Revista Española de Educación Médica

UNIVERSIDAD DE MURCIA

Assessment in medical education from the virtual context: a systematic review

Evaluación en la educación médica desde el contexto virtual: una revisión sistemática

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Received: 5/6/24; Accepted: 6/27/24; Published: 1/7/24

Summary: Assessment is one of the most studied topics by the scientific community due to its complexity and impact on learning. In virtual contexts, evaluation has been the subject of analysis in several higher education studies to understand its implementation with the use offered by technologies. Although the contributions on this topic are applicable to all educational areas, the evaluation may vary according to specific didactic and pedagogical factors, as is the case of medical education. In this direction, there is a lack of theoretical research that determines trends in evaluation in medical education in virtual contexts. This research contributes to solving this theoretical gap through a systematic review. To do this, the PRISMA protocol was applied to studies present in the Web of Science Core Collection (2018 - May 2023) and a content analysis was carried out on the scientific literature (n = 46). The results showed similarities in evaluative tendencies in virtual contexts in both higher education and medical education. It is concluded that evaluations with the use of multimedia resources, online exams, through games, through videoconferences, educational platforms and flipped learning are evaluative trends in virtual contexts similar to general education studies. However, it is highlighted that evaluation based on simulations, artificial intelligence, virtual and augmented reality are the most accentuated trends in medical education.

Keywords: evaluation ; virtual learning ; medical education ; virtual evaluation ; higher education

Abstract: Assessment is one of the most topics studied by the scientific community due to its complexity and impact on learning. In virtual contexts, assessment has been a focal point of analysis in several higher education studies to understand its implementation with the benefits offered by technologies. While contributions on this topic are applicable to all educational environments, assessment can differ based on specific didactic and pedagogical factors, such as in medical education. Consequently, there is a lack of theoretical research determining trends in assessment in medical education in virtual contexts. This research aims to address this theoretical gap through a systematic review. The PRISMA protocol was applied to studies in the Web of Science Core Collection (2018 - May 2023) and a content analysis of scientific literature (n = 46) was conducted. The results showed similarities in evaluative trends in virtual contexts both in higher education and medical education. It is concluded assessments using multimedia resources, online exams, gamification, video conferencing, educational platforms, and flipped learning are evaluative trends in virtual contexts similar to general education studies. However, assessment based on simulations, artificial intelligence, virtual and augmented reality are the most pronounced trends in medical education.

Keywords: evaluation; virtual learning; medical education; virtual evaluation; higher education

1. Introduction

Evaluation is conceived as a complex and necessary activity in learning, since it contributes, among other factors, to the academic performance and motivation of the student body. In virtual contexts, evaluation is one of the concerns of teachers regarding its implementation with the opportunities offered by technologies (1). Systematic reviews in higher education studies on assessment in virtual contexts have determined the types, modes and formats of assessment (2-3). However, although the studies are interesting for the scientific community, they are general and perhaps not entirely applicable to specific didactics, as is the case of medical education.

In medical education, evaluation in virtual contexts acquires relevance due to the nature of clinical practice and the increase in the adoption of technologies in recent years (4). Traditionally, although there are various types of evaluation in Medical Education, the most used is characterized by being type (5):

- Diagnostic. Prior to the training process to explore the knowledge and skills that students have.
- Formative. To assess the progress of the training and development of knowledge, skills and competencies that the student body is having.
- Summative. It allows teachers to promote a final judgment of the student's development based on their school performance in carrying out learning activities.

These forms of evaluation are based on the zone of proximal development and the potential that students have in their learning, allowing the teacher to design learning activities, the adaptation of content, collaborative work and the use of active methodologies. Educational research indexed in the Web of Science (WoS) reports the use of various forms of evaluation with multimedia resources (6), telemedicine or telesimulation (7-8), flipped classroom (9) and open-book online exams (10) , among other. However, in scientific research there are more systematic reviews in general educational studies than those related to medical education. In this sense, there are few systematic reviews that determine trends in evaluation in medical education in virtual contexts. The authors of the present study identified three reviews related to the topic in question (11-13). In the first review, a summary of evaluation methods in medical education to measure the effectiveness of e-learning is made, but the research is limited to 2017. The second examines the evaluation methods of e-learning to measure the effectiveness of online education and aspects of program content are discussed; However, information on the forms of evaluation used is limited. The latter discusses virtual global health education activities, but details about the evaluative activities are not described. Therefore, through this systematic review we aim to determine the trends in evaluation in medical education in virtual contexts.

