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Interactive whiteboards in teacher education: a systematic review of technopedagogical practices

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ABSTRACT

Interactive whiteboards (IWBs), or smartboards, improve the teaching and learning process in higher education. The objective of this study was to analyze the use of these whiteboards as a teaching technology resource that contributes to improving this process. A systematic review of the literature was conducted, based on the preferred reporting items for systematic reviews and meta-analyses (PRISMA) methodology. The databases used were Scopus and Web of Science (WoS). The results indicated that 25 studies were included in the review. The year 2019 had the highest number of publications, with 20% of the studies identified. In addition, 80% of the research was published in Scopus and 92% of the total was written in English. There is evidence of the positive impact of IWB on student participation, motivation, and performance, as well as a favorable effect on their academic performance. It is concluded that IWB improve student performance by allowing teachers to make engaging presentations, process curriculum information, incorporate diverse resources, combine text and graphics, and store and reproduce created materials. These devices can capture attention through the use of games and the integration of images, text, and sound during learning. They also influence patterns of interaction between teachers and students, promoting communication dynamics in the classroom.

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1. INTRODUCTION

Currently, much of the world's societies are influenced by information and communication technologies (ICT), including the education sector; hence, many developing nations seek to improve the quality of education in large cities and in rural and remote areas. Therefore, various methods have been developed in the education sector to facilitate and update the work that, at a higher level, focuses on the training of student-teachers in educational technology. The aim is to provide the necessary training to improve teachers' pedagogical and technological knowledge [1], [2].

The innovations achieved aim to learn through the different situations provided in both traditional and electronic classrooms. The latter have become scenarios where a series of tools are deployed, ranging from the use of web 2.0, videoconferencing, Google Classroom, and social networks, to the use of an

interactive whiteboard (IWB), to mention a few. The use of these tools shows how ICTs have been included in teaching and learning activities, creating a rich educational environment with various technological means. In this sense, Pandey [3] points out that currently in universities, professors use classrooms well equipped with projectors, and their facilities are permanently operational. The projectors are used to teach through presentations, videos, and other materials [4], [5].

In turn, the student is encouraged to make presentations supported by these tools to explain the topics to the professors, while being evaluated during the process [6], [7]. The most used ICT tools in higher education are desktops, laptops (portable computers), printers, Wi-Fi, email, MS PowerPoint, scanners, Smart Board MS Office laptop, smart board, interactive board, Google Classroom, USB memory (Pen Drive), Zoom, and WhatsApp [3], [8]. In the specific case of the IWB, also known as smart boards, it is a tool that takes everything you need in a whiteboard and mixes it with the excitement of a touch screen to bring a teacher's classes to life [9], [10]. It is an IWB-like display that reacts to a person's input, either directly or through different devices [9], [11].

This type of tool is intended to make teaching easier and reduce stress on teachers and students. In addition, their use should generate significant changes in both the teacher and the student regarding the way of teaching and learning. Therefore, it is necessary to understand that, during the information society or knowledge society, the practice of the educational process involves implementing activities that modify the traditional dynamics of the classroom, through the design and development of plans and strategies supported by technological innovation.

Currently, communication in many sectors is carried out digitally, making the use of interactive technology an essential skill in university education. The use of IWB, for example, in teaching English as a foreign language, allows students to develop skills in creating digital content, collaborating with others, and using technology as a means to enhance their language skills [12]. In the case of nursing students, IWB facilitate the application of specific procedures and methods to strengthen clinical judgment skills. Their implementation promotes dynamic and interactive learning, both in the classroom and in the simulation lab, and offers various opportunities for students to practice and refine critical thinking and clinical judgment skills [13].

Clinical judgment skills in nursing students can be refined through the use of these visual platforms, as they enable early identification of patterns and signs, promoting team communication and collaborative decision-making; all of which are essential skills for clinical practice [14]. Similarly, in teacher training programs, the literature shows that students rate microteaching and activities with IWB as the most satisfying. The enthusiasm of both students and teachers is evident; in addition to being attractive, classes that incorporate IWB offer great flexibility, as they allow for the use of optional software and the design of activities for any subject, age group, or teaching purpose [15].

