



Toward a new educational reality: A mapping review of the role of e-assessment in the new digital context

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Abstract

Today, education is facing a new reality in which technology and new teaching methods are being quickly introduced into educational systems and institutions. Educational institutions are now dealing with the challenge of providing continuity to e-learning, turning it into a more flexible and up-to-date field, and considering assessment as a quality element in this transition. Therefore, with the aim of determining the current state of the research focused on assessment in digital environments (e-assessment), a mapping of the literature has been carried out. After examining 1,771 results extracted from Web of Science and Scopus and after the application of seven inclusion criteria, a total of 159 publications from the period of the past five years were read. The answer four research questions on the evolution of publications, the authors, the tools used, the contexts, the objects of study, and the future avenues of research, among others. The results show the increasing importance of e-assessment in this new context, moving toward a new reality in which technology plays a decisive and fundamental role in the teaching and learning processes. Thus, educational systems are heading towards a new context in which both teachers and students should rethink their roles and functions leading education to a more flexible, current, and digitally mediated context.

Keywords E-assessment · Mapping · Review · Education · Trends

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1 Introduction

The educational transition toward the online environment is an area of particular interest in the field of education, with virtual environments and information and communication technologies already being positioned as the main lines of educational change. This change in the educational perspective leads education to a new scenario in which there are only references of a few specific experiences; therefore, a new stage for education arises, one that has been brought about by the coronavirus crisis and digitalization of teaching throughout the world (Schwartzman et al., 2021; St-Onge et al., 2022).

In this broad field, it is essential to pay attention to one of the most complex activities (Cabero-Almenara & Palacios-Rodríguez, 2021; Chacín, 2021)—the assessment—to better understand the state of its transformation and the guarantees it offers in the new teaching contexts. An e-assessment has been defined by Ruiz-Morales (2013) as the planning, design, and development of an assessment in the digital environment to guarantee the same training competencies as in face-to-face scenarios and promote student participation in their learning.

In this new context, the transition of assessment toward digital environments makes it possible to study how the processes related to teaching are developed and implemented in this new setting, paying special attention to the assessment processes (Alruwais, 2018; Doğan et al., 2020). Morales et al. (2018) found that different competencies were prioritized in the two learning environments. Tomas et al. (2015) defended the idea of the necessary reconstruction in e-assessment, here as conceived from the prioritization of rapid adoption and not from a deep understanding of it; therefore, its transformation is still a major challenge.

Sellés et al. (2018) suggested that this new conception and reconstruction of e-assessment must be based on a holistic character, enhancing meaningful learning, promoting collaboration between students, and promoting self-reflection of learning. In addition to being supported by information and communication technologies (ICT), it enables more flexible scenarios that allow for a greater volume and management of data, less effort for the student, and faster and more objective correction (Ghouali et al., 2020). This concept contrasts with the rigidity of traditional assessment methods, which are excessively focused on marking, lack creativity, and are not very motivating for students (Pearse-Romera & Ruiz-Cecilia, 2019). This perspective on an assessment today represents a complete challenge for educational institutions because it must overcome the inflexibility maintained by specific teaching contexts, improve its articulation with training, and achieve an effective change (Jiménez et al., 2021), hence understanding assessment as an orientation toward improvement and guarantee of the quality of teaching.

The new digital contexts in education have presented limitations and doubts on the part of society in their development regarding the accessibility and training of both teachers and students in digital matters (Domingo-Coscollola et al., 2020), along with the terms of security and quality assurance (García-Aretio, 2021; Lee & Fanguy, 2022). Field research, such as that of Dermo (2009), with 130 university students, or that of Sellés et al. (2018), with 106 students at the same level,

and other research (Burgos-Videla, 2021; Geomar, 2020; Humanante-Ramos et al., 2019; Palacios et al., 2021), have shown that the advantages outweigh their limitations, being an opportunity for the future of teaching organizations.

Working in this context, the present study aims to focus on the literature that has been researched on e-assessments over the past five years, covering all those investigations published in Web of Science and Scopus in English. The current research is presented under a mapping study, given that it will summarize and focus the current state of research in the e-assessment field. The importance of mapping research lies in its ability to structure and classify an area of research: e-evaluation (Ramírez, 2020). Among its advantages, this methodology is a more open-ended systematic review that can facilitate a global view of the field by evaluating existing quantitative evidence (Marshall & Brereton, 2013).

The remainder of the present article is divided as follows: Section 2 depicts the theoretical framework followed by the related works (Section 3); Section 4 describes the methodology of the review; the Section 5 presents the research results; and Sections 6 and 7 include the discussion and conclusion derived from the results, respectively.

2 Theoretical framework

E-assessment is an increasingly important field in both online and face-to-face teaching–learning processes, and, as happens with most technology-mediated activities, it is subject to a process of continuous change (Ghouali et al., 2020).

