Fall 10-16-2021

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Abstract

IoT technologies can be defined as hardware and software solutions that enable the execution of services between physical and virtual elements, supported by network infrastructures, communications protocols and intelligent devices. Their use facilitates the collection, processing, and storage of data using smart algorithms and cloud computing. They enable the connection of human-machine, machine-thing, and thing-thing, establishing a high interaction between the various devices included in the process. Nowadays, several areas make use of this technology to perform multiple tasks related to human needs. This technology can play an essential role in the teaching-learning and training process, creating conditions to make the methods and contents more efficient. In this article, we have tried to identify and analyze the impacts of using this technology in the educational system, to research the contributions and challenges faced in the e-learning environment.

Keywords: *e-learning; teaching-learning; IoT; professional training*

1. INTRODUCTION

The term Internet of Things (IoT), initially coined by Ashton (1999), is increasingly following the path of the Internet of Everything (IoE). As these technologies have an ever-expanding reach, it is possible to incorporate them into a broader range of products and use a more significant number of solutions that satisfy an infinite range of needs of people, businesses, and countries. As noted in Gul et al. (2017), "*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"*.

Nowadays, the Internet has completely changed most tasks performed in various fields of human activity, contributing to several improvements and increasing our well-being. Education and training sectors can benefit from IoT technologies, allowing a greater exchange between the various institutions linked to the industry and a more excellent perception of the needs faced by other areas, which allows timely action. As stated in Barakat (2016), "IoT will connect educational and academic institutions to industry to transfer the skills and talents needed due to the new technological revolution".

IoT technologies can play an essential role in the educational field, supporting solutions that contribute to the teaching-learning process, the security, maintenance, management of facilities and equipment, and administrative functions. As mentioned in Barakat (2016), "IoT technologies can reduce costs in room occupancy, electricity, and air conditioning systems".

Besides the technical and technological technologies introduced in the educational system, other aspects are related to the interaction. These different aspects can improve student performance and make teachers' tasks more manageable. The more significant interaction between those involved in this activity contributes to more profound and broader knowledge. According to Marquez, Villanueva, Solarte, & Garcia (2016), "integrating IoT technologies as a new actor in educational environments can facilitate the interaction of people (students and teachers) and objects (physical and virtual) in the academic environment".

This study seeks to investigate whether IoT technologies can facilitate the teaching-learning process in adult vocational training in an e-learning environment. In this paper, we try to present the recent research, benefits, challenges, and future impacts of IoT use in the context of adult vocational education and training. As stated in Gul et al. (2017) "*IoT technologies significantly impact education. IoT has changed traditional teaching practices and brought about changes in the infrastructure of educational institutions*".

Section 2 presents the conceptualization of IoT technology, teaching-learning, and the training process in e-learning. Section 3 presents the methodology used. Section 4 discusses some contributions and challenges of IoT technology to teaching and learning. In Section 5, we offer the conclusions and point out future clues for research in this area.

2. TECHNOLOGY AND THE TEACHING-LEARNING AND TRAINING PROCESS

Technology has played an essential role over several periods in supporting the teaching-learning and training process. The Internet and associated technologies have developed the techniques and methods used in the educational system and citizens' training. The introduction and use of the new technologies brought some contributions that improved and facilitated the task of teachers/trainers and students. Challenges have arisen that must be faced and solved for this whole process to run smoothly. According to Alghamdi & Shetty (2016), "aspects related to security, privacy, interoperability, and configuration issues should be considered and the costs and benefits of implementing the solutions".

Although IoT technologies can introduce profound changes in the teaching-learning process and management of the resources used, its effect is primarily manifested in the increased efficiency obtained in the work of teachers and trainers. These professionals are freed for tasks more related to the pedagogical aspects of their activity, contributing to a closer follow-up of the educational activities to improve the performance and results achieved by the students. This environment will

qualify and retain more people in the educational system as mentioned in Barakat (2016), "the implementation of IoE will facilitate teachers' tasks and produce more efficient results".

