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PAPER

Smart Environments through the Internet of Things and Its Impact on University Education: A Systematic Review

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ABSTRACT

At present, there is diverse scientific evidence of the contributions of smart environments (SE) that have positively impacted various urban problems. However, the concept of SE is very broad, so it is relevant to investigate how these technological trends have been integrated into the university educational environment. Therefore, the objective of this study is to explore and describe the state of the art on the impact of intelligent environments implemented through the Internet of Things (IoT) in university education. Therefore, a systematic review of the literature was developed. The research was developed with a mixed approach and descriptive scope. From this study, it was determined that the purpose of implementing SE in university education is focused on contributing to the teaching and learning process and managing and optimizing the use of resources provided by the educational environment. In addition, smart classrooms are the type of environments that have been implemented to a greater extent and whose results show a positive impact on indicators such as motivation, participation, interaction, satisfaction, and student attitude. With which it is concluded that universities should reflect on the implementation of institutional policies that lead to the progressive implementation of SE, seeking to transcend from being just simple learning classrooms to sustainable environments that contribute to student health and environmental conservation.

KEYWORDS

university education, higher education, intelligent environments, Internet of Things (IoT)

1 INTRODUCTION

In recent years, the educational system in general has faced changes and transformations, such as the transition from formal face-to-face education to technology-mediated education [1–3]; where digital instructional platforms and resources have become a support for the development of the teaching-learning process [4] [5]. There is no doubt that distance education and online learning became one of the options with the greatest possibilities to continue being assumed by

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educational institutions in the context of the pandemic [6–8]. Thus, virtual education was the best alternative to the scenario generated by COVID-19; however, it also showed certain advantages and disadvantages in its use [9–12], and the application of teaching strategies developed by the teacher allowed for improved the interaction among all the persons involved in learning [13] [14]. In teaching, virtualization behaves as an extension of the face-to-face classroom [15], but is supported mainly by the permanent communication that is established from a distance between the participants of the process through the different channels [16] [17]. Thus, in the indicated context, virtual learning became the means to conceive of the continuity of an education as similar as possible to face-to-face education; of course, it was taken abruptly and with almost no preparation [12] [18–20].

In these times, universities face the need for digital transformation, the essence of which is based not only on the introduction of digital technologies in the activities of universities but also on cultural and organizational changes [21] [22]. The real implementation of this model demands radical changes in the philosophies of educational institutions; therefore, the use of vitality is not synonymous with distance education [23]. However, the crisis of educational institutions is one of the most relevant consequences of the changes derived from the technological revolution [24]. With the advent of Industry 4.0, considered the fourth industrial revolution, it brings with it the so-called Education 4.0 [25], whose emerging technologies that allow its implementation are artificial intelligence, big data, robotics, and Internet of Things (IoT) [26–28]. These technologies must generate transfer processes for the formation of the students' own competences, allowing communication in real time as well as knowledge exchange, data management, and knowledge in the cloud [29] [30]. Education 4.0 should be reflected in the creation of intelligent educational environments that manage to shape not only the professional skills of future professionals [31–33] but also to develop environmental awareness and social responsibility for future generations [34].

Advances in technology in recent years have changed learning behaviors and teaching methods, relying on a new paradigm of the study environment and making everyday environments intelligent [35]. Considering that education is an act related to the social and spatial, in which students interact with curricular aspects and the resources provided by the classroom environment, it is proposed that every smart campus should foster the construction of collaborative networks, conversation, and innovation for the benefit of students and teachers [36]. Smart campuses seek to improve the quality of education through the convergence of new technologies [37] that, like smart cities, base their environments on satisfying the needs of their members. For this, it is necessary to create processes or systems that acquire information about them [38]. An intelligent environment combines various aspects related to the design of the classroom space, innovative pedagogical methodologies, and technological means or devices [39]. Smart environments (SE) use a combination of IoT Internet devices, software solutions, user interfaces, and communication networks; however, they are primarily based on IoT [40] [41].

The growth and variety of things connected to the Internet have allowed the environment around us to become intelligent [42–45]; such is the case of cities, transportation systems, energy systems, homes, health systems, industry, education, logistics, and culture [46–49]. IoT refers to the interconnection through the Internet of a set of equipment, also called "things," and that we use on a daily basis [50–54]. The use of IoT facilitates daily life, and the data generated allows decisions to be made according to the scenario and context in which a problem occurs [55–56]. The IoT implementation in the field of an educational institution allows for the generation of an intelligent environment, contributing to the generation of different pedagogical strategies based on the student's daily information, for example, mitigating the demotivation of the

student each time that factor hinders the teaching-learning process [41] [57]. IoT has been involved in most of the branches that constitute the education sector [36]; however, the most significant impact is evident in higher education [58]. In the university educational field, it allows the monitoring of students' abilities in real time during the performance of any activity [36] [59], generating a positive impact on students [60].