2. Methods

The PRISMA protocol (14) was used through a three-phase design.

Phase 1. Extraction of scientific information from the WoS Core Collection. The research questions, inclusion and exclusion criteria and search strategy were formulated.

2.1. Research questions

Question 1: What types of evaluation (diagnostic, formative and summative) predominate in the scientific literature?

Question 2: What are the educational resources, learning methodologies and technologies used in evaluation in medical education in virtual contexts?

Question 3: How has evaluation been carried out in medical education in virtual contexts?

2.2 Inclusion and exclusion criteria

Publications on evaluation in medical education in virtual contexts were included; in English or Spanish language; indexed in the WoS, free access and full text. Studies implemented with in-person evaluations were excluded; research with little experimental or theoretical scope (tutorials, conference proceedings, comments, opinions, editorial notes, letters to the editor, essays, meta-analysis, systematic reviews and narratives); studies that do not argue their results or are not related to medical education.

2.3 Search strategy

Combinations between the logical operators AND/OR were used. The keywords were virtual assessment, virtual evaluation, online evaluation, elearning, medical education, medical science. And in Spanish, virtual assessment, online assessment, virtual learning, medical education, medical sciences. The following text was used, in the Education & Educational Research category and the MESH Education descriptor:

TITLE (virtual assessment OR virtual evaluation OR online evaluation OR elearning OR virtual evaluation OR online evaluation) AND ABSTRACT (medical education OR medical science OR medical education OR medical sciences).

Phase 2. Classification, synthesis and grouping of scientific information data.

The classification procedure began with the analysis of the title, summary and keywords in response to the objective. To reduce bias, this analysis was developed by three researchers (authors of the research) so that in case of divergences, they could rely on the judgment of a third party. The in-depth analysis of the relevant contents was stored in a data matrix as established for synthesis and grouping (15). Among the stored information, the type of evaluation, authors, publication date, evaluation means, educational resources, learning methodologies and technologies stood out.

Phase 3. Analysis of the validity of the data.

A form was developed according to the keywording technique (16) and the criteria established by the Joanna Briggs Institute (15) to reduce the threat of internal and conclusion validity. Regarding external validity, those articles that were not very descriptive and that did not validate or argue their results were discarded. The VoSViewer tool was used to represent author keyword networks.

3. Results

The analysis carried out in this research is based on a qualitative methodology. In the implementation of the search strategy, 46 studies were selected (Figure 1), all in English and 72.3% correspond to the last three years.