Implementing educational solutions based on IoT technologies requires an architecture that allows interoperability and communication between people, objects, and services. As mentioned in Marquez et al. (2016), "IoT reference architecture allows natural space objects to communicate and become part of the virtual space, while Service-Oriented Architectures (SOA) can provide modularity and interoperability". Technological solutions supported by IoT technologies to improve educational systems provide opportunities and face challenges briefly defined as technical, financial, and political. Alghamdi & Shetty (2016), said: "*it is essential to implement a privacy and data security policy and define financial plans that ensure the accuracy of calculations related to costs and benefits*".

2.1 IoT Technology

IoT technologies can be defined as a set of hardware, communications protocols, and software that enable the realization of services between physical and virtual elements, supported by network infrastructures. These solutions allow the interaction between the various devices included in the process. As mentioned in Georgescu & Popescu (2015), "IoT is a global network that uniquely connects natural and virtual objects, using data captured by sensors and communication and location devices from a technological perspective".

These IoT technologies improve teaching-learning conditions and adjust learning processes and content to students' needs appropriately. Simić, Despotović-Zrakić, Đurić, Milić, & Bogdanović (2015), "these technologies enable the personalization and customization of courses according to the students' needs and improve teaching-learning processes by introducing sensors, actuators, and other intelligent devices".

2.2 Teaching-Learning

The teaching-learning process has changed over time, taking advantage of the support of technology to present better results and facilities for both students and teachers. It is possible to introduce new content and make the student centre to the educational system using IoT technology. These changes involve establishing a first interaction between the educational system and the family to create participation and interaction between the various actors. As mentioned in Charmonman & Mongkhonvanit (2015), "IoT technologies allow students to connect with teachers and access full-time educational tools. It also facilitates collaboration with teachers and other students. Parents can also access learning analytics through IoT technologies".

The use of intelligent environments in the educational system frees different actors from routine tasks, leading them to occupy themselves with more excellent added value. This process enables the improvement and refinement of the functions that lead to a teaching-learning of better quality. With

closer monitoring, identify and correct the deviations that may improve the results, as Gul et al. (2017) mentioned: "IoT technology can help provide a better teaching-learning environment".

Lifelong learning is a growing demand of our times, so IoT technologies and their possible solutions and applications may have a decisive and determining contribution to education and vocational training. The populations become more equipped with technical and professional knowledge and skills necessary for a more effective performance regarding the markets and the labour market. Marquez et al. (2016), stated: "learning analytics and IoT technologies can effectively improve students' learning effectiveness in lifelong learning".

The new technologies have brought extensive benefits to the teaching-learning process, allowing teachers to be aware of each student's learning path, the critical element of the process. The teacher can intervene promptly to correct and adjust the appropriate educational needs for each student, improving and avoiding distortions. Simić et al. (2015), said: "intelligent classrooms allow teachers to assist students in transmitting knowledge, which benefits the teacher's work and student learning".

School curricula and vocational training programs must be in line with the needs required by employers to meet the demands of the labour market, responding quickly to the changes that are introduced in that field as a result of the conjunctures of each moment. To this end, there must be flexible and adjust the required tasks in each period. As stated in Vihervaara & Alapaholuoma (2017), "*vocational education and training should introduce solutions based on IoT technology to have insight into the new types of skill requirements in IoT technology before entering the labour market*".

Countries with higher development and quality of life have made a clear and decisive commitment to their populations' education and vocational training, using technology from two vectors. Firstly, creating physical infrastructures supported by new technologies reformulating programs and content, helping them with technologies, and taking advantage of IoT technologies. As stated in Vihervaara & Alapaholuoma (2017), "many countries and companies have identified IoT technology as one of the critical factors when trying to ensure the industry's future competitiveness. Vocational education institutions play a vital role in these strategies because these institutions educate future workers. Therefore, IoT technology should be more widely integrated into vocational education".