For Mun and Abdullah [16], many studies on the use of these boards base their approaches on constructivist theory, as technology-mediated instruction promotes student-centered learning. Furthermore, this theory proposes active learning, where learning is an active progression based on individual cognitive development. Similarly, sociocultural theory has served to justify the use of technological tools such as IWB. This theory proposes that learning that begins with participation in social, cultural, and historical contexts is mediated by interaction. Thus, by using digital whiteboards in teaching, it is possible to build literacy knowledge with different tools that both students and teachers use in everyday life, inside and outside the educational environment [17]–[19].

Similarly, reasoned action theory supports the use of IWBs and, based on this, the technology acceptance model was created. For Panjaitan *et al.* [20], this theory became the basis for researching individual behavior in the use of information technologies. For their part, Erdener *et al.* [21] developed and validated a scale of perceived attributes of IWBs using the theory of diffusion of innovations. This theory explains how a new idea or innovation is accepted and identifies five factors (perceived attributes) that are essential for adopting an innovation. These are: relative advantage, compatibility, complexity, trialability, and observability.

The theory of planned behavior, social cognitive theory, technology acceptance model, technology acceptance and use theory, theory of reasoned action, and technology acceptance model stand out and have been used to test and understand the acceptance and use of technology integration in teaching and learning. All these theories in research on the use of IWBs provide a conceptual framework that allows different subtopics to be addressed in order to identify their use as an e-learning tool for teaching and learning. Likewise, its postulates allow us to understand the influence that cognitive and social factors have on the intention of the student or individual to adopt and use a new technology.

Based on the above, it is essential to examine the literature on the use of IWBs, and thus analyze their contribution to the improvement of the teaching-learning process. These objectives will be addressed through a systematic review of the literature. This type of review is ideal for a comprehensive summary of

current literature and for answering a research question. The process followed to synthesize information from a study is rigorous and transparent, as the aim is to evaluate and minimize bias in the findings [22], [23]. Based on the above, the following research question is posed: how do IWBs influence teaching practices in teacher training programs? The objective has been to analyze the use of IWB as a techno-pedagogical resource that contributes to improving the teaching-learning process of future teachers.

2. METHOD

A systematic review of the literature was carried out since this type of review is aligned with a qualitative research methodology that is appropriate to the scope of the proposed objective. In addition, it makes use of systematic processes that allow the collection of information, assessing the chosen studies, synthesizing the most relevant findings, and correlating them [24]. Likewise, for the search process, the review was supported by the preferred reporting items for systematic reviews and meta-analyses (PRISMA) methodology [25], which consisted of three stages: identification, selection, and inclusion. The purpose of this review was to analyze studies related to the use of IWB and its contribution to improving the teaching and learning process.

Once the research questions and objectives were established, the databases, the selection criteria for the primary studies, and the search parameters were chosen. The literature search began in January 2024 and ended in November 2024, was conducted in the scientific databases Scopus and Web of Science (WoS). The choice of these platforms was because both have a global scope, are the only ones that cover all areas of knowledge, and have the necessary metadata to perform detailed bibliometric studies [26].

The keywords used in the article search process were the following: digital IWB, technology, training, teacher-student, educational technology, and ICT. Boolean search terms, including AND and OR, were used; their use allowed for limiting and broadening the scope of the findings. The search equation was as: (‘interactive whiteboard*’ OR ‘teacher-student*’ OR ‘technolog*’) AND (‘educational technology*’ OR ‘training*’ OR ‘information and communication technologies (ICT)*’).

2.1. Inclusion and exclusion criteria

After reading the abstracts of the 721 peer-reviewed articles, only 25 relevant studies were chosen for inclusion in this review, as in Figure 1. The following inclusion criteria were used: peer-reviewed journal articles focused on the use of IWBs, whose sample is constituted by teachers and students in training or service; studies published in English and Spanish; published between 2015 and 2024; that they are empirical and review studies; and that they are available in open access journals and belonging to the Scopus and WoS databases. The search was not only focused on empirical studies but also included theoretical-documentary publications and revisions that analyze the use of IWB as techno-pedagogical resources that contribute to improving the teaching-learning process. The exclusion criteria were as follows: grey literature (master’s theses, doctoral theses, conference papers, and book chapters) and studies not published in English or Spanish will not be considered.