Currently, most online assessment systems are based on learning management systems (LMS) for their development, here contemplating the use of multiple-choice questions (MCQs), essays, forums, virtual portfolios, or wikis, among others (Gupta et al., 2019). Technological development in assessment is also focused on countless applications or resources, depending on the purpose (Blackboard, Kahoot, Posterlet, Google Classroom, among others) (Jaiswal, 2020) that are adapted according to the assessment modality and based on the teacher’s preferences for formative assessment or summative assessment (Black, 1993; Dixson & Worrell, 2016; Nasab, 2015).

The first one, formative assessment, focuses on information and feedback, the understanding of the content, and continued performance (Daly et al., 2010; Stanković et al., 2017). Technology-based formative assessments focus on different applications and software that allow for the continuous monitoring of the student and implementation of feedback activities (portfolios, dossiers, practical activities, etc.), which have been claimed to be the most developed modality in its relationship with technology in practice and in the literature (McCallum & Milner, 2021; Mimirinis, 2019). Summative assessment, on the other hand, focuses on the certification and measurement of the knowledge acquired once the process has been completed, after the evaluation of products, and on the performance of final tests (Knight, 2002). In this modality, technology is used in the form of the implementation of tools that make it possible to perform objective tests in a safe and reliable manner (Atoum et al., 2017) and on the systematization of these for the systematic

certification of performance (Riera et al., 2018), a lesser route given the quality, control, and safety standards that these processes require (Timmis et al., 2015).

The development of e-assessment has been accelerated in the last few years by two main factors: the technological advances experienced in recent years (González-González & Silveira-Bonilla, 2022; Muñoz-Guevara et al., 2021) and the impact of the COVID-19 pandemic (Ozdamli & Karagozlu, 2022).

The technological changes experienced by the inclusion of new technologies in teaching offer new opportunities for the assessment in new educational scenarios (use of mobile devices), the automation of results and feedback (development of artificial intelligence in education), the identification of patterns in assessment and the detection of learning difficulties (implementation of learning analysis strategies), and the assessment in new immersive and technology-enriched environments (use of extended reality in the classroom) (Sembey et al., 2023).

Moreover, e-assessment has been completely disrupted by COVID-19, which forced all educational systems to adapt their teaching to nonvirtual learning environments, taking on the challenge of assessment in alternative spaces and leading to new strategies, policies, and rapid training aimed at enabling the educational community to carry out assessments (formative and summative) on institutional platforms (Zharova et al., 2020). As a result, the volume of resources, new tools, and derivative publications on e-assessment have drastically increased (Almossa, 2021; Kundu & Bej, 2021; Montenegro-Rueda et al., 2021; Seraj et al., 2022), suggesting the focus on technology and flexibilization of educational institutions regarding what is termed the new educational normality (García-Peñalvo, 2021; Grande-de-Prado et al., 2021).

The combination of these two elements has created a new context presenting a wide spectrum of possibilities for developing e-assessments (Kotiash et al., 2022) and a significant increase in its popularity (Szymkowiak et al., 2021).

3 Related works

Systematic literature reviews and their variant of systematic mapping studies have been increasingly used in investigations focused on analyzing the state of the art in a particular area or context, being one of the most relevant techniques in research (Kitchenham et al., 2011).

There are examples of previous reviews that have addressed technological implementation in educational processes (Lai & Bower, 2019; Martínez-Soto & Prendes-Espinosa, 2023), in education during the pandemic in higher education (Muhaimin et al., 2023), in lower levels (Crompton et al., 2021), or in the inclusion of mobile devices for the development of new teaching methodologies (Dorris et al., 2021).

The current review has combined two aspects: the pandemic and technological development. Regarding assessment during the pandemic, the review conducted by Montenegro-Rueda et al. (2021), which was an analysis of 13 studies, highlighted the challenges faced by teachers and students, the lack of training, the honesty of assessment processes, and the differentiation between formative and summative assessment during the pandemic. Second, on technological development in

e-assessment, reviews such as the one by Heil and Ifenthaler (2023) focused on the characteristics of these environments and the evaluative modalities in higher education, here determining the potential of these processes and the need for training and capacity building; the review by Sembey et al. (2023) on assessment, emerging technologies and feedback practices through an analysis of 38 accepted articles highlighted the advantages of the inclusion of technologies in assessment and provided a list of technological tools.

Alrofou et al. (2019) conducted a review on the acceptance and inclusion of mobile devices in assessment processes; the study analyzed 53 publications over a 10-year period and concluded the need to overcome the limitations of the educational community for the effective incorporation of mobiles in assessment processes. Other reviews looked at the incorporation of artificial intelligence (Chiu et al., 2023; Samala et al., 2023) and virtual reality in educational and assessment processes (Ifanov et al., 2023).