In this sense, this article aims to describe the state of the art regarding intelligent environments implemented through IoT with the purpose of identifying the impact generated in university education. For which a systematic review of literature will be developed based on the preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement, with which we will proceed to determine the articles to be included for the stage of analysis, processing, and synthesis of the findings found regarding the topic under study. A mixed, descriptive-scope approach will be used. To determine the research questions, the PICO strategy will be used. Based on what has been indicated, the systematic review article consists of a methodological section detailing the phases followed for data extraction (quality scientific articles). It also contains a section on results and discussion, in which an answer is given to each research question (RQ) to later compare these results with those obtained in other investigations. Finally, the conclusions section is shown, in which the limitations and future studies to be carried out based on the results of this systematic review are also specified.

2 METHODOLOGY

2.1 Research focus and scope

This systematic literature review will be developed under a mixed approach because, initially a qualitative analysis will be carried out by reviewing the content of each scientific article based on the research questions defined for this study. Then, through a quantitative analysis, the degree of frequency or incidence of the categories identified in each research question will be determined. The mixed approach makes use of qualitative and quantitative techniques for the analysis of information [61] [62]. Mixed research approaches allow for a greater analysis of the data collected as well as a greater perspective and depth on the subject under study [63].

In addition, the scope of the research is descriptive because it will seek to categorize the aspects that allow us to understand and interpret the results that will be obtained for each research question. In other words, it will seek to categorize the intelligent environments implemented through IoT as well as the indicators that show the impact generated in university education. Descriptive scope studies consist of addressing characteristics or aspects that identify processes, objects, or any phenomenon that is submitted to analysis [64]. This scope was chosen because it allows the conceptualization of categories of the study variables [65] [66].

2.2 PICO strategy and research questions

Taking into account the methodological aspects indicated in the previous paragraphs, the research questions were defined, for which the PICO strategy was used. The PICO strategy allows establishing and delimiting the criteria to be used for the identification and selection of scientific publications to be reviewed [67], which guarantees the eligibility of quality bibliographic sources [68]. Table 1 shows the elements that make up the PICO strategy.

Table 1. PICO strategy used to define the research questions

Participant or Population (P)	Intervention (I)	Comparison (C)	Outcome (O)
Institutions of higher education	Application of Intelligent Environments through IoT	Indicators related to university education before and after the implementation of IoT	Improvement of university education

Once the elements of the PICO strategy were defined, we proceeded to establish the research questions that would allow the delimitation and conduct of systematic review of the literature. As the research questions are linked to the objectives, they allow for determining the path to follow in a systematic review [69]. Based on the above, the research questions for the study to be developed were defined by:

RQ1: What is the purpose of the university educational institutions for which they implemented intelligent environments through IoT?
RQ2: What are the intelligent environments that were implemented through IoT in university education?
RQ3: What are the results that show the impact of intelligent environments implemented through IoT in the field of university education?

2.3 Search strategy and data extraction

The search strategy used in this systematic review will be developed based on the PRISMA statement, which defines four phases that will lead to the establishment of the "scientific articles" that will be included in the phase of analysis, processing, and synthesis of the findings and that will allow answering the research questions. The PRISMA statement represents a guide that contains the guidelines to follow to identify, select, evaluate, and synthesize systematic review studies [70] [71]. It also makes it possible to reduce bias in the selection and evaluation of studies that were part of the systematic review of the literature [72] [73]. Based on what has been indicated, the search strategy had as its starting point the definition of the search equations, established through keywords related to the variables under study: "intelligent environments through IoT" and "university education." Thus, the following keywords were defined: "Smart environment," "Smart classroom," "Smart campus," "Smart library," "Smart e-learning," "Internet of things," "IoT," "Education Superior," and "university." With these words, the search equations for the ERIC, Scopus, and IEEE Xplore databases will be determined. The search equations are supported by boolean operators [74] [75], such as the AND and OR operators [76], in order to generate a logical chain between the keywords that will optimize the results and response of the database search engines. Table 2 shows the search equations for the ERIC, Scopus, and IEEE Xplore databases.