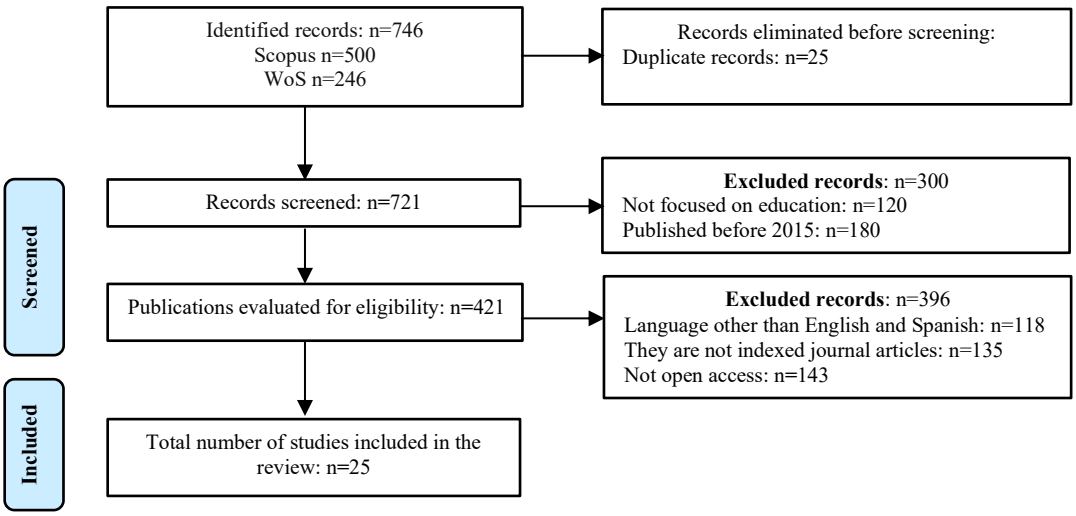

Figure 1. PRISMA flow diagram

We then proceeded to extract and synthesize data from the 25 selected studies, focusing on the results achieved on topics, approaches, technological tools, and the use of IWBs to improve the teaching and learning process. The search process yielded a total of 746 initial studies, considering the descriptors and search criteria (500 belonging to Scopus and 246 to WoS). After eliminating duplicates (n=25) 721 articles remained for screening, after being reviewed 300 were excluded, mainly for not focusing on the educational area (n=120) and for having been published before 2015 (n=180). After this second process, 396 were eliminated for being in a different language than the one presented in the eligibility criteria (n=118), for not being in indexed journals (n=135), and finally, for not being open access (n=143). A total of 25 articles were included in the review, as in Figure 1.

3. RESULTS AND DISCUSSION

The documents were analyzed taking into consideration the authors/years of publication, source (name of the journal), database, type of study, and language of publication. Each of these aspects helped answer the first question posed, as in Table 1. Furthermore, this information concisely characterized the literature reviewed on the use of IWB in the teaching and learning process.

3.1. Quantitative data on the use of interactive whiteboards as a techno-pedagogical resource

Studies related to the use of IWB were published between 2015 and 2024. In that aspect, the year with the highest scientific production was 2019 with 20% (5). Figure 2 presents the articles published by year.

Table 1. Consolidated data on the reviewed articles

Author	Journal	Database	Language
[18]	Technological Information	WoS	Spanish
[27]	Migration Letters	Scopus	English
[28]	International Journal of Learning, Teaching and Educational Research	Scopus	English
[29]	Indian Journal of Natural Sciences	WoS	English
[30]	Heliyon	Scopus	English
[31]	AIP Conference Proceedings	Scopus	English
[32]	International Journal of Information and Education Technology	Scopus	English
[33]	Interactive Technology and Smart Education	Scopus	English
[34]	Cypriot Journal of Educational Sciences	Scopus/WoS	English
[35]	European Journal of Educational Research	Scopus	English
[36]	International Symposium on Educational Technology (ISET)	Scopus	English
[13]	Teaching and Learning in Nursing	Scopus	English
[37]	Research in Science Education	Scopus	English
[38]	International Journal of Information and Education Technology	Scopus	English
[39]	International Conference of Educational Innovation through Technology (EITT)	Scopus	English
[40]	Revista Luz	Scopus	Spanish
[41]	Automation in Construction	Scopus	English
[42]	Social Work Education	Scopus	English
[43]	Review of International Geographical Education Online (RIGEO)	Scopus	English
[44]	Participatory Educational Research (PER)	Scopus	English
[45]	European Journal of Contemporary Education	Scopus/WoS	English
[46]	International Journal of Technology Enhanced Learning	Scopus/WoS	English
[47]	Journal of Computers in Education	Scopus	English
[48]	Computers in Human Behavior	Scopus	English
[49]	IEEE Access	Scopus	English