The mapping described in the present study has aimed to achieve a broader vision than the reviews above. For this reason, after not detecting any updated study for the field and given the volume of systematic reviews and related publications, a mapping is justified as a broad synthesis, allowing us to map the current publications, detect new avenues of research and identify, in a generic way, the current state of knowledge after the latest changes and advances in research (Cooper, 2016). In addition, this review approaches the field of e-assessment without prior restrictions, not limiting itself to a specific educational level, a particular tool, or an assessment modality so that the results achieved summarize all the publications on the field in the past five years, enabling the mapping analysis in a synthetic and accurate way.

4 Methods

The method followed in the present research was a mapping of the literature, which summarizes the state of the art of relevant research and contextualizes the work in the international landscape while explaining which findings if any, are being challenged or extended. In this mapping research, the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement for systematic reviews was followed (Page et al., 2021).

5 Research questions

To provide an overview of the complete state of the field, research questions have been designed to describe the main data of the publications (country, annual evolution, authors, journals, etc.) and to describe the general lines of each study (objective, educational level, sample, methodology followed). The research questions posed in the mapping study are as follows:

MQ1) What is the relevance of the included studies?

MQ2) What has been the current state of e-assessment research in the past five years?

MQ3) What is the studies' approach to e-assessment?

MQ4) What are the future trends in the e-assessment field?

5.1 Exclusion criteria

The inclusion/exclusion criteria that will determine the publications making up the analysis and answers to the research questions posed are as follows:

- 1 Any publication that is not published in a scientific journal indexed in Web of Science or Scopus and that has not undergone a peer review process is not accepted.
- 2 Articles that did not focus on the educational field were excluded.
- 3 Articles that did not have e-assessment as their object of study were excluded.
- 4 Articles that did not present empirical methodologies (theoretical studies) were excluded.
- 5 Articles written in languages other than English were excluded.
- 6 Articles that did not directly refer to the e-assessment tool under study were excluded.
- 7 Articles that did not describe the population and sample participating in their research were excluded.

5.2 Search string and database

The search was conducted on December 10, 2021, in the Scopus and Web of Science databases. The results have been limited in time to offer a broad perspective of the past five years. A search string was used (“E-ASSESSMENT” OR “EASSESSMENT” OR “COMPUTER BASED ASSESSMENT” OR “MOBILE BASED ASSESSMENT”), obtaining all those articles that addressed assessment in virtual environments or those that addressed it through technological devices. The datasets generated during the current study are available in the Google Sheets repository at the following: bit.ly/3N8xBXf.

5.3 Publication selection process

The initial number of publications was 1,771 (907 from Scopus and 891 from Web of Science). After removing duplicates, the figure dropped to 1,136. After applying the exclusion criteria, 159 publications were accepted as part of the present research (acceptance rate of 13.99%) (Fig. 1). The complete list of accepted references is available at the following: bit.ly/3Noh55Q.