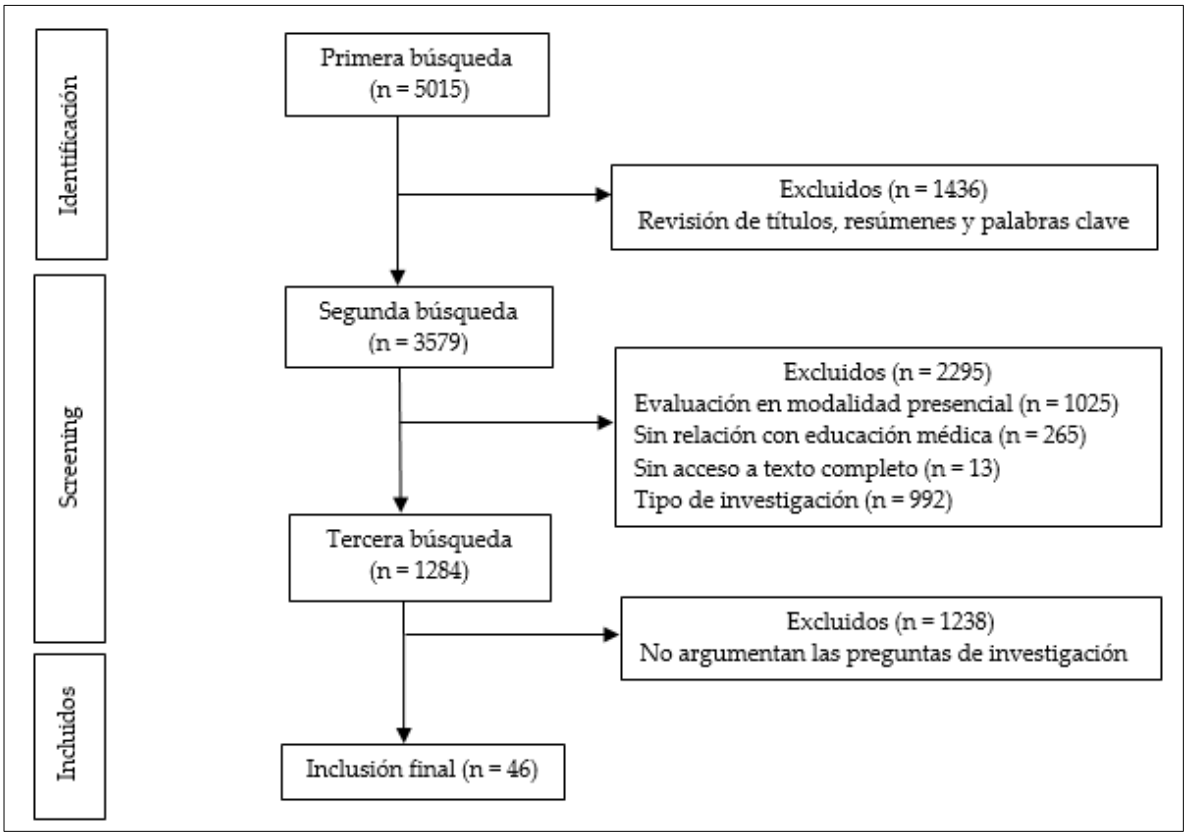

Figure 1. Summary of the search and review process

The VoSViewer tool allowed visualization of the keyword network (Figure 2). Larger circles indicate higher frequencies in the data set. The yellow and green zone are the most discussed terms and the blue zone the least addressed in the articles. In the analysis of the author keywords, 146 were identified, and of them, only 16 presented a strong correlation between them, focusing on the following clusters:

- Cluster 1. *Active learning; collaborative learning, medical education; medical students; radiology.*
- Cluster 2. *Augmented reality; flipped classroom gross anatomy education; undergraduate education; virtual reality.*
- Cluster 3. *Anatomy* ; *covid-19* ; *remote learning* ; *students* .
- Cluster 4. *E-learning* ; *physiotherapy* .

E-learning ", " *COVID-19* " and " *Medical Education* " was highlighted in the selected studies . The most studied areas of medicine were anatomy, radiology, neurosurgery and physiatry with the use of virtual and augmented reality technologies.