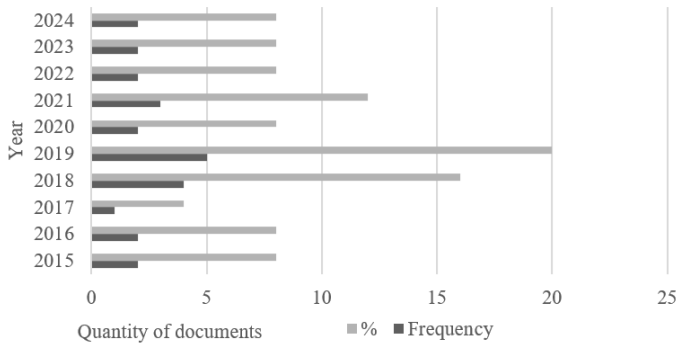

Figure 2. Number of articles according to year of publication

Regarding the database in which the studies are included, it is observed that the authors choose or prefer to publish their studies in Scopus since most of the reviewed papers 20 (80%) were published there. On the other hand, only 2 articles (8%) were published in WoS; while 3 studies (12%) belonged to journals indexed in two databases (Scopus/WoS), as in Figure 3. These results highlight, on the one hand, the interest that Scopus-indexed journals have in technological topics at the educational level; and on the other hand, the importance of this database as a publication option for researchers.

Regarding language, 23 articles were published in English, while only 2 were published in Spanish. Thus, it is evident that the English language dominates the production of scientific articles on this topic (92%), while publications in Spanish are insignificant and represent a scant 8% of the total number of published documents. The review showed that the most representative type of study is quantitative. In these studies, the samples consisted of both teachers and students; however, it is noteworthy that in 15 of these publications, the sample consisted of teachers, and therefore, the study focused on them. Only in 6 documents was the sample made up of students. Likewise, the largest sample of teachers was found in Al-Rabaani [35], with 483; and the most representative sample of students was observed in the study by İpek and Sözcü [45], with 1,013. Finally, the works of Cala *et al.* [18] and İpek and Sözcü [45] included a sample composed of both teachers and students. Regarding the instruments, 16 investigations used the questionnaire, two the tests, and four the surveys, as in Table 2.

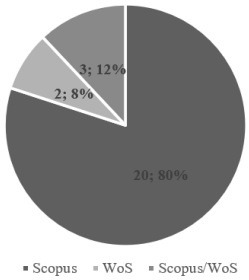

Figure 3. The database used to publish the articles reviewed

Table 2. Descriptors of the articles selected for review

Author	Methodology	Sample/instruments
[18]	Quantitative	25 teachers and 206 students. Questionnaire
[27]	Quantitative descriptive	357 teachers. Questionnaire
[28]	Quantitative descriptive	47 students. Performance test
[29]	Quantitative	215 students. Questionnaire
[30]	Qualitative	80 teachers. Interviews
[31]	Quantitative	40 teachers. Questionnaire
[32]	Quantitative	224 teachers. Cross-sectional survey
[33]	Qualitative	3 teachers. Interviews
[34]	Quantitative	124 teachers. Questionnaire
[35]	Quantitative descriptive	483 teachers. Questionnaire
[36]	Systematic review	23 items
[13]	Mixed	89 students. Interviews and the Lasater Clinical Judgment Rubric (LCJR)
[37]	Qualitative	9 students. Recordings
[38]	Quantitative	344 participants. Questionnaire
[39]	Quantitative, quasi-experimental	93 students. Test
[40]	Documentary review	
[41]	Quantitative	45 participants. Surveys
[42]	Qualitative	81 students. Interviews
[43]	Quantitative	101 teachers. Surveys
[44]	Quantitative	887 students. Surveys
[45]	Quantitative	1013 students and 65 teachers. Questionnaire
[46]	Quantitative	123 teachers. Questionnaire
[47]	Quantitative	252 teachers. Questionnaire
[48]	Quantitative	246 students. Questionnaire
[49]	Mixed, quasi-experimental	90 students. Pre and post-test

3.2. Influence of IWBs on teaching practices in teacher training programs

The following is an overview of the findings obtained in the review on the use of IWB in the training of student-teachers in educational technology. There are numerous studies on smart education, specifically, on the use of ICT tools such as IWB. The findings are oriented to the positive impact they have

on student participation, motivation, and performance, as well as their positive effect on students' academic performance. However, as of 2021, a decrease in scientific production on the subject has been observed, so it is important to establish their contribution to the training of student-teachers in educational technology.