2.3 E-Learning and IoT

According to Simić et al. (2015), "e-learning is defined as learning delivered on a digital device". IoT technologies can, through their numerous functionalities, support and make more efficient the e-learning process. For Charmonman & Mongkhonvanit (2015), "IoT technologies can enhance e-learning by making it easier to deliver, reducing costs, and improving learning outcomes". IoT technologies contribute to a better and more efficient teaching-learning process, enabling more

significant interaction between the various actors involved to reach many students. This reality imposes a change in the teachers' mentality and a change in pedagogical methods, which requires permanent training and motivation from the professionals of the educational system to apply the defined plans to obtain results that meet the established objectives.

As mentioned in Zahedi & Dehghan (2019), "e-learning strongly depends on the evolution of teachers and their willingness to adopt changes in their traditional methods. The implementation of e-learning education requires the teacher to tackle new ways by learning new technologies and working. Tutors should receive special and regular training to keep up to date with the e-learning system". IoT technologies can introduce changes in the educational process, new content, and teaching methods that provide greater interactivity and knowledge sharing. According to Bayani, Leiton, & Loaiza (2017), "by using IoT-based applications in e-learning activities, students can interact with instructors remotely doing all the assigned work, online assessments, and real-time results". When applied in the teaching-learning context, IoT technology can help the educational and training process facilitate and improve the tasks of students and teachers, increasing the performance of those involved. As mentioned in AjazMoharkan, Choudhury, Gupta, & Raj (2017), "we can harness the power of IoT to implement an intelligent learning environment that facilitates better learning and higher retention rates. This advancement in education will help produce better individuals in terms of skills and knowledge".

From the technical support point of view, IoT comprises solutions, devices, and functionalities that improve the teaching-learning process based on e-learning. Amasha et al. (2020), state "IoT technologies in e-learning require a wide range of tools and technologies, sensors, actuators, internet connectivity, cloud computing, wireless sensor networks, and many communication infrastructures".

3. METHODOLOGY

Concerning this research, we present a model that allows contextualizing IoT technologies in a vocational training environment in an e-Learning regime, performing validation by application in real scenarios whose typology enables their generalization.

We will use the Design Science Research methodology to characterize, build and validate a suitable model for adult vocational training in an e-Learning environment supported by IoT technologies. This process consists of **six activities** in a standard sequence: problem identification and motivation, the definition of objectives for a solution, design, development, demonstration, evaluation, and communication.

It is a flexible methodology and follows firmly accepted principles, allowing us to be aware of the various stages of evolution of the research process.

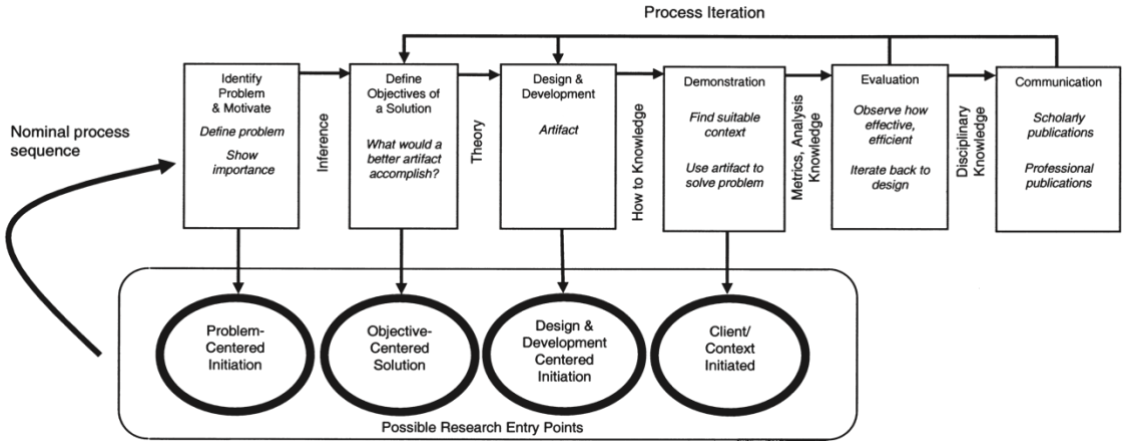

Figure 1 – DSRM Process Model according to Peffers, K., Tuunanen, T., Rothenberger, M. A. & Chatterjee, S. (2007) A design science research methodology for information systems research