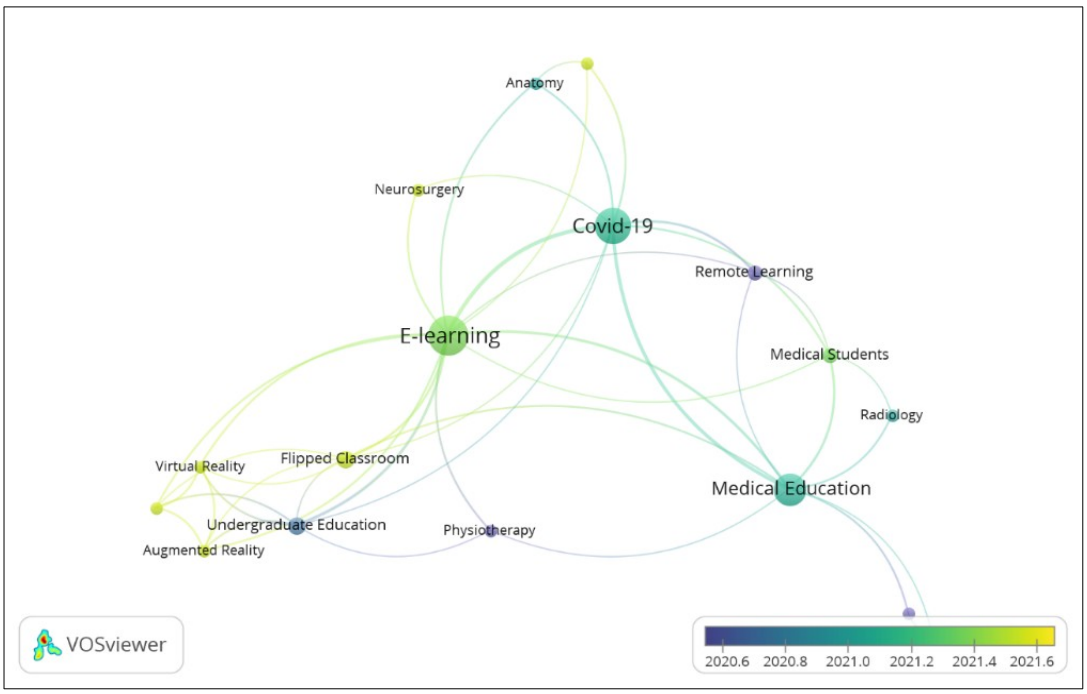

Figure 2. Network display of selected keywords.

In relation to question 1, a predominance of formative evaluations and the combination of formative-summative evaluations was observed (figure 3). Diagnostic evaluation was little applied, since in several studies the level of knowledge of students about a subject was already known and in others, it was used to compare the impact of an educational intervention before and after its implementation.

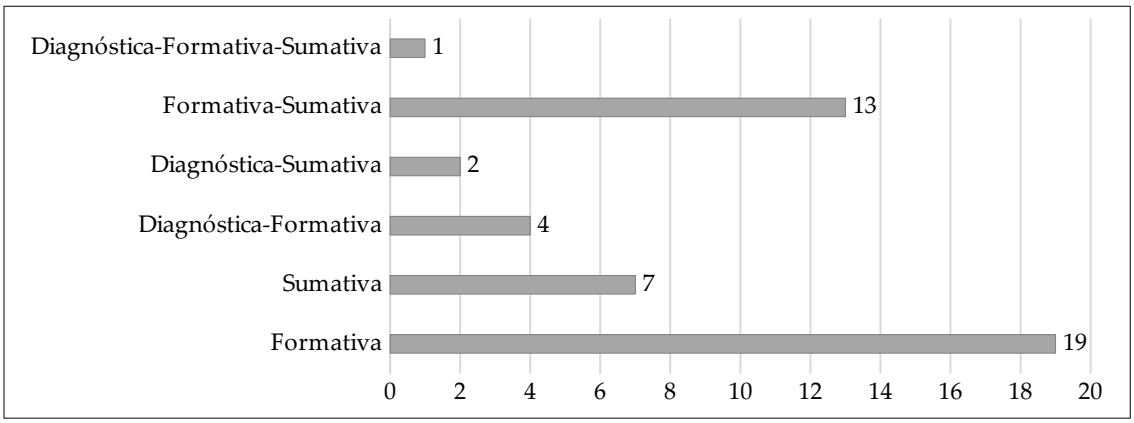

Figure 3. Types of evaluations present in the selected studies

Table 1 shows the educational resources, learning methodologies and technologies used in the studies analyzed in response to question 2.

Table 1. List of the 46 studies reviewed

Reference number	Educational resources	Learning methodologies	Technologies
17	Debate	Case-based learning Simulation Peer learning	Blackboard Collaborate Microsoft Teams
18	Multiple choice questions	Learning with multimedia resources Case-based learning Simulation	Website
19	Case analysis Multiple choice questions	Collaborative learning Problem-based learning Case-based learning	Viber Zoom Google forms
20	Simulation	Simulation Experiential learning Simulation	Zoom
21	Multiple choice questions Webinars	Learning with multimedia resources Problem-based learning	Zoom Qualtrics
22	Debate Webinars	Case-based learning Problem-based learning	Zoom
23	Debate Tasks	Task-based learning	Google forms Google classrooms
24	Multiple choice questions and short essay	Peer learning Learning with multimedia resources Collaborative learning Task-based learning	Zoom Moodle
25	Tasks	Case-based learning Flipped learning Collaborative learning Task-based learning	Zoom Weebly
26	Multiple choice, matching and short answer questions Simulation with virtual and	Case-based learning Peer learning Flipped learning	Canvas