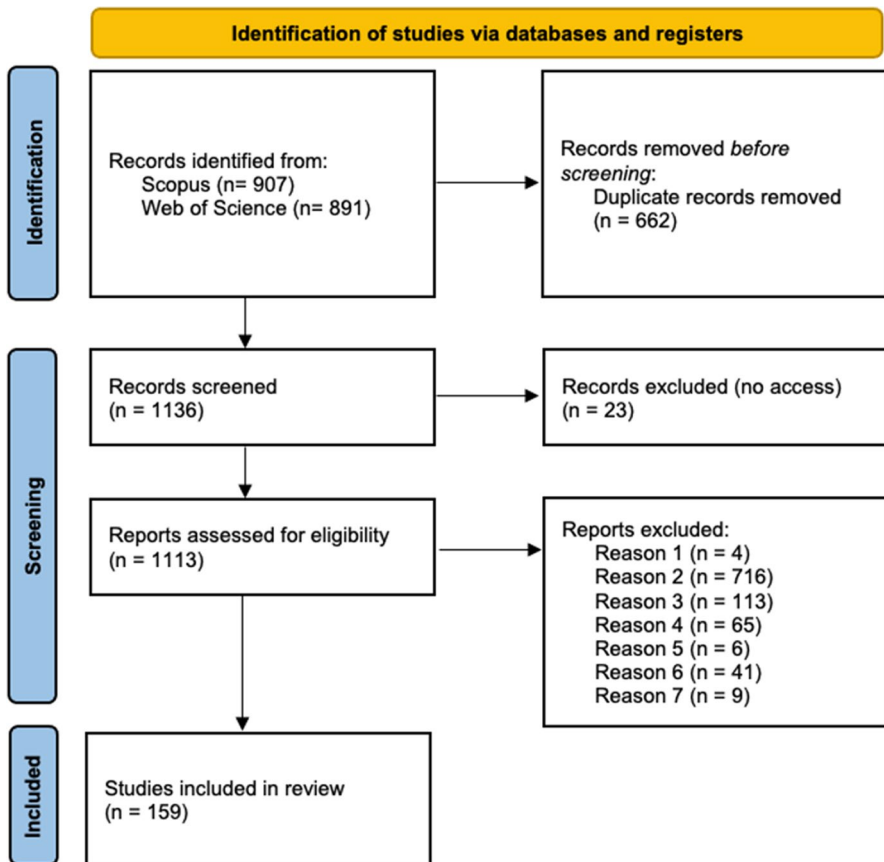


Fig. 1 PRISMA flow chart of the review

6 Results

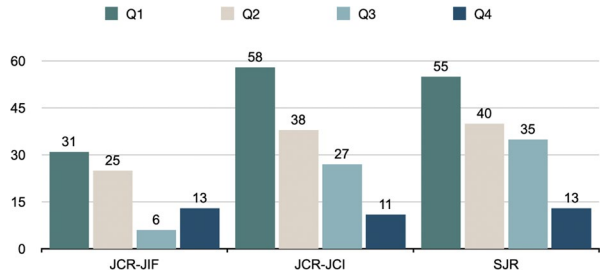
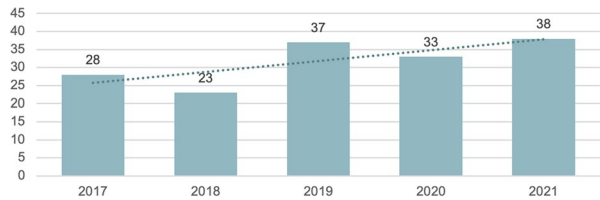
6.1 What is the relevance of the included studies?

To study relevance (MQ1), the number of citations of each article and the bibliometric indicators of the journals were considered. For citation extraction, Scopus was used as the search database on January 10, 2023. The results indicate an average citation level of 14.21 (145 valid articles, 15 not included in Scopus). The two most relevant articles focused on the technological acceptance of e-assessment and were developed by the same authors (Nikou & Economides, 2017a, b), accumulating a total of 354 citations between them since 2017, followed by references such as Nguyen et al. (2017) and Faber et al. (2017), at 79 and 74, respectively.

Table 1 shows the results; the item identification number is available in the supplementary database under the tabs “Final Phase” and “Metrics.” The

Table 1 Number of citations of the selected publications

Number of citations	Identification number
181	42
173	40
80	43
79	37
74	117
73	79
70	96
48	31
43	19
42	107
38	28
37	17
36	148
34	103
30	48
29	36, 100
26	89
24	102
23	29, 126
22	3, 18, 49
21	30, 55
19	25, 65
18	47, 121
17	86
15	10, 159
14	22, 90, 101, 104, 113, 153
13	58, 60, 64, 105, 129
12	39, 114, 139, 146, 155
11	16, 137
10	4, 20, 27, 75, 116, 138, 152, 154, 156
9	24, 54, 106, 112
8	6, 35, 53, 78, 97
7	38, 84, 115, 132, 136
6	14, 76, 88, 125
5	15, 41, 56, 70, 72, 80, 98, 99, 158
4	8, 26, 34, 45, 46, 50, 51, 59, 74, 87, 91, 94, 95, 111, 118, 128, 134, 135
3	13, 21, 23, 32, 61, 69, 77, 131, 141
2	2, 7, 12, 52, 81, 85, 93, 108, 109, 120, 124, 144, 150
1	1, 33, 44, 57, 62, 63, 68, 82, 92, 122, 130, 142, 145, 149
0	11, 73, 119, 123
No data	5, 9, 66, 67, 71, 83, 110, 127, 133, 140, 143, 147, 151, 157

Fig. 2 Publications metrics**Fig. 3** Annual evolution of publications

extended table with each publication reference and complete list can be found at the following: bit.ly/3oU1Wzy.

For further analysis of the publication metrics, the data relating to SJR, JIF, JCI, and quartiles (Q) corresponding to the year of publication of the article in each journal were extracted. The results indicate that, of the 159 results, 75 were included in JIF (31 in Q1, 25 in Q2, 6 in Q3 and 13 in Q4) and 134 in the JCI index (58 in Q1, 38 in Q2, 27 in Q3 and 11 in Q4). Finally, 143 publications have an SJR index (55 in Q1, 40 in Q2, 35 in Q3 and 13 in Q4) (Fig. 2).

Full information about the publication metrics including impact factors, quartiles, and categories in JIF, JCI, and SJR can be found in the “Mapping Question 1 (MQ1) sheet” of the complementary database.

6.2 What has been the current state of e-assessment research in the past five years?

To position the e-assessment field (MQ2), it is important to first describe the publication trend occurring. For this purpose, the publication date of each study has been taken, as presented in Fig. 3.

The data show a growing trend in the number of publications, from 28 in the first year analyzed (2017) to 38 in 2021. This trend indicates the efforts and relevance of e-assessment in current educational trends, as reflected in the increase of studies linked to the subject. This growing trend also indicates an interest in the field of e-assessment. This must also be supported by theoretical research into the means, methodologies, limitations, and possibilities of this assessment form.