Similarly, the results show a combination of three subject areas: technology (IWBs, uses of IWBs in education, educational technology, and ICT integration), training of teacher education students in technology (teachers, students, teacher training, higher education), and the influence that the use of IWPs has on teaching practices developed in teacher training programs. These thematic areas facilitate a better analysis of the uses of IWBs in higher education and their potential to promote better academic performance.

3.2.1. Technology in education

Concerning technology, it was observed that in the educational field, a large part of these tools is framed in ICT. Their expansion has accelerated in the last decade, due to the use of various applications, such as Web 2.0 and the IWB. The latter has become an essential part of digital classrooms, as it allows constant innovation in teaching practices, greater motivation and attention from students; it also offers versatile tools to support different learning styles [18], [30], [31]. For Al-Kahlan and Khasawneh [27], their inclusion was mainly aimed at helping teachers plan each pedagogical activity and involve students in it.

IWBs are characterized by being composed of a touch-sensitive layer that functions as a computer system, as it can store the information that has been written on it. The IWBs have a board that is connected to electricity; a USB cable allows its connection to a laptop, which in turn is connected to a video projector and a pointer control device, which facilitates the projection of digital content on the interactive surface. Once the smart board is connected and recognized by the laptop, the image is projected onto it; then, the teacher or students can use pens or their fingers to write on the board, select a website, underline, and highlight. The software used in this type of tool includes multi-touch technology, which allows up to four students to write on the screen at the same time [50]–[52]. In addition, it is used in presentations or learning materials. It is also possible to record material presented during lectures [34]. This benefits the students, as they can then revisit the material to review and analyze it in a better way.

The IWB combines several features and functions of a computer, a whiteboard, and a projector in a single system [49]. This combination of three technological tools is very useful when sharing any instruction, whether visual, auditory, or tactile. Shi *et al.* [39] go a step further and propose that these boards are touch screens with multiple capabilities, integrating the functions of traditional whiteboards, flipcharts, dry-erase boards, and video players. The board is operated as a projection and its use is monitored by software installed on a computer. In addition, the software allows recordings to be made during the presentation, which integrate the presenters' voices, as well as existing and edited presentation materials [32], [36].

On the other hand, the IWB software includes functions that allow the teacher or student to write, underline, or draw. For this purpose, it has colored pencils that are used to write by hand, hide and show tools, drag and drop, as well as a web browser, instant screen capture, and interactive exercises. Among the most outstanding features is its ability to make lecture presentations and interactive Zoom technology. In addition, it can transform handwriting into text on the screen, and even transform what has been typed into images [47].

Despite the advantages offered by IWB, Torres *et al.* [53] demonstrated that they have not been able to replace traditional blackboards due to the limited resources available to some institutions, as well as the fact that students and teachers show little motivation and deficient training in the use of these technologies. Similarly, they state that, in the case of teachers, the effort made when planning classes is affected by their knowledge and skills acquired during technological training. This occurs because, given an inadequate training process, the professional feels frustrated, since he/she does not manage to master the technical resources of the IWB correctly. This research was able to establish that 97% of the teaching staff did not know the operating system installed on the IWB.

Its use has highlighted the attitude of many teachers towards ICT since a large percentage of them are called "digital immigrants" [54]. Moreover, after the emergence of the COVID-19 pandemic, it was necessary to increase training in individual competencies related to the use of ICT, both for teachers and students. This is because the lack of training is not only present in immigrant teachers but also in digital native students [55].

3.2.2. Technology training for teachers

Regarding student-teacher training in technology (teachers, students, teacher training, higher education), Vásquez *et al.* [40] point out that teachers should be trained to adapt methodologies and make the most of the resources provided by (ICT). On the other hand, Poveda-Pineda and Cifuentes-Medina [56] explain what is known as relationship, information, and communication technologies (RICT), which have become a determining factor to validate the formative process of future teachers. The term RICT highlights the relational factor that exists in digital communication, which integrates some indicators that intervene in

the creation, development, and maintenance of existing relationships in learning processes. Thus, the study carried out by these authors showed that the training model used in student teachers required gradual changes, ranging from the use of Moodle as the main management system to manage learning, to training to design pedagogical scenarios in which the reality and teaching practice of future graduates is evidenced.