	augmented reality	Collaborative learning Simulation	
6	Debate Meme, concept map or diagram	Motivational learning Peer learning Case-based learning	SOLE Facebook
27	Multiple choice questions Simulation Webinars	Case-based learning Problem-based learning Simulation	Christmas-LAMS WhatsApp Adobe Connect
7	Telesimulation	Simulation	skype
9	Multiple choice questions	Learning with multimedia resources Flipped learning Collaborative learning	OPENPediatrics
28	Case analysis	Learning with multimedia resources Collaborative learning	Picture Archiving and Communication System
29	Debate Tasks	Case-based learning Task-based learning Game-based learning	Google Meet Moodle
30	Multiple choice questions Lessons	Learning with multimedia resources Collaborative learning	Pharm-Ed Articulate Storyline Youtube LearnDash
8	Debate Virtual rotations Telemedicine	Case-based learning Collaborative learning	Video conference
31	Debate Videos Multiple choice questions	Case-based learning Learning with multimedia resources Collaborative learning	blackboard Zoom Microsoft Teams
32	Debate Virtual rotations	Flipped learning Case-based learning Collaborative learning Simulation	Google forms Zoom Website
33	Debate surgery instruments	Case-based learning Game-based learning	Zoom

	Multiple choice questions		
34	Debate Virtual rotations	Case-based learning Flipped learning	Zoom
35	Videos	Case-based learning Learning with multimedia resources	BOTH
36	Debate Multiple choice questions	Case-based learning	Open edX Youtube Zoom blackboard Proscia Concentriq
10	Case analysis	Experiential learning Case-based learning	Online test
37	Simulation in three-dimensional spaces	Simulation Collaborative learning	HoloLens
38	Debate Podcasts Tasks Virtual rotations	Game-based learning Case-based learning Collaborative learning Task-based learning	Online MedEd CaseX Microsoft Teams Sublux Radiology App Night in the ER App
39	Debate Questions with development answers	Case-based learning Simulation	Canvas Zoom
40	Debate Questions with development answers Images	Case-based learning Learning with multimedia resources	Google forms Zoom
41	Debate Webinars	Active learning Collaborative learning Problem-based learning	Zoom
42	Debate Social networks	Case-based learning Learning with multimedia resources Collaborative learning	Zoom Lt/ADInstruments Mentimeter Youtube Facebook

			instagram
43	Single Choice Questions and Short Essay Videos	Learning with multimedia resources Flipped learning Case-based learning Task-based learning	Tencent Classroom WeChat
44	Debate Lessons	Case-based learning Flipped learning	LMS SATT
45	Debate Infographics and scientific articles Videos Questions with development answers	Learning with multimedia resources Motivational learning	Zoom Mentimeter Lt Platform Socrative Youtube Facebook Lucidchart
46	Questions with development answers	Learning with multimedia resources Experiential learning	Turnitin Blackboard Learn
47	Debate Videos 360° evaluation Multiple choice questions	Case-based learning Learning with multimedia resources Collaborative learning	Youtube SimMon
48	Debate	Case-based learning	Facebook Zoom
49	Multiple choice questions	Case-based learning Learning with multimedia resources Problem-based learning	CaseViewer Aperio ImageScope QuPath Zoom Moodle
50	Debate	Case-based learning Peer learning Flipped learning Collaborative learning Task-based learning	Zoom PathPresenter Canvas Microsoft Teams
51	Debate	Task-based learning	Canvas