Once the annual trends have been identified, it is important to identify the trends followed according to the publication location and identify research leaders in terms of their geographic nature. The analyzed studies have been carried out in a total of 49 countries, led by the United States (24) and followed by Spain (14), the United

Table 2 Country where the studies were carried out

<i>N</i>	Country
24	United States
14	Spain
13	U.K
12	China
8	Saudi Arabia
6	Greece
5	Australia, Malaysia, Turkey
4	Germany, Indonesia, Portugal
3	Finland, Israel, Morocco, Pakistan, Taiwan, The Netherlands
2	Canada, Hungary, Iran, Ireland, Singapur, South Africa, Switzerland
1	Argelia, Ajman, Austria, Chile, Croatia, Dubai, Egypt, France, Greece, India, Iraq, Jordan, Mexico, Namibia, New Zealand, Norway, Qatar, Ruanda, Serbia, Slovakia, Thailand, Tunisia Yemen

Table 3 Authors according to the number of publications

<i>N</i>	Author
6	Economides, A.A.; Nikou, S.A
4	Kurniawan, D.A
3	Babo R., Suhonen J., Astalini A., DeMara R.F., Guerrero-Roldan, AE, Kocdar, S, Lin, JW, Whitelock, D
2	Chemsi, G., Chen B., Darmaji D., Hartshorne R., Karadeniz, A., Maison, Ninkovic, S., Noguera, I., Okada, A., Omar N.N., Perdana, R., Peytcheva-Forsyth, R., Radid, M., Sa'di, RA., Sancho-Vinuesa, T., Sharadgah, TA., Tukiainen M., Yilmaz, R
1	457 authors (accessible in the attached database)

Kingdom (13), and China (12). The countries mentioned above are the only ones with more than 10 studies carried out in them. The rest of the countries can be seen in the following table (Table 2).

Regarding the most relevant authors in the literature, a total of 486 contributors have been listed. Of these, Anastasios A. Economides and Stavros A. Nikou each stood out with six publications, followed by Dwi A. Kurniawan with four. Eight authors followed with three publications, 18 with two, and 457 with only one (Table 3).

Finally, the field is positioned by describing the publication source in which the research has been published. The analysis extracted a total of 106 journals that published 159 publications (Table 4). Among them, the *International Journal of Emerging Technologies in Learning* stood out as the leading journal in this research field, with a total of seven publications, followed by *Assessment and*

Table 4 Journals by number of publications

<i>N</i>	Journal
7	International Journal Of Emerging Technologies In Learning
6	Assessment & Evaluation In Higher Education
5	British Journal Of Educational Technology, Computers & Education
4	The Asia–Pacific Education Researcher
3	Advances in Physiology Education, BMC Medical Education, Education And Information Technologies
2	Asian EFL Journal, Computer Applications In Engineering Education, Computers In Human Behavior, Eurasia Journal Of Mathematics, Science and Technology Education, Frontiers In Education, Frontiers In Psychology, Hacettepe University Journal Of Education, Interactive Learning Environments, International Journal For Educational Integrity, International Journal Of Stem Education, Irish Educational Studies, Journal of Information Technology Education: Research
1	86 journals (accessible in the supplementary database)

Evaluation in Higher Education (6) and the *British Journal of Educational Technology and Computers and Education* (5).

The publications are next identified in terms of their main characteristics, helping determine the key aspects of current e-assessment research. Concerning the educational level at which e-assessment has been studied, higher education was the main field (133 research studies), followed by secondary education (with only 12) and then the other educational levels with lower figures, as can be seen in Table 5.

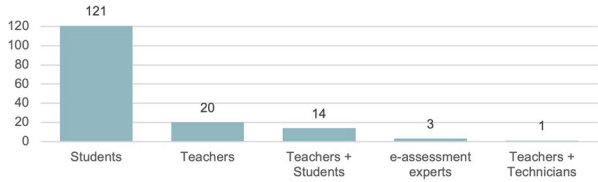
Once the educational levels have been established, it is necessary to identify the target group of the research studies. In this analysis, student samples (120 of 159), followed by teachers (20), and combined studies with teachers and students (13) have stood out by a large margin. The remaining figures are presented below (Fig. 4).

After studying the groups, the present research examined the methodological processes of each one. The results show that mainly quantitative studies were

Table 5 Educational fields of the analyzed studies

<i>N</i>	Field
133	University Degree
12	Secondary Education
5	Primary Education
4	Vocational Education and Training (VET)
2	Certificate of Higher Education (HNC)
1	Preschool, Software Development, mixed (Primary Education + Secondary Education)

Fig. 4 Publications according to each study group



conducted (66%), followed by qualitative studies (18%), and, finally, mixed studies (16%) (Fig. 5).

Looking further into these methodological processes and addressing the techniques used in each study to collect information, 26 studies used two techniques in their studies. In contrast, the remaining 133 applied only one.