The results derived from the study by Poveda-Pineda and Cifuentes-Medina [56] are congruent with the research by Al-Rabaani [35], who states that IWB are more beneficial if teachers know how to use the technology; hence the importance of technological training for both teachers and students themselves. Some studies point out that the use of IWB presents some difficulties and disadvantages. For example, Mohite and Raverkar [29] state that these disadvantages are basically due to two reasons: one of them is the time needed to prepare the course material by teachers, since compared to traditional teaching methods, this requires a greater amount of time. The second reason has to do with the lack of teacher training.

Likewise, Al-Rabaani [35] points out that teacher training programs for using the IWB do not keep pace with the constant changes that technology is currently undergoing. There are educational institutions eager for technological innovation that often purchase IWBs systems without considering that the staff requires prior training, resulting in a useless and quite costly acquisition. In turn, teachers end up dissatisfied because they do not know how to handle this type of whiteboard, which hinders their adoption, even if they are available in classrooms.

This shows that the potential benefits of the IWB are hindered by poor integration in teaching and learning due to poor teacher training. These difficulties demonstrate the need for training programs to expand the use of IWB [39]. Both studies [35], [39] employed the quantitative approach; one of them adopted a descriptive design [35] and the other, a quasi-experimental design [39]. This approach made it possible to analyze two main aspects. The first focused on the opinions of a group of teachers on the advantages and challenges associated with the use of the IWB in the classroom. The second addressed the effects of IWB-supported instruction on students' academic performance.

On the other hand, a group of teachers in rural areas assumed that the operation of the use of IWB was more complicated in teaching and learning activities due to the conditions of the institution. This finding was in line with the study of Olelewe and Okwor [47], who established that this situation was due to the lack of ease in increasing the intention to use the IWB. In addition, teachers were more willing to use it if they had adequate infrastructure, training, and tools to implement it. It is worth noting that the study by Olelewe and Okwor [47] presented a methodological limitation, since most of the participants apparently did not have sufficient experience in the use of IWB, which could have affected the generalizability of the results obtained. In view of this situation, the authors recommended that future research on teachers' perceptions of the IWB use a purposive sampling to select only teachers with experience in its use in their academic activities.

On the other hand, the technological training of students in the use of the IWB stands out. In this regard, Cala *et al.* [18] point out that the teacher plays a preponderant role in this regard since he/she is responsible for preparing his/her students to learn content, providing them with the necessary technological tools that facilitate such learning. For example, in primary school, the teacher must have previous training in ICT, in addition to being willing to innovate with the support of new technologies to introduce children to the use of IWBs [33], [45], [51]. For their part, university teachers can guide the teaching process of students by showing them that the IWBs will allow them to visualize and even interact with any type of document, internet, or information in different formats, such as multimedia presentations, disk documents, or videos [30], [40], [47].

In support of this, the study by Torres *et al.* [53] showed that there is a direct correlation between the teacher's level of technical training for IWB, their frequency of use, and the use of interactive functions of IWBs by their students. When teachers train their students through the appropriation, implementation, and use of new technologies, it is possible to foster conditions for quality education, emphasizing the development of human capabilities. Some of these include affective, cognitive, volitional, and value-based abilities; from these, it is possible to generate training in skills and competencies to perform effectively in the world of work.

The studies examined found a positive impact between the use of IWB and student learning outcomes, which becomes a valuable techno-educational resource derived from ICTs, and which has strongly entered the educational environment and professional training in the 21st-century [18]. In contrast to this statement, the study by Luo *et al.* [30] presented contrary opinions from teachers, who sometimes expressed a perception of uselessness regarding the use of IWB. They noted, for example, that it "does not facilitate English learning" or that it "negatively impacts learning". As they explained, students tend to be distracted initially due to the surprise factor, which makes it difficult for the teacher to regain the attention and learning process of each student. In addition, they indicated that students' curiosity and interest can quickly disappear once they become familiar with the stimuli, since the IWB does not offer constant novelty.