	Virtual rotations Telemedicine	Case-based learning	Zoom Epic Systems VidyoConnect WebEx
52	Multiple choice questions, drop-down lists, drag and drop labels	Learning with multimedia resources Case-based learning	Smart Sparrow Questionmark Perception
53	Debate Remote workshops Case studies Tasks	Case-based learning Learning with multimedia resources Task-based learning Peer learning Collaborative learning	Zoom Pacsbin Nearpod Google forms blackboard Microsoft Teams Website
54	Multiple choice questions Case reports	Case-based learning Learning with multimedia resources Task-based learning	Articulate Storyline Google Cloud Adobe Activate
55	Videos Multiple choice and short answer questions	Learning with multimedia resources Task-based learning	SmartSparrow blackboard
56	Multiple choice questions Images	Learning with multimedia resources Game-based learning	kahoot Aiforia Moodle
57	Multiple choice and short answer questions Problem resolution	Learning with multimedia resources Problem-based learning Case-based learning	Moodle Articulate Story Line

4. Discussion

In the selected studies, the predominance of formative evaluations is higher than summative evaluations. This result is contradictory to a similar systematic review in which summative evaluations predominate (11). It is valid to highlight that in recent years formative assessment has been presented as a more effective tool to boost student motivation in virtual contexts, which provides the opportunity to adjust learning without waiting for the end of the process. However, other authors propose that the combination of both allows students to obtain a comprehensive view of their performance through continuous and personalized feedback while also being assigned final grades based on a summative evaluation (58). Although the analyzed studies that carried out a type of evaluation met the proposed objective, it should be noted that those in which formative - summative were combined, more detailed qualitative and quantitative analyzes were obtained.

Assessment from the virtual context requires exploring innovative approaches to measure student learning and not replicating traditional assessment methods. The teacher changes his role as a tutor and develops strategies that allow evaluating the practical skills that the student must have using educational resources, learning methodologies and technologies. In this sense, Table 1 shows a predominance in the use of debate, multiple choice questions and tasks as educational resources, as well as case-based learning and collaborative learning as methodologies. There is significant use of educational platforms and video conferencing, especially Zoom, as technologies.

Additionally, actions by teachers in their role as practice tutors were reflected with the use of virtual clinical simulation platforms in virtual patient scenarios, videos where students recorded their clinical skills in action, such as performing a physical examination or communication with a patient. Another relevant aspect was carrying out virtual clinical interviews through telemedicine with real or simulated patients to demonstrate their communication skills, design of clinical histories that allowed evaluating the student's practical performance. These actions of the teacher-tutor were enriched with the timely and necessary feedback to the students about their clinical performance, highlighting the reasoning capacity in the analysis of case studies, interpretation of laboratory results and medical images with the use of intelligence systems. artificial. All of the above transformed traditional teaching methods, procedures and evaluations into face-to-face mode and enabled more interactive, efficient and motivating teaching for the student, which prepares them to perform in an increasingly technological professional environment (8, 17, 32, 38, 52).

Now, with the growing adoption of online education, the importance of understanding how evaluation has been carried out in medical education in virtual contexts arises and to this end, question 3 is answered by identifying trends:

- Simulation-based evaluation. It allows you to practice knowledge and make mistakes until you achieve the desired skills and abilities. It is based on scenarios to evaluate decision making, complex problem solving and feedback on results (7,17).

While virtual learning cannot replace the experience gained through clinical practice with the patient, virtual and AI-based simulations offer a significant improvement over conventional simulations by providing personalized feedback and correcting student errors. in a timely manner to develop the practical evaluation. Simulated patients, online simulation workshops, telesimulation, virtual rotations and clinics, simulation in three-dimensional space, virtual reality and augmented reality were used.

- Evaluation with multimedia resources. Stimulates participation, creativity, interactivity and critical thinking in students. The use of videos and interactive presentations allowed students to learn about complex medical topics and answer evaluative questions after observing and interacting with these resources. In turn, students were encouraged to create their own multimedia content as a form of evaluation, simulating clinical situations and medical procedures for meaningful learning (55). Videos, images, animations, infographics, memes, concept maps, diagrams, presentations and podcasts were used.

- Evaluation with online exams. Evaluates levels of knowledge from understanding to creation or application. Questions are designed in response to the learning objectives. Programs are required that guarantee security and integrity against plagiarism in open book exams (46). Several exams were carried out with open questions, closed answers or both, although there was a greater predominance in the design of questionnaires with multiple choice and short answer questions.