1. **Problem identification and motivation** - It defines the specific research problem and justifies the value of a solution and how the problem definition will be used to develop an artefact that can effectively provide a solution. We will proceed to the research and collection of bibliographic articles relevant to the subject under study. This research seeks to facilitate the teaching-learning process in adult vocational training in an e-learning environment supported by IoT technologies.
2. **Defining the objectives for a solution** - They infer the objectives of a solution from the problem definition and knowledge of what is possible and feasible. The objectives defined for the realization of the work will be presented. The artefact will aim to facilitate the adult vocational training process in an e-learning environment. The artefact's design, development, testing, and improvement seek to leverage the adult vocational training process.
3. **Design and development** - Create the artefact. The development phase will be where we will build the artefact, which will solve the proposed problem. The main objective will be to verify whether it improves adult vocational training in an e-Learning environment through a model supported by IoT technologies. This phase of the study seeks to inform the next iteration by eliminating defects or flaws towards finalizing the artefact through the learning obtained by each iteration.
4. **Use of an artefact to solve one or more problem instances** may involve experimentation, simulation, case study, evidence, or other appropriate activity. We will study the artefact in a controlled environment to check its qualities (e.g., its usability). We will try to discover possible flaws and identify defects in the artefact. We will build detailed scenarios around the artefact to demonstrate its usefulness for the problem under study. The artefact created will be demonstrated in a training scenario.

5. **Evaluation** - This activity involves comparing the objectives of a solution to the actual observed results using the artefact in the demonstration. We will seek to carry out all the procedures that ensure the performance of the artefact. At this stage, and after discussing with the work supervisors, we will make any necessary adjustments and corrections. Each iteration of the artefact will be subject to evaluation by the study participants. Supervisors will participate in the review of the final artefact.
6. **Communication** - Communicate the problem and its importance, the artefact, its usefulness and novelty, the rigour of its design, and its effectiveness to researchers and other relevant audiences, such as practising professionals, where appropriate. The research will be communicated, published, and presented to the more vocationally oriented audience and technology-oriented one.

4. CONTRIBUTIONS AND CHALLENGES OF IoT TECHNOLOGY TO TEACHING AND LEARNING

From the research carried out, we can state that IoT technologies enhance education and training solutions. They introduce features that make management processes more efficient. They help make life easier for students, teachers, and staff. They extend their action in spatial and temporal terms, enabling, and facilitating resources anywhere and anytime. The student/trainee can access many educational resources anywhere. They reduce the teaching tasks, accessing materials that enhance higher performance. Facilitates sending and receiving assignments.

IoT technologies are suitable for large-scale production, distribution, and deployment of educational content, reducing the costs inherent in the whole process, making them reach more destinations than before. Thus, unit production costs can decrease, making solutions cheaper.

With IoT technology in distance learning, the teacher can identify the student's situation through the collected data and adjust the teaching method's progress. This process will contribute to better results for the education system, better student retention for the education system, and rationalizing the resources employed. It allows advanced remote monitoring, allowing the teacher to monitor the work of several students simultaneously and using similar treatment criteria.

Concerning the pedagogical process, IoT and the devices and tools that integrate it can enable more effective teaching-learning, whether at the individual or collective level. It allows monitoring students' degree of performance and involvement in each of the contents, contributing to faster learning and better use of resources. Provides teaching-learning mechanisms capable of being adjusted to the individual needs of each student, which will facilitate, foster, and create interactive study environments. From a pedagogical point of view, a teaching-learning process based on IoT technology becomes more flexible and accessible in responding to the training needs of current generations, allowing a more remarkable adaptation to technological novelties. These changes