Table 2. Search equation

Database	Search Equation
ERIC	(smart environments OR smart classrooms OR smart library OR smart campus) AND ((internet of things) OR (IoT)) AND (university education)
Scopus	(((TITLE-ABS-KEY (smart AND environments) OR TITLE-ABS-KEY (smart AND classroom) OR TITLE-ABS-KEY (smart AND campus) OR TITLE-ABS-KEY (smart AND e-learning) OR TITLE-ABS-KEY (smart AND library))) AND ((TITLE-ABS-KEY (IoT) OR TITLE-ABS-KEY (internet AND de AND las AND cosas) OR TITLE-ABS-KEY (internet AND of AND things)))) AND (higher AND education AND university)
IEEE Xplore	(smart environments OR smart classrooms OR smart library OR smart campus) AND ((internet of things) OR (IoT)) AND (university education)

2.4 Inclusion and exclusion criteria

In order to improve the accuracy of the bibliographic references to be included in the systematic literature review stage, inclusion and exclusion criteria were defined. These criteria were defined based on a specific time frame of the study, the type of document in which the scientific evidence is published, the level of rigor of the review to which it was submitted, and access to the content of the entire reference bibliography. These criteria make it possible to identify relevant and significant information for the process of systematic review of the literature in such a way that it guarantees that the selected publications are in accordance with the research questions and the study time frame [77] [78]. Table 3 specifies the inclusion and exclusion criteria considered in this review article.

Table 3. Criteria used for the inclusion and exclusion of publications

Criteria	
Inclusion	**Exclusion**
• Publications that specify the degree of improvement after the implementation of intelligent environments with IoT in the university environment. • Published scientific articles in whose evaluation process peer evaluation was considered. • Scientific articles must have been published between 2018 and 2023. • Scientific articles that allow the download of all their content.	• Publications on intelligent environments with IoT in the university environment that only describe the application without evidencing the degree of improvement in the university environment. • Scientific articles that have not gone through a peer review process. Theses, books, and conference articles are not considered. • Scientific articles, which were published before 2018. • Scientific articles in which you only have access to their summary or partial content.

2.5 Quality assessment of scientific articles eligible for the systematic review

As mentioned, in this systematic review article the PRISMA statement was used with the purpose of following a set of phases that lead to establishing the scientific articles that are considered in the phase of review and synthesis of the findings regarding the implementation of intelligent environments through IoT and its impact in the university environment. These phases of the PRISMA declaration are the identification phase, the projection phase, the eligibility phase, and the scientific article inclusion phase.

The first phase consisted of applying the search equations in the ERIC, Scopus, and IEEE Xplore databases and establishing the number of publications. Thus, a total of 1,045 publications were obtained, and after excluding repeat publications from this list, a total of 1,004 publications were identified. The second phase consisted of carrying out a preliminary review of the abstracts of each scientific publication identified in the previous phase. Based on this guideline, we proceeded to select the publications in projection for the systematic review, reaching a total of 769. In the third phase, the inclusion and exclusion criteria were applied to all the publications considered in "projection", thus establishing that 27 scientific articles were "eligible" for the systematic review.

Finally, the fourth phase consisted of rigorously evaluating the quality of the scientific articles selected in the previous phase, which were called "eligible" articles. The purpose of this phase is to eliminate the possibility of bias that may arise in the scientific articles to be included in the processes of review and synthesis of the scientific evidence on the subject under study. Therefore, the instrument validated by [79] was used. In which four aspects to be considered in the evaluation are defined. Adapting it to the subject under study; The following criteria are defined:

Criterion 1: It develops intelligent environments through IoT and applies it to the university environment.

Criterion 2: It shows methodological agreement with the topic under study.

Criterion 3: It specifically shows the arguments that justify its solution proposal.

Criterion 4: The results shown contribute to the topic under study addressed.

This instrument is based on a comparison table in which a score of zero, three, or five points is assigned according to whether it meets the indicated criteria. A value of one means that the scientific article does not meet the criteria requirement; a value of three means that the scientific article moderately meets the criteria; and a value of five means that it largely conforms to the criterion, evidencing an optimal level of quality in the publication. Table 4 shows the score obtained for each article evaluated.

Table 4. Quality assessment of the articles included in the systematic review

Reference	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Total
[80]	3	1	1	3	40%
[81]	3	5	5	5	90%
[82]	3	3	1	1	40%
[83]	1	1	3	1	30%
[84]	5	5	5	5	100%
[85]	3	3	5	5	80%
[86]	1	3	1	1	30%
[87]	1	1	1	1	20%
[88]	1	1	1	1	20%
[89]	3	5	5	5	90%
[90]	3	5	5	5	90%
[91]	5	5	5	3	90%
[92]	1	1	1	1	20%
[93]	3	3	5	5	80%
[94]	5	5	5	5	100%
[95]	1	1	1	1	20%
[96]	5	3	5	5	90%
[97]	3	3	5	5	90%
[98]	5	3	5	5	90%
[99]	5	5	5	5	100%
[100]	5	3	5	5	90%
[101]	3	3	5	5	80%
[102]	5	5	5	3	90%
[103]	3	5	5	3	80%
[104]	1	1	5	1	40%
[105]	1	1	3	1	30%
[106]	1	5	1	1	40%

Of the 27 "eligible" scientific articles that underwent quality assessment, only 16 publications went to the "included" article phase for review and synthesis. By applying this quality instrument, we managed to minimize the risk of bias since the eligible articles are those that are largely related to the research questions established in this review article. Figure 1 shows the results obtained progressively in each phase of the PRISMA statement in general. As can be seen, these guidelines begin with the phase of identification of publications obtained through the search equations in each database and end with the scientific articles included for the systematic literature review.

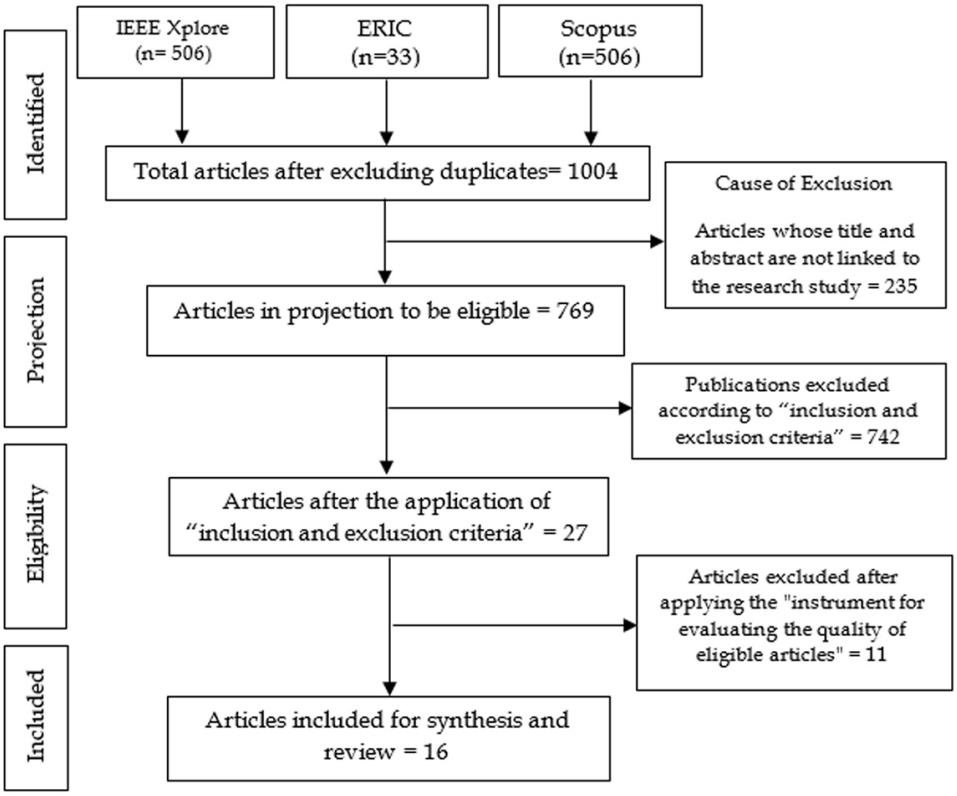

Fig. 1. Results obtained progressively in each phase of the PRISMA declaration

3 RESULTS AND DISCUSSION

Of the 16 articles included for the phase of review and synthesis of scientific evidence regarding the implementation of intelligent environments through IoT in the university environment, it was identified that in recent years there has been an increasing trend in studies in this field of knowledge. Thus, between the years 2021 and 2023, 68.75% of the total scientific articles eligible for this systematic review are concentrated. In addition, in the year 2022, the largest number of publications regarding the subject under analysis will be concentrated, reaching 37.50%. These results show that the pandemic scenario generated by COVID-19 has motivated the development of research related to the use of disruptive technologies with the purpose of building learning environments or environments that offer a greater number of tools and that go beyond a simple virtual classroom. Figure 2 specifies the number of scientific articles included for the review and synthesis phase, grouped by year of publication.

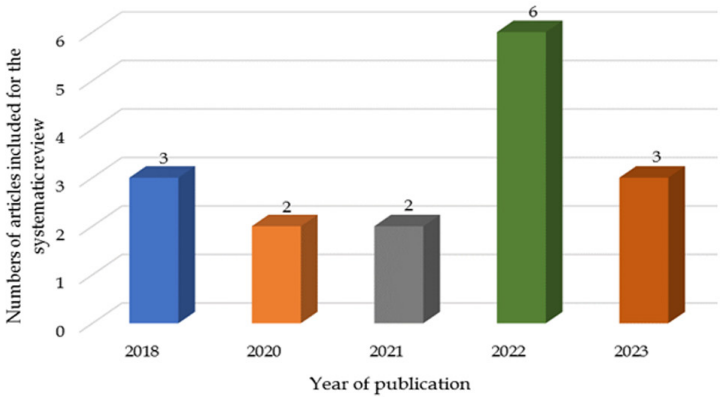

Fig. 2. Number of scientific articles included for the review and synthesis phase, grouped by year of publication

The results obtained in accordance with the research questions defined in the section methodology are presented in this section.

3.1 RQ1: Purpose of the implementation of intelligent environments through IoT in the university education

From the articles reviewed, it was identified that the purpose of the implementation of intelligent environments through IoT can be categorized according to the field of action in the university environment; thus, it was possible to identify three categories in the 16 articles reviewed: teaching and learning process (FOA-1), management of learning environment resources (FOA-2), and optimization of the use of learning environment resources (FOA-3). However, from a quantitative point of view, it was determined that of these three categories, there are some in which the applications of intelligent environments through IoT have been concentrated to a greater extent. Thus, of the articles reviewed, it was identified that 68.75% took FOA1 as their field of action, 25% FOA-2, and 6.25% FOA-3. Figure 3 shows the percentage distribution of articles reviewed by purpose of implementation.

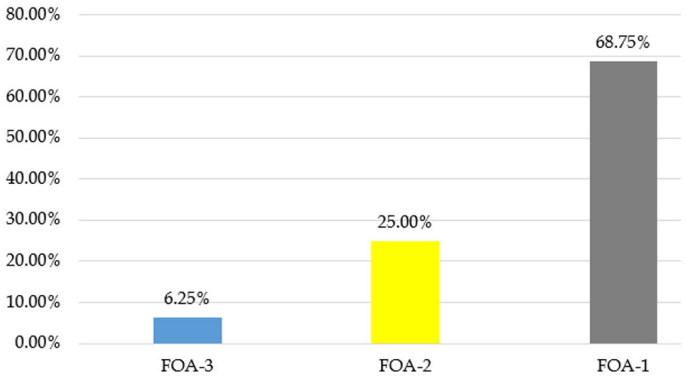

Fig. 3. Percentage distribution of articles reviewed for purpose of implementation

These results show that the intelligent environments developed through IoT in the university environment seek to contribute to a greater extent to the improvement of the teaching and learning process. This is due to the fact that through the IoT technology implemented in classrooms or class laboratories, it is sought to extract information about the development and interaction of students with the resources

provided by the intelligent environment. Thus, according to the articles reviewed, information can be obtained in real time on academic performance, student satisfaction, degree of motivation, and student attention. Being relevant factors that influence the improvement of the teaching-learning process. However, other purposes in which intelligent environments also take part as a field of action in the university environment cannot be left aside. Thus, there is also the resource management of the learning environment, which seeks to provide the teacher or university manager with information regarding the usability of learning platforms, libraries, theory environments, and laboratories. Finally, they also contribute to the optimization of the use of resources in the learning environment, seeking to monitor and analyze information on energy consumption in lighting, the operation of computers or laboratory equipment, all under an approach of rational use of energy, thus contributing to the environment and the health of students, teachers, managers, and university workers. Table 5 shows the categorization of the purpose of the implementation of the intelligent environment based on its field of action.

Table 5. Categorization of the purpose of the implementation of the intelligent environment according to its field of action

Field of Action at the University Level	Purpose of the Implementation of the Intelligent Environment	Reference
Teaching and learning process	Analyze the interactive system assisted by IoT, for the improvement of student learning	[84]
	Develop an IoT-based application for monitoring the interactions of the teaching-learning process.	[85]
	Monitor student satisfaction regarding the implementation of an intelligent classroom through IoT for learning the English course.	[91]
	Identify the variables of a smart laboratory implemented through IoT that influence the motivation, attention and learning of students.	[101]
	Identify the factors that influence teacher performance through the implementation of a smart campus through IoT.	[98]
	Monitor the operation of the flipped classroom developed through IoT to improve the learning of the subject of mathematical logic	[97]
	Develop a monitoring system through IoT for the extraction of data regarding the use of learning resources.	[105]
	Improve student learning through the development of an intelligent classroom through IoT.	[103]
	Improve the practice of physical education through an intelligent classroom based on IoT.	[89]
	Monitor the motivation, participation and interest of the students on the implementation of a smart laboratory through IoT.	[99]
	Monitor student satisfaction regarding the contribution of a smart classroom implemented through IoT, in the learning process.	[102]
Resource management of the learning environment	Monitor the quality and efficiency of the implementation of the smart campus through IoT for student services.	[81]
	Identify the degree of contribution of an intelligent platform implemented by IoT for the improvement of the administrative service to students.	[90]
	Identify the level of student satisfaction on the use of a smart library implemented by IoT.	[93]
	Monitor the use of a smart classroom implemented with IoT, to determine its impact on the learning of the English subject.	[94]
Optimizing the use of learning environment resources	Extract relevant information from users regarding the use of conference rooms in a smart school implemented with IoT technology, in order to optimize energy consumption.	[96]

In relation to the result regarding the purpose of intelligent environments developed through IoT in the university environment, Segundo [107] concludes in his study on a systematic review of the application of IoT technology in higher education

that, of the total number of In the reviewed articles, 40% focused on the use of IoT technologies in the teaching and learning process, 40% on applications in higher education, 10% on general studies of IoT technologies in higher education, and 10% on applications in smart universities. The above supports the results found that, to a greater extent, the purpose of implementing intelligent environments through IoT is focused on improving the teaching and learning process. In this regard, Rico-Bautista et al. [108] point out that intelligent environments developed through technological innovations such as IoT are influencing the teaching-learning process and the interactions between the student and their academic environment, with the purpose of permanently generating and sharing knowledge. Likewise, Herrera [41], in his research on the development of an intelligent educational assistant for the use of IoT technologies in classrooms, concludes that the main purpose of this type of application is that they turn out to be useful as part of learning methodologies, which allow meeting academic objectives to strengthen the teaching and learning process.

3.2 RQ2: Intelligent environments that were implemented through IoT in the university education

In relation to the intelligent environments that were implemented through IoT, it was possible to identify in the articles included for this systematic review what these are: smart classroom, smart campus, smart laboratory, smart e-learning platforms, smart library, smart tutoring system, and smart conference rooms. In addition, when carrying out a quantitative analysis regarding which of all these intelligent environments has been implemented to a greater extent, it was identified that of the total articles reviewed, 43.75% focused their studies on the development of intelligent classrooms. Likewise, 12.50% focused on the development of intelligent campuses, 12.50% on the development of intelligent laboratories, and the same percentage on the development of intelligent e-learning platforms. While, to a lesser extent, smart bookstores were identified with 6.25%, smart tutoring systems with 6.25% and conference rooms also with 6.25%. Figure 4 shows the percentage distribution of intelligent environments implemented through IoT at the university level.

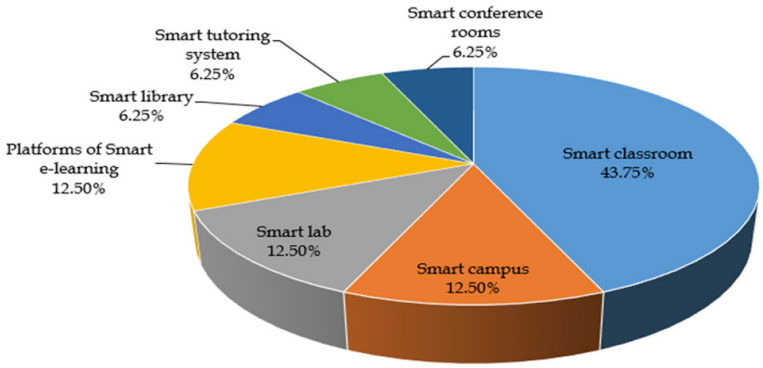

Fig. 4. Percentage distribution of intelligent environments implemented through IoT at the university level

However, when carrying out a deeper content analysis, it was possible to identify that intelligent environments seek to influence in such a way that a positive impact is generated on certain indicators, all of which are linked to the university environment. These identified indicators are student interaction (I1), student participation (I2), academic performance (I3), student satisfaction (I4), attitude for learning (I5), teaching quality (I6), and service quality (I7). Table 6 shows the intelligent environments

implemented through IoT, specifying the indicators on which a positive impact was generated. In addition to this table, it can be determined that, to a greater extent, the indicators on which a positive impact was sought were "academic performance" and "student satisfaction."

Table 6. Intelligent environments and indicators on which a positive impact was generated

Identified Smart Environments	Indicator Influenced by the Smart Environment							Reference
	I1	I2	I3	I4	I5	I6	I7	
Smart classroom	✓	✓						[85]
		✓				✓		[89]
			✓	✓				[91]
			✓					[94]
			✓	✓				[102]
			✓	✓	✓			[103]
				✓				[105]
Smart campus						✓		[81]
	✓		✓			✓		[98]
Smart lab	✓	✓						[99]
	✓	✓						[101]
Platforms of Smart e-learning			✓					[90]
		✓	✓					[84]
Smart library				✓			✓	[93]
Smart tutoring system				✓		✓		[97]
Smart conference rooms				✓			✓	[96]

Regarding the intelligent environments that were implemented through IoT in the academic field, García-Peña et al. [51] point out in their quantitative approach study on IoT as a pedagogical tool for higher education that 81.63% of teachers make use of the intelligent classroom and the intelligent laboratory seeking to facilitate the teaching and learning process. In addition, they specify that IoT applications in the smart classroom generate a positive impact on the academic performance of students, awakening their motivation, autonomy, and assimilation of knowledge. Likewise, Rueda-Rueda et al. [109], in their research under a qualitative approach on IoT in higher education, conclude that of the various relationships that have been developed between university educational institutions and IoT, the administration of educational facilities and resources is the one with the most cases of application. Have been found; And it is that universities around the world are perceiving the positive impact offered by the IoT and are beginning to incorporate it into other processes, such as teaching and learning and monitoring the skills of students in real time. In this regard, Kaur et al. [110] point out that in a traditional class, it is difficult to identify the interest and motivation of the student manually; however, by introducing IoT technology in the classroom to generate the so-called smart classrooms, it is possible to monitor and measure the level of participation. In the same line of opinion, Gallardo et al. [36] point out that smart classrooms cover all areas of the individual, not only academic life, but also have an influence on personal, emotional, and intellectual development and have an impact on society and the environment, with the aim of training efficient, inclusive, and socially responsible people.

3.3 RQ3: Results that evidenced the impact of intelligent environments through IoT in the field of university education

Regarding the results that evidenced the impact of intelligent environments through IoT in the field of university education, of the sixteen scientific articles reviewed, it can be identified that these can be categorized based on their methodological approach and analysis of their results. Thus, the first category is made up of scientific articles whose improvement results are presented qualitatively, while the second category is made up of those that show their results quantitatively. In this way, of the total articles, 62.5% present their results qualitatively, while the articles that present them quantitatively represent 37.5%. Regarding the articles that show the impact of the application of intelligent environments through IoT in the university field in a quantitative way, they focused to a greater extent on evaluating student satisfaction with respect to the contributions that it generated as a tool that contributes to the teaching and learning process. While the articles show the impact of the application of intelligent environments through IoT in the university field in a qualitative way, to a greater extent they focused on the improvement of the motivation, participation, interaction, and attitude of the students, contributing to the improvement of their academic performance. Likewise, to a lesser extent, they focused on identifying the improvements generated by the application of intelligent environments in resource management and sustainable development to improve the quality of the environment. Table 7 shows the results that show the impact of the application of intelligent environments through Internet of Things.

Table 7. Results that evidenced the impact of intelligent environments through IoT in the university environment

Results Obtained	Results Obtained from Intelligent Environments through IoT	Reference
Quantitatively	The intelligent classroom used for the English subject contributes to the improvement of academic performance, achieving in this way that the average grade is 9.2 out of a maximum value of 10. This meant that students are satisfied with the use of this tool in your learning.	[91]
	When evaluating student satisfaction regarding the contribution provided by the intelligent classroom, a relevant level of satisfaction was obtained, since the level of satisfaction turned out to be an average of 4.41 with respect to the maximum value of 5. Therefore, it led to affirm that the smart classroom has a positive impact on the learning experiences of students, improving their performance.	[102]
	When applying a survey to students about their satisfaction regarding the teaching-learning process through the intelligent classroom implemented through IoT, it was identified that on average satisfaction reached a value of 3.5 out of a maximum value of 5 points. This is because through the intelligent classroom it was possible to improve the student's attitude to face their learning process, thus improving their academic performance.	[103]
	By implementing an intelligent library, 83% of undergraduate and graduate students agreed with the service. Therefore, it generated a positive impact on student satisfaction in relation to the quality of service of the library service.	[93]
	The application of the intelligent tutoring system has a positive impact on the improvement of the quality of the teaching of the subject of mathematics. Which is evidenced by 66% of students satisfied with the new tutoring system.	[97]
	By implementing IoT technology in conference rooms, it was possible to save 19% in energy consumption, compared to the previous year. Therefore, it was possible to show that it generates a positive impact on the environment, on the health and well-being of students. Contributing to their satisfaction and improvement of the quality of educational service in general.	[96]

(Continued)

Table 7. Results that evidenced the impact of intelligent environments through IoT in the university environment *(Continued)*

Results Obtained	Results Obtained from Intelligent Environments through IoT	Reference
Qualitatively	The smart classroom contributed to generating greater student participation, as well as greater interaction between them during and after class sessions. It also allowed for better monitoring of student participation in the activities carried out, such as access to class sessions, as well as the use of subject materials, and the delivery of homework.	[85]
	The intelligent classroom improved participation and the attitudes of the students regarding the achievement of their learning of the subject of physical education, improving the quality of teaching.	[89]
	By applying IoT technology in a virtual classroom, it generated a positive impact on the management of educational resources, which was reflected in the improvement of student academic performance.	[94]
	The application of the intelligent classroom generated a positive impact on student satisfaction, reflected in the improvement of learning and academic performance.	[105]
	The smart campus evidenced a significant impact on the perception of the improvement of quality and efficiency in the academic services provided by the university.	[81]
	By using an intelligent campus based on IoT technology, it allows better interaction between students and teachers, as well as improving their academic performance. With which it is possible to improve the process of evaluation of teaching performance, since the data issued by the students allow obtaining a more scientific judgment and with greater precision.	[98]
	The intelligent laboratory allowed a positive impact on the interaction and participation of students with the academic resources provided by the environment. In addition, when applying a student survey on the impact of the laboratory, a positive trend in the scores was evidenced during the five continuous semesters.	[99]
	The intelligent laboratory allowed to monitor and establish the level of influence of the conditions of temperature and humidity of the environment with respect to the attention, motivation and participation of the student in the class sessions. By taking this relationship into account, it was possible to improve such indicators.	[101]
	The smart platform used in classrooms demonstrates that it can significantly control the level of usability of smart environment resources. It was identified that the platform guarantees optimal performance, low latency and high practicality, thus contributing to the improvement of the academic performance of students.	[90]
	By applying smart e-learning platforms overall student performance improved. Attention and participation during class sessions also improved.	[84]

In relation to the fact that the results that evidence the impact of intelligent environments through IoT in the field of university education are linked from a qualitative point of view, to a greater extent with the motivation, participation, interaction, and attitude of the students contributing to the improvement of their academic performance. In this regard, Aldowah et al. [111] point out in their study on the impact of IoT on university education that intelligent environments developed through IoT contribute to a great extent to university education by improving student interaction and motivating them to develop effective learning. Likewise, Abbasy and Quesada [112] of IoT conclude that intelligent environments through IoT will significantly contribute to the meaningful learning of students since they allow access to various resources, which is not possible with traditional learning. However, the final purpose of intelligent environments always aims to contribute to the improvement of learning. Supporting this assertion, Asad et al. [113], in their research on IoT applied to the academic performance of university students, point out that IoT technology in higher education seeks to contribute mainly to the teaching-learning process, seeking knowledge that is in accordance with the requirements of companies and industries. However, it was also identified in this systematic review that intelligent environments contribute to student well-being by monitoring environmental

indicators and better managing resources. In the same line of opinion, Bagheri and Movahed [114] point out that IoT applications generate an impact on university education, one of these categories being the management of energy resources in the ecosystem, monitoring of the resource use, monitoring of mood of students, and improvement of the teaching and learning process.

4 CONCLUSION

In relation to question RQ1, which pertains to the purpose of university educational institutions in implementing intelligent environments through IoT, it can be concluded that these purposes can be categorized based on their area of focus, such as the teaching and learning process, the management of learning environment resources and the optimization of resource utilization. However, all of purposes ultimately converge towards a common purpose that is to enhance the conditions of the learning environment and improve teacher performance. This is achieved by providing bidirectional resources that provide information to the students and by continuously extracting information about student interaction in the classroom. In relation to question RQ2, which refers to the implementation of intelligent environments through IoT in university education, it can be concluded that there has a greater development of intelligent classrooms. This suggests that the trend in IoT applications is not solely focused on isolated platforms, libraries, or intelligent tutoring systems. Instead, there is a comprehensive and holistic vision to provide a wide range of resources that contribute to the teaching and learning process. Finally, in relation to question RQ3, which refers to the results that evidenced the impact of intelligent environments implemented through IoT in the field of university education, it is concluded that although these have focused on improving motivation, participation, interaction, and attitude of the students, closely linked to the improvement of learning, IoT technology also focuses on the conditions of the environment in which the student receives the class sessions, monitoring various environmental indicators that contribute to the improvement of student health.

The results obtained from this systematic review were limited to academic contributions generated by intelligent environments implemented through IoT. Therefore, aspects such as communication protocols, hardware and software tools for their implementation, or interfaces between IoT objects and the intelligent environment were not included in the study. The reason why future studies could use the findings as a reference and is to further research on IoT technology standards in the implementing intelligent environments within the university settings.

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