- Evaluation through play. Promotes creativity in learning. It is important to integrate the learning objectives with the dynamics of the game, establish the rules, evaluation criteria and feedback on the performance achieved. Motivation and better academic results are achieved (56).

- Evaluation through videoconference. Evaluates oral expression through the debate of cases to prepare students in the use of telehealth services (8). They are used in practical telemedicine evaluations and students from home use laboratory kits to present their results (33).

- Evaluation through educational platforms. It allows the design of online courses with individual, collaborative and peer evaluations, as well as the adaptation of these to different levels of complexity. It allows the design of a variety of instruments to evaluate and monitor student progress.

- Evaluation through virtual and augmented reality. It allows you to recreate interactive medical environments to contribute to realistic medical simulations in practical evaluations. Anatomy studies stand out with the development of evaluation scenarios with three-dimensional visualization technologies that explore the human body in detail for the practice of medical procedures in real time (26,37). The above allowed the development of immersive teaching involving the student within the realistic scope to guarantee efficient learning.

- Evaluation using artificial intelligence systems. It allows academic integrity by incorporating algorithms that analyze student responses in research papers and detect possible plagiarism (46). It guarantees the analysis of clinical data, such as in radiology, by incorporating an artificial intelligence system (28). This allowed the development of clinical practice, problem-solving and decision-making skills, but with personalized educational content, automated evaluation and self-instructed feedback. In this way, errors made by students are identified and corrected in time, resulting in better patient care and radiologist efficiency.

- Evaluation through flipped learning. It facilitates the understanding and retention of complex content (26). It allows to improve the preparation of students before being examined. Increase critical thinking and creativity skills. Moderation techniques are used to ensure equal participation (32).

The COVID-19 pandemic forced medical institutions or universities to quickly adapt to virtual environments. While this transition has been challenging, it has also provided opportunities to explore other forms of assessment. On the one hand, virtuality expanded flexibility in evaluation schedules, which is beneficial for students who face difficulties physically traveling to study centers. However, the challenge arises of how to avoid academic traps or evaluations of clinical practice to guarantee student-patient interaction. It is essential that educational medical institutions implement measures to ensure academic integrity and equity in virtual assessments. This positioning reflects a balanced vision on the impact towards virtuality in evaluation, highlighting both the benefits and challenges that this transition entails. The authors suggest that, if the challenges are appropriately addressed, the training and subsequent assessment could be enriching for students.

5. Conclusions

- In the findings of this research, the use of multimedia resources, online exams, through games, through videoconferences, educational platforms and inverted learning in virtual contexts is observed as a trend to evaluate the student. However, it is highlighted that evaluation based on simulations, artificial intelligence, virtual and augmented reality are the most accentuated trends in medical education.
- Evaluations in medical education require the use of emerging technologies (telesimulation, telemedicine, artificial intelligence, virtual clinics, virtual and augmented reality), interdisciplinarity, clinical skills and constant updating to contribute to medical training more adapted to the needs of today's society. .
- The predominance of formative assessments improved the learning process and student motivation. This type of evaluation must be adaptable to the study plan, with active participation, progress monitoring and immediate and timely feedback. Although, it is valid to highlight that the combination of formative - summative evaluations presented a more complete approach to the evaluation process.
- This research enriches educational practice by guiding teachers about what educational resources, learning methodologies and technologies they can use to

guarantee effective evaluation in virtual environments that, although focused on medical education, is applied to other educational areas.

- This systematic review has the limitations of the possibility of bias in the interpretation of the results by including only studies in medical education, in Spanish and English from the Web of Science. It will be necessary to explore studies in health sciences, in other languages and databases to compare the results of the scientific literature.

Financing: There has been no financing.

Declaration of conflict of interest: The authors declare that they have no conflict of interest.

Author contributions : Miguel Alejandro Fernández Alemán: conceptualization of the idea, methodology, data validation, data curation, writing and preparation of the research design stages, review and final editing of the document. Odiel Estrada Molina: methodology, writing, review and final document editing. Denise Alvarez Sam: data validation, writing and preparation of the research design stages.

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