It should be noted that the nature of the studies reviewed shows certain methodological weaknesses that limit the generalizability of the results. In this sense, the research developed by Cala *et al.* [18] was

essentially exploratory in nature, which restricted, to a certain extent, the robustness of the conclusions presented. A similar situation was observed in the study by Mohite and Raverkar [29]. The abundance of descriptive studies analyzed highlighted the need to carry out similar research in different subjects and educational levels, as observed in the works of [29], [33], [35]. In the same vein, Luo *et al.* [30] suggested that future studies should contemplate the diversity of participants' backgrounds.

On the other hand, Zincume and Marimuthu [32] collected and analyzed data at a South African university, which precludes extrapolating the results to other institutions in the same country. Therefore, they recommend working with a larger sample of academics from a variety of universities to allow generalization of the findings to the South African higher education system as a whole. This recommendation is supported by Redman and Vincent [33], as well as Malkawi *et al.* [34] who also stress the importance of expanding the number of participants in the samples.

3.2.3. Impact of the use of interactive whiteboards on student achievement

The use of IWB is perceived positively and the studies reviewed demonstrate this, since they have a positive impact on both motivation and student achievement. That is, by integrating IWBs and the interactivity provided by technology in teaching and learning, it is possible to maximize the motivational effect of students, as well as their academic performance [29], [39], [49]. However, the use of the IWB to contribute to the success of the educational process is based on the teacher's ability to prepare and present the educational material and strategies in a sequential and direct way with the purpose of achieving the desired educational outcomes [28], [29].

Among the advantages offered by IWBs is that they allow students to participate in different learning activities during classes. In the case of higher education, it favors class participation, allowing them to play a more active role in their learning. In addition, it helps to overcome many obstacles when presenting educational content and provides flexibility to present it in an attractive way, thus facilitating the assimilation and understanding of the knowledge imparted [4].

Likewise, the use of the various functions provided by IWB, such as videos, images and simulation tools, significantly improves the comprehension of the learning material [4], [5]. This is because these whiteboards allow the presentation of the content in a visual way, making the concepts worked on clearer and as realistic as possible. The functions available on the IWB help teachers reduce the time spent on preparing teaching materials and allow students to learn with pleasure, all of which can have a positive impact on their academic performance.

Similarly, the review established that IWB can help in the training of future teachers. Compared to other teaching methods, IWB is a relatively new teaching tool, but it is widely used in some higher education institutions. Its effect on student achievement has been extensively explored and shown to be positive. According to the evidence reported in the articles, a positive impact of the use of the IWB on student performance was observed.

However, the advantages of integrating the use of IWBs in teaching will depend on the quality of teacher professional development offered in this area. In this regard, Olelewe and Okwor [47] showed that the majority of faculty (68%) who participated in their study perceived IWBs as an important ICT tool for teaching in higher education institutions, and 61% of the participants agreed that it enables them to actively participate in their teaching practices. However, they noted a serious deficiency in the ICT skills needed for their effective use, largely due to lack of institutional support and inadequate power supply. Finally, they established that the lack or underuse of IWB translates into poor learning outcomes for students in most courses.

On the other hand, Latin America stands out for not having enough studies on the use of IWBs in higher education institutions. This is confirmed by Mendoza *et al.* [57] when they point out that there are no previous studies conducted in Peru and Latin America that explore, contrast, and show the perceptions of teachers and students on the use of, for example, the blackboard collaborate tool. Rojas-Segovia and Romero-Varela [55] conducted a literature review on teacher motivation in the use of IWB and found no studies on this topic in Peru. They therefore turned to international studies, reviewing the factors related to the facilities and obstacles observed, with the aim of encouraging future studies on the use of this tool for adaptation to new demands and with a technological approach in current education.

3.2.4. Pedagogical improvements with the use of interactive whiteboards

The use of IWB at different educational levels has a positive and significant influence on the attitudes of students in training towards educational technology. This effect is due to various factors, including their familiarity with current technologies and their frequent use in different everyday activities. When teachers use IWB, it improves visual quality, content specificity, and the resolution of doubts, which contributes significantly to better academic performance among students. Although IWBs are used in more

curricular areas in primary school classrooms than in universities, there is great potential for integrating IWB training into various areas of initial training for future teachers.