Of the 185 total techniques applied, the survey (78 studies) was the most frequently used. This was followed by an analysis of the results of e-assessments carried out through questionnaires and objective tests (68 studies) and then the rest of the techniques (interviews, validation questionnaires, focus groups, and observation processes) (Fig. 6).

Finally, the population, methodology, and instruments used were explored. For this purpose, we have maintained the grouping categories proposed by the authors in their research data collection instruments. Given the samples' dispersion and the nonrepresentativeness of means, the information is presented according to the different groups and sample sizes (Table 6).

Regarding the 18 studies that carried out interviews, their classification according to their sample sizes is presented below (Table 7).

Fig. 5 Methodology of the analyzed publications

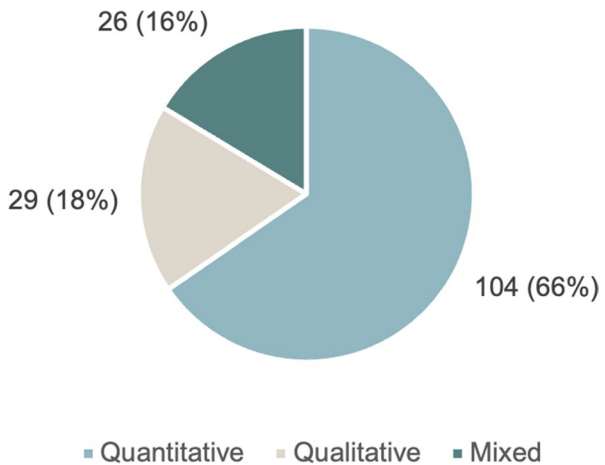


Fig. 6 Techniques used in studies by frequency

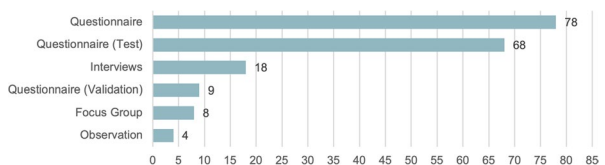


Table 6 Sample sizes for questionnaire studies

	N = 1–100	N = 101–200	N = 201–300	N = 301–400	N = 401–500	N = 501–600	N = 601–700	N = 701–800	N = 801–900	N = 901–1000	N = > 1001
Questionnaire	25	23	8	5	3	1	5	1	2	2	4
Questionnaire (Test)	26	10	6	6	5	1	1	1	0	2	10
Questionnaire (Validation)	3	3	1	-	-	1	-	-	-	-	1

Considering the eight studies that used a focus group, their classification in terms of ranges for their sample sizes is given below (Table 8).

Of the articles using an interview process, the article by Washburn et al. (2017) presented a sample of 138 participants that was carried out in a total of 12 focus groups. Finally, the analysis of sample sizes is presented for those studies using observation processes (Table 9).

6.3 What is the studies' approach to e-assessment?

The third research question (MQ3) explores the way in which researchers have approached e-assessment, where we describe the variable with which it is approached (object of study). These objects were generated following an inductive method after the categorization of each of the investigations (Table 10).

These categories are exhaustive and exclusive and have been validated after ascertaining that each selected publication is part of a single category (Fig. 7).

Regarding the technological tools on which the e-assessment processes have been based, these have been classified into LMS systems (integrated learning management systems), mobile technologies (tools or applications for exclusive use through mobile devices), and other software (i.e., all those accessible through the network). Of the 159 articles, three (Nikou & Economides, 2019; Rolim & Isaias, 2018; Smith, 2021) addressed three different e-assessment tools, three studies looked at two different tools (Egarter et al., 2021; Liu et al., 2021; Ninković et al., 2021), and the remaining 164 focused on only one (total of 170 tools found). These tools, classified according to their typology, are presented in Fig. 8.

The LMS platforms were a main focus of the studies (59%). Of these, the presence of Moodle ($n=42$) and educational institutions' own LMS platforms ($n=35$) has stood out, as well as Blackboard ($n=14$) and Canvas ($n=3$). Moodle and Blackboard can be seen as the critical representations of this type of platform, accounting for 59.6% of the category.

Second, other publications focused on software and tools accessible through the web (they are not only access devices, and their operation does not allow for the integrated management of teaching as an LMS). This category represented 31% of the 159 publications and included tools from different fields, such as security and authentication (Proctorio, Tinfolec); web-based e-assessment tools (Kahoot, Dewis, JCQuest, Posterlet; among others); the Google suite for virtual teaching (Google Forms, Google Classroom); and communication and social networking tools (Microsoft Teams, Zoom, Yammer, WebEx). The rest of the educational software and digital tools can be seen in the complementary database.

Regarding mobile technologies, some research looked at applications aimed at teaching and group management (Snappet, Socrative, Tronclass), applications aimed at communication and team management (Slack, WeChat, Viber), applications focused on assessment (ExamSoft, tExam), and applications focused on the teaching and assessment of specific subjects (GeoGebra, GotItLanguage), among other applications with lower representations. These apps represented only 14% of the total.