require that educational institutions reinvent themselves in what concerns their offer of the educational process to use technology and its associated tools efficiently. Through these transformations, academic institutions can add value to the whole process and the community involved (students, teachers, and other collaborators). The changes that are possible to introduce in the teaching-learning process through IoT will modify the teaching-learning panorama. The teacher ceases to be the holder of knowledge and assumes the mediator's role, with the concern to stimulate students to find answers to the proposed challenges, encouraging them to create critical thinking. As a result of the introduction and use of IoT, the relationship between teacher and student gains a new dynamic. This process contributes to more creative ways to foster students' interaction with content, emphasizing distance learners. IoT in the educational environment allows faster learning, a more personalized educational process, a strong incentive for collaborative work, and greater automation of tasks. Better tools for teaching contributing to teachers carrying out their lessons efficiently since there is greater control of internal processes.

IoT introduces unique features in Distance Education (EaD) and teaching-learning in e-learning environments, expanding access to the knowledge universal, with the democratization of the whole process, breaking the physical barriers imposed by traditional teaching. Conditions are created for permanent and lifelong teaching-learning since they can overcome geographical, social, and cultural limits. The educational process will benefit from the more excellent added value, and the students' quality of teaching-learning will be improved. These solutions increase the students' awareness and participation in the whole learning process and allow them to adjust to their needs and abilities the entire training pathway, providing new and better opportunities in adult education and training.

IoT technologies are also a key element in providing support to students with special needs, contributing to their training and education and their insertion in community and social terms.

IoT technologies also make a significant contribution to the security of facilities and equipment, mitigating and protecting their vulnerabilities. Since schools are vulnerable places that need continuous surveillance, they also allow streamlining all procedures related to calls for help and alerts in response to disaster situations or urgent or serious intervention, improving the safety of the surrounding environment.

Given the technological advances and support they have introduced in education/training, younger generations expect technology to facilitate lifelong learning pathways and social integration.

As a result of the introduction and implementation of IoT technologies in the education system, growing concerns are arising regarding the generation and processing of data, implying the need to adopt tools and solutions capable of transforming this data into valuable and relevant information for the optimization of the services provided.

One of the main challenges in this area is to provide teachers with technology training, giving them knowledge and experience that can be applied in the education system. In this way, it will be possible

to increase the motivation of all stakeholders. The teachers dedicated to distance education best adhere to and deepen the teaching supported by IoT technologies. The way forward is to invest more in IoT technologies in distance education. The effectiveness that IoT technologies have in this type of teaching should be publicized.

IoT systems consist of interconnected devices involving different organizations or stakeholders, with non-coinciding objectives that may conflict. Security and privacy risks must be considered. IoT technologies amplify these risks due to the proliferation of interconnected devices. Among these risks are attacks and intrusions. Therefore, it is essential to adopt physical security measures and establish universal regulations and international data protection standards for institutions that want to join the Internet of Things technologies online in e-learning.

In short, the adoption of unified standards and protocols in developing devices and solutions that fall within the scope of projects based on IoT technologies is considered relevant. The adoption of IoT technologies in e-learning faces challenges related to security, privacy, and financial costs.

5. CONCLUSIONS

This study sought to identify and analyze the impacts of IoT technologies in the teaching-learning and training process in e-learning environments. Using the Design Science Research (DSR) methodology, we will develop an artefact that effectively provides a solution. The artefact must be relevant to the resolution of the problem under study. The usefulness, quality, and effectiveness of the artefact will be rigorously evaluated. Accuracy will be applied in both the development of the artefact and its evaluation. The artefact will constitute a search process based on existing theories and knowledge to solve the defined problem.

In this phase, we will research and collect bibliographic articles relevant to the topic under study.

We will construct an artefact, which will solve the proposed problem. Its main objective will consist of verifying if it is possible to improve adult vocational training in an e-Learning environment through a model supported by IoT technologies. We will study the artefact in a controlled environment to verify its qualities. We will seek to discover possible flaws and identify defects of the artefact. We will build detailed scenarios around the artefact to demonstrate its usefulness for the problem under study.

We will seek to carry out all procedures that ensure the performance of the artefact and make any adjustments and corrections that become necessary.

The research results will be presented to the more vocationally oriented audience and the more technology-oriented one.