A clear example of the improvements achieved through the use of smartboards can be found in the study by Abdullah *et al.* [49], who designed and developed an active learning instruction with a smartboard (ALuSB program) to enhance higher order thinking skills (HOTS) in data management among students. This program proved to be the most effective method compared to active learning instruction and the conventional learning method. It promotes active and autonomous learning among students, encourages learning through practice, enhances HOTS, and facilitates peer exchange.

In terms of teachers' perceptions, the findings of this review show a positive attitude and a high degree of satisfaction with IWBs among most teachers. Preparing lessons, teaching, engaging, and motivating students is easier when using these boards. In this regard, it is recommended that professional development sessions on IWB be held on an ongoing basis to enable teachers to learn about their benefits and effectiveness for teaching practice [46].

Interactive or smart boards are most effective when teachers are proficient in their use, hence the importance of technological training for both teachers and students. In the case of teachers, they must be trained to know how to prepare the material they will use when handling the whiteboard, so its advantages will depend on having qualified teachers, i.e., teachers who are sufficiently prepared to adopt and apply this tool in pedagogical environments. It is clear, then, that training in IWB should become a feature of teacher training courses for these future teaching professionals. However, although these whiteboards are not integrated into all higher education classrooms, their number is increasing every year, making them an extremely important teaching tool. Their use requires teachers to have the skills and pedagogical understanding to use them effectively.

The need to improve the skills of future teachers with IWB should result in the design and implementation of refresher programs integrated into teacher training courses. Educational policies should be geared toward providing constant access, technical support, and ongoing professional training in the use of these whiteboards. In addition, staff should be given time to explore their benefits and to provide and receive support from both their colleagues and management. All these aspects taken into consideration can improve future teachers' confidence levels, their perception of the usefulness of IWB, and their attitudes towards them. Finally, in the future, university institutions and educational centers could seek to establish collaborative links with the aim of ensuring that future teachers take advantage of the experience of practicing teachers who use these technological tools and are competent in their use.

4. CONCLUSION

The model of technological instruction based on the use of the IWB has been studied among teachers at different educational levels. The review synthesized the findings of 25 peer-reviewed studies. These empirical and documentary research articles made it possible to summarize the information found on the use of IWB as technological pedagogical resources that contribute to improving the teaching-learning process. The review showed that IWB are highly effective teaching and technological tools, as they meet the requirements for fostering a culture of information among students. In addition, they allow teachers to give engaging presentations, process information from the curriculum, incorporate data from different applications, combine text and graphics, and store and reproduce materials created when necessary.

IWB perform various functions in primary, secondary, and higher education, including demonstration, training, implementation, and activity control. The improvements achieved through their use encompass both practical aspects and teacher-student interaction. On a practical level, they stand out for their ability to capture students' attention through the use of games and the combination of images, text, and sounds during learning. On a communicative level, IWBs influence the patterns of interaction between teachers and students, promoting a dynamic of communication in the classroom and contributing significantly to learning outcomes. Likewise, the review made it possible to establish that the use of the IWB as a vital ICT tool requires, necessarily, an updated teaching staff to teach with the support of this tool. Some of the studies reviewed showed that the skills possessed by a certain group of teachers regarding the effective use of the IWB were quite low; this has resulted in the non-use or underuse of IWB in institutions that have them. Adequate technological training, not only at the technical level but also at the pedagogical level, is essential to generate true innovation in education and achieve the objectives established by the educational system. However, all of this will depend on the ability of universities to equip classrooms with the IWBs that best suit the needs of their students and to evaluate their relevance in terms of cost-benefit ratio.

Likewise, the literature highlighted the latest developments in IWB technology, which has been used in innovative ways to enhance the educational experience. Among these developments is, for example, the use of IWBs to create virtual field trips, allowing elementary and middle school students to visit and travel around the world without leaving the classroom. At these educational levels, they are also used for

games and interactive activities. At the university level, IWBs promote the development of virtual reality experiences, allowing students of architecture, medicine, graphic design, and other specialties to explore different situations and scenarios in an immersive way. In higher education, online collaboration is essential, and IWBs allow students to work together on projects in real time. The technological and educational possibilities provided by these boards, coupled with their new versions supported by artificial intelligence, reflect better horizons for 21st-century learning.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
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CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

DATA AVAILABILITY

The authors confirm that the data supporting the findings of this study are available within the article.

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