Table 7 Sample sizes for interviewing studies

	N = 1–10	N = 11–20	N = 21–30	N = 31–40	N = 41–50	N = 51–60	N = 61–70	N = 71–80	N = 81–90	N = 91–100	N > 101
Interviews	8	2	3	2	-	-	1	-	-	-	2

Table 8 Sample sizes for focus group studies

	N=1–5	N=6–10	N=11–15	N=16–20	N=21–25	N=26–30	N=>30
Focus Group	1	4	-	-	1	-	1 (138)

Table 9 Sample sizes for observational studies

	N=1–2	N=3–4	N=5–6	N=7–9	N=>10
Observation	1	-	1	1	1 (120)

Table 10 Object of study for each study

Object	Description
Attitude	Studies focus on attitudes and perceptions towards e-assessment tasks
Acceptance	Studies focus on the technological acceptance of e-assessment
Efficacy	Studies focus on the effectiveness of e-assessment processes
Innovation	Studies focus on describing innovation processes in e-assessment without focusing the study on a specific variable
Monitoring	Studies focus on monitoring and surveillance in e-assessment processes
Performance	Studies focus on outcomes and performance in e-assessment processes
Quality	Studies focus on the quality of e-assessment processes
Satisfaction	Studies focus on studying satisfaction after an e-assessment process

Fig. 7 Publications categorized according to the object of study and their frequency

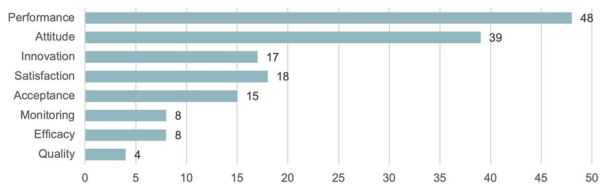
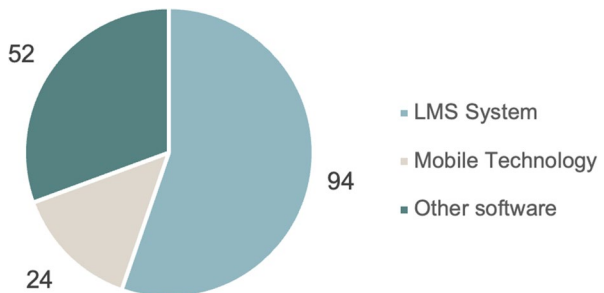
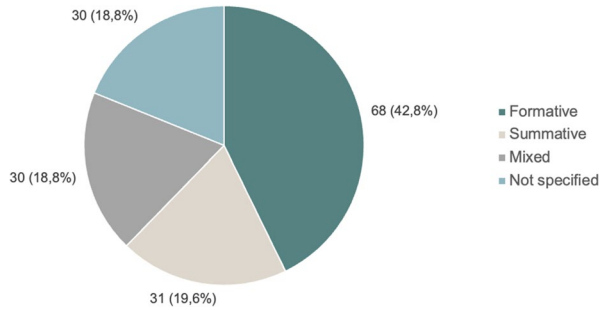


Fig. 8 E-assessment tools grouped according to their typology



Lastly, we examined how the research conceived of e-assessment, that is, distinguishing between formative, summative, and mixed assessments (Fig. 9). Of the 159 studies, 42.8% ($n=68$) focused on the analysis of e-assessment in formative

Fig. 9 Studies according to the assessment's purpose



processes, while only 19.6% ($n=31$) did so for summative assessments. A total of 30 (18.8%) studies addressed e-assessment as a tool for comprehensive assessment (formative and summative), and another 30 (18.8%) studies did not specify the e-assessment method (focusing on other aspects such as plagiarism, supervision, or risks, among others).

6.4 What are the future trends in the e-assessment field?

Finally, the aim of the present review was not only to focus and unify the advances in the field, but also to bring together the main lines of research arising in the field of e-assessment; this was done by considering the lines proposed by the authors as future paths of research (MQ4). Here, 11 of the 159 studies did not propose lines of future research, focusing only on describing the progress and results achieved. Twelve others do not focus on future areas. Regarding this transfer, eight authors suggested the need to promote institutional development and collaboration to promote e-assessment (e.g., Cheng et al., 2021; DeMara et al., 2017; Slade et al., 2022), and four focused on promoting teacher education and training as an element of quality within these assessment processes (Abdou, 2020; Cutumisu, 2018; Wu & Wang, 2021; Zhang et al., 2021).

Therefore, a total of 136 studies suggested into future lines of research in the e-Learning field. After their complete extraction and analysis, these lines were categorized into six categories, as shown in Table 11.

The main future line focused on the development of new methodologies, instruments, and software related to e-assessment processes ($n=51$, 37.5%). This line synthesized the proposals made by the authors in relation, on the one hand, to the need for continuity in developing instruments and software that support e-assessment processes, which was one of the main pillars of this assessment modality (Lin et al., 2020; Liu et al., 2021). On the other hand, another group of authors highlighted not only the need to introduce new software, but also to improve the reliability of technology-mediated assessment processes, hence improving the reliability and stability of instruments (Bickerton & Sangwin, 2021), tools (Nyland et al., 2017), and assessment processes (Khlaisang & Koraneekij, 2019).

On the other hand, another stream of researchers raised the importance of introducing processes and mechanisms for supervision and monitoring in online

Table 11 Proposed lines of research

Line	<i>n</i>	Objective
1	51	To develop new methodologies, tools and software related to e-assessment
2	40	To replicate the study to confirm the findings (populations, samples and platforms)
3	27	To explore further conditioning factors for the e-assessment acceptance
4	11	To extend the study with other research methodologies (qualitative, quantitative, mixed)
5	5	To study the effects of long-term e-assessment on academic performance
6	2	To expand on the rationale and theoretical underpinning of e-assessment

assessments, highlighting the importance of having a supervisor and valid e-authentication practices (e.g., Mellar et al., 2018; Okada et al., 2019a, b), and with systems of safeguards and policies in place against plagiarism and cheating (e.g., Hassan et al., 2020; Snekalatha et al., 2021; Vázquez et al., 2021). Finally, another group of studies advocated for improving the instruments from the feedback given (e.g., Judge, 2021; Misut & Misutova, 2017; Wang et al., 2019).

Another group of studies showed interest in replicating each study in different populations, samples, and platforms to confirm the findings ($n=40$, 29.4%). Of these 40 studies, 38 proposed their methodological and instrumental replication in different populations (different educational levels, different contexts) or different samples. These studies focused on confirming the results by comparing different populations and samples to certify the performance of online assessment processes. An example is the study carried out by AlTameemy et al. (2020), who proposed replicating their investigation on writing assessments through platforms at other educational levels, or that of Witchel et al. (2018), who proposed the replication in a different course with a different population.

Third, some studies explored the conditioning factors of teachers' e-assessment acceptance ($n=27$, 19.9%). These studies sought to continue the search for different factors that may help the inclusion of e-assessments in teaching processes through teachers. These studies proposed searching for new dimensions in established acceptance models (Bacca-Acosta & Avila-Garzon, 2021; Balta et al., 2018; Nikou & Economides, 2018) or the search for other factors, such as social and cultural ones (Pu & Xu, 2021).

Next, 11 publications (8.1%) addressed the importance of extending the research through a new methodology. Most proposed complementing the existing study with qualitative data (Babo et al., 2020; Cakiroglu et al., 2017; Delaney et al., 2019, among others) or conducting multicenter studies by changing the methodology (Dutton et al., 2017).

Finally, from a more theoretical point of view, five (3.7%) publications proposed addressing the effects that this assessment modality has on the student's future academic performance, such as Kühbeck et al. (2019) or Boote et al. (2021), and two (1.4%) proposed expanding the theoretical justification of this type of technology-mediated assessments (Guerrero-Roldán & Noguera, 2018; Sirianni et al., 2017).

The lines of research proposed by the authors can guide future research in this field, so attending to them should be a fundamental task for experts and researchers, institutions, and teaching professionals.

7 Discussion

7.1 Evolution, relevance, and methodology trends of the publications

First, addressing the number of publications over time, the scientific community has been increasingly interested in e-assessment in digital environments, with the number of research works published showing a clear upward trend, even though the average number of citations is low at 14.21 (this may be because most articles are very recent and do not yet have enough time to be cited in other research). This trend may be a result of studies being conducted because of the coronavirus pandemic, which was a significant educational change and methodological breakthrough in education. Moreover, given the temporal proximity of the review to the pandemic (still ongoing) and the publication deadlines of the journals and volume of articles written in all fields about COVID-19 and its impact (Forero-Peña et al., 2020), a substantial increase in the number of future publications is expected.

The research questions provided insights into the research trends over the past five years, anticipating where the research in e-assessment may be heading. First, higher education was the educational level with the highest number of studies (83.7%), and students were the most frequently addressed group (76.1%). Here, 104 out of 159 studies dealt with evaluation in higher education with students (65.4%), while only 15 (9.4%) did so with university teachers and 11 (6.9%) from a joint perspective. Therefore, students in higher education has been one of the most explored areas of research, while there were a small number of investigations focused on the preprimary, primary, and high school levels (Al-Emran et al., 2018).

Of these 104 studies that investigated e-assessment in higher education from the perspective of the students, 36 analyzed the results of e-assessment processes, 23 on the study of attitude and perception, and 12 on satisfaction. In contrast, only 11 studies focused on e-assessment with teachers, and the most repeated trends were the teaching attitude toward perspective (5), satisfaction (4), and acceptance (3). These can be potential areas of research in higher education.

7.2 Target population trends in the research studies achieved

The scarