the learning such as : hybrid learning, blended learning, online & personalized learning (Digital Learning, 2017). Although, the traditional systems are enhanced by using the different types of the



technologies but missing the **smartness** feature in the learning system, yet.

After a while, the cognitive influence of multimedia shapes the digital learning to other educational technology called E-learning. This is accompanied with emerging of prevalent deep technology such as Internet (Mayer & Moreno, 1998; Moreno & Mayer, 1999); Mayer, 2001).

E-learning: Internet-based digital learning as a revolutionary non-centralized methodology created a novel form of the educational system calls E-learning. The origin of the E-learning concept is originated during the 80's and refers to employ the soft & hardware applications, multimedia, Internet and web-based tools in the learning process (Moore, Dickson-Deane & Galyen, 2011). It is the straight product of practice, using the innovative format of process and resources in order to produce materials and courses that finally can help in increasing the performance of learning (Fry, 2001).

E-Learning is considered as the use of a wide variety of multimedia and Internet technologies to improve learning quality and performance, by facilitating access to the support & services as well as distant interactions and online collaboration. Using the Internet and related technology such as the WWW (web) has been created a **pioneering form** of learning process that enhances the efficiency of knowledge access & presentation, and qualifications through relieve access to a large amount of educational resources (Arkorful and Abaidoo, 2015).

Though, e-learning try to apply a vast variety of the Internet and online technologies, such as other preceding methodologies can not involve the instance of the **smartness** in the learning process. It is required to put together many web-based and conventional programming languages and tools in order to establish intelligent educational systems, yet. But the emerging the **novel form** of technology (IoT) resolved this weakness/shortage. In the IoT as was discussed previously, huge number of physical and virtual smart objects connects and **shapes** an intelligent platform for a wide range of applications in the human life, in special in the Education.

Smart learning by IoT: is an up-to-now innovative **shape** of the educational approach by using the IoT technology.

Smart learning is a type of advanced learning in which almost all objects in the process smartly interact with each other. One of the most powerful and flexible novel technologies that can enable this feature is Internet of thing (IoT) (Shin, Choi, Kim, Lee & Park, 2017).

IoT can provide connections between electronic objects physically and virtually. Also, it can facilitate communication between the physical world and the Internet globally which prior to be not wide usable & practicable. IoT allows the global interconnection of different points, schools, centers, universities, institutes, labs, libraries, and organizations, located around the world, with the physical things (Bayani & Vilchez, 2017). Also, it can link the internal educational organizations, as well as global structures to the online learners, and lecturer which means to access the huge didactic resources by teachers and students. The students can implement their practices connecting to the advanced labs around the world. They can research to find many solutions for their projects and queries, by connecting to the huge volume of Data Bases & warehouses anytime (online) in order to develop the E-



learning smart process (Cohen, 2019 ; ISOC, 2014 ; Sun & Shen, 2016).

The presented model and IoT era: the exclusivity of IoTs' features in the educational applications, permits forming a novel theoretical smart learning based on the IoT. As an assumption, several related attributes were defined to describe the model in order to study the weight of those features in the modern educational system and discovering the last *scheme* of the Educational system in the actual era.

They are explained in details as follows (Figure 4) getting along with a theoretical analysis of each factor and the possible impact of them on the *learning process form*.

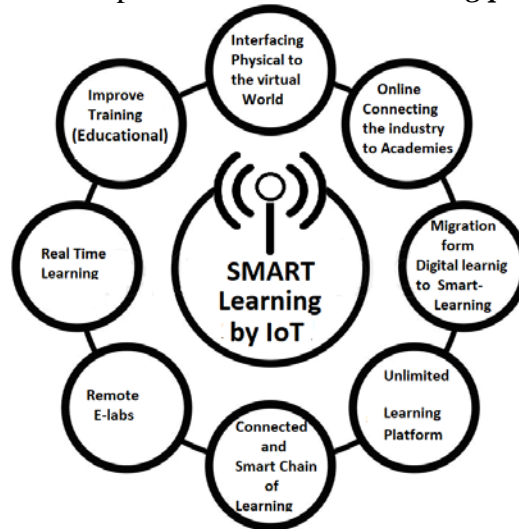


Figure 4. Smart Learning Dimensions by IoT

Interfacing physical to the Virtual world: The most natural feature of the IoT is connecting the objects. IoT facilitates connection between the huge numbers of the institutes, and research centers globally, in the real time and off-line. This can enable the investigators to get access to the information in order to search the almost unlimited and open access information for the projects that are investigating. On the other side, the large number of objects and devices generate information and can send via Internet to the institute, schools and research centers to be studied. Thanks of IoT, now is possible to get access to the information related to an alive object that is the subject for study through the sensors. This object can be a tree or an animal (a lion), etc. In different areas of study areas such as the biology, medicine, etc no more need to have a direct contact to the object in order to obtain information about them.

Online Connecting the Industry to the academics

By using IoT technology the objects can connect to other virtual or physical things through the inter-networking architecture with external things (Internet). The universities in different areas can obtain directly information from the industry section to study that. All production lines of data will be sensed and sent to the gateway and then to a warehouse or data base to be analyzed. IoT also, facilitates a 24/7 monitoring the natural phenomenon and sending online information from the factories to the research center. The people can attach sensors to themselves sending data related to their body-health, automatically or

manually, to the medicine department to further checking. Also, chemical research centers can connect directly to the production lines which produce the chemical materials to observe and study the related processes. Electronic students can watch, observe and design online the electronic devices and boards. A full connection between industry segment and institutes is feasible which has a direct impact on the *form* of teaching and learning in the educational centers.

Improve training (Education based Training)

Until now, the training process is a particular, short and intensive type of education. By using IoT, almost all objects that can receive IP address (an identifier for connecting to the Internet) interact with the learner. In this scheme, the trainer acts as the intermediary and no act as the direct teacher. The trainers convert to the learners. They can interact and obtain without third intervention with the machine. They can try different input data obtaining answers to know the operational mechanism.

Migration from digital learning to smart learning

As IoT elements are smart objects, the IoT-based architecture incorporates the smartness feature into the system. By using an intelligent technology such as IoT, the traditional digital learning system structure migrates from a traditional to a *smart* system that can inherit all attributes of a smart platform. An intelligent algorithm employed in IoT makes the education system more agile and fault tolerant. In a smart e-learning system, all elements will be smart related to their environments. A smart learning educational system encompasses the smart school, smart building, smart exam & evaluation, etc. For example, the evaluation will be based on the knowledge of the learners. As all students don't have the same knowledge about the subjects, a smart individual evaluation will be applied for learners. The homework also, will be designed based on the disadvantage the each student has on a particular themes. The students uses the intelligent backpack, the building will be equipped with the smart energy consumption and security. The parents can track their children from home to the school, etc.

Real time learning

Because there are different time-zones in the world, some people are active and others are inactive. IoT make possible a global linking between the large numbers of people and institutes in real time 24/7 ((Bayani et al., 2018)).

Learners can get access to the online resources, lab, libraries and projects anywhere anytime as well as access to the teachers in anytime of the day or night. IoT also provides connection to the online resources and receive automatically the answerers. Also by using of IoT and related technology a learner can interact with the other students in the real time.

Remote E-lab

One of the main features that IoT facilitates is forever interaction between smart elements physically and virtually. As Figure 5 shows, the students remotely, can connect to the object of the labs directly or and globally getting access to the devices through the Internet. The structure of IoT makes feasible for a Learner to remotely connect to the equipments and implement the projects, gather and receive information for further analysis or experiments. Also, they can implement some experiments virtually, physically or mixed



and obtain the results in real time. For example in an electric-machine lab, a student can turn the motor remotely, changing the speed and checking the behavior of the motors, scientifically. The structure of IoT allows testing the applications physically and virtually by running on the high or low density of the physical devices in the labs, remotely.

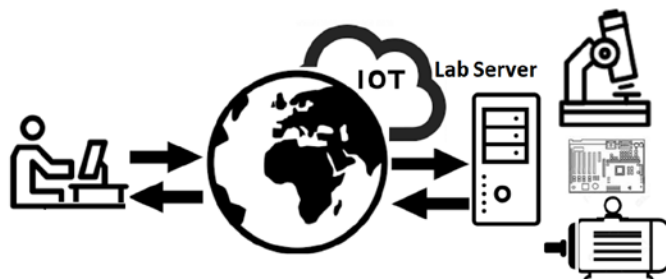


Figure 5. IoT Remotely Access to Lab (Taken from: Bayani, , Leiton, & Loaiza, 2017)

Unlimited Learning Platform

Operational platform area of Internet and IoT covers the entire globe. IoT provides the biggest infrastructure which can connect every object that can receive an IP address. It means the most widely educational platform is presented by IoT. The learner through the Internet can interact with any teacher, student, library or material over the world. Internet could apply as the biggest and flexible virtual classroom for users and IoT connect this wide area classroom to the millions of the physical objects.

Connected and smart Chain of learning

All elements of an educational system such as student, teacher, schools, materials and equipment, building and other “**Things**”, by applying IoT, will be connected 24/7. They can form a permanent connected chain. A learner opposed to other learning models has access to the chain of an IoT educational system. If a user is looking for an answer at midnight or in the morning can find the related information in anytime from any things of the sequence. The IoT system can receive all information of the learners, applying a particular algorithm (artificial intelligence) to respond the questions. The algorithm also can guess future queries of the users. By using of IoT communication technology a smart chain of the real time educational system which 24/7 of time is online is created.

Conclusions

In this paper a brief exploration of benefits which Internet of things (IoT) can introduce for educational system was discussed. IoT is transforming the scheme of current e-learning structure to a revolutionary smart learning model. IoT facilitates the global permanent connection of different elements of the learning sequence such as learner, lecturer, online services and schooling platform. A multi-dimensional learning model is developed and discussed. A theoretical concise analysis was explained the main advantages of the IoT on the e-learning in the smart infrastructures. It can be said that with certainty that actual form of e-learning in comparison with previous approaches is transforming, significantly.

As **IoT chain** of devices **never sleep**, is creating a 7/24 online connected education that is capable of novel functions that before were not feasible. IoT is removing all obstacles



between all the things around the world. So, a learner is facing to a big online platform & classroom in such a way can implement their experiments connecting to the advanced labs and objects round the globe. Almost, an unlimited technically access to the materials, teachers, lectures, presentations, researches, labs, equipments is *shaping the face* of previous version of e-learning. Direct connection between educational and industry sectors which always a vision will be realized thanks of IoT. Finally, involving the element of *smartness* in the learning process converts the current scheme of e-learning to a novel smart edition of learning. A smart learning system can offer the materials, receive and answer the queries, take a smart exam and evaluation, and predict weakness of the learners.

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