We considered the various aspects of IoT technology applied to the teaching-learning method in the e-learning environment, weighing the technical, economic, legal, social, and ethical aspects.

We analyzed the contributions and challenges of education and training solutions supported by IoT technology, particularly data security and privacy issues and other vulnerabilities affecting physical and logical media, to understand what research topics can be investigated and developed within this theme.

There is a need to develop and improve universal safety standards and content quality in this area to adjust them to the needs of educational programs. These improvements will contribute to a more efficient performance of teachers/trainers, bringing their tasks closer to the needs of students/trainees.

As a result of this study, we consider that IoT technologies introduce processes with more excellent added value in the educational system, allowing new content, an expansion, and more excellent coverage of the academic community and its instruments. The free teachers/trainers for tasks related to the follow-up of students/trainees. They centre the student in the teaching-learning process. They lead to higher success and retention rates in education and training. In the future, we intend to research this area, seeking to improve the quality of adult vocational training using IoT technology.

REFERENCES

AjazMoharkan, Z., Choudhury, T., Gupta, S. C., & Raj, G. (2017). Internet of things and its applications in e-learning. 2017 3rd International Conference on Computational Intelligence Communication Technology (CICT), 1–5. https://doi.org/10.1109/CIACT.2017.7977333.

Alghamdi, A., & Shetty, S. (2016). Survey toward a smart campus using the internet of things. 2016 IEEE 4th International Conference on Future Internet of Things and Cloud (FiCloud), 235–239. Vienna, Austria: IEEE. https://doi.org/10.1109/FiCloud.2016.41.

Amasha, M. A., Areed, M. F., Alkhalaf, S., Abougalala, R. A., Elatawy, S. M., & Khairy, D. (2020). The future of using internet of things (iots) and context-aware technology in e-learning. Proceedings of the 2020 9th International Conference on Educational and Information Technology, 114–123. Oxford United Kingdom: ACM. https://doi.org/10.1145/3383923.3383970.

Barakat, S. (2016). Education and the internet of everything. International Business Management, 10(18), 4301–4303. https://doi.org/10.36478/ibm.2016.4301.4303.

Bayani, M., Leiton, K., & Loaiza, M. (2017). Internet of things (iot) advantages on e-learning in the smart cities. International Journal of Development Research, 07(12), 7.

Charmonman, S., & Mongkhonvanit, P. (2015). Applications of internet of things in e-learning. International Journal of the Computer, the Internet and Management, 23(3), 4.

Georgescu, M., & Popescu, D. (2015). How could internet of things change the e-learning environment (p. 51230 B) [Data set]. Adlro. https://doi.org/10.12753/2066-026X-15-009.

Gul, S., Asif, M., Ahmad, S., Yasir, M., Majid, M., & Arshad, M. S. (2017). A survey on role of internet of things in education. IJCSNS International Journal of Computer Science and Network Security, 17(5), 7.

Marquez, J., Villanueva, J., Solarte, Z., & Garcia, A. (2016). IoT in education: Integration of objects with virtual academic communities. New Advances in Information Systems and Technologies, 444, 201–212. https://doi.org/10.1007/978-3-319-31232-3_19.

Simić, K., Despotović-Zrakić, M., Đurić, I., Milić, A., & Bogdanović, N. (2015). A model of smart environment for e-learning based on crowdsourcing. Journal of Universal Excellence, (1), 10.

Vihervaara, J., & Alapaholuoma, T. (2017). Internet of things: Opportunities for vocational education and training - presentation of the pilot project: Proceedings of the 9th International Conference on Computer Supported Education, 476–480. Porto, Portugal: SCITEPRESS - Science and Technology Publications. https://doi.org/10.5220/0006353204760480.

Zahedi, M. H., & Dehghan, Z. (2019). Effective e-learning utilizing internet of things. 2019 13th Iranian and 7th National Conference on e-Learning and e-Teaching (ICeLeT), 1–6. https://doi.org/10.1109/ICELET46946.2019.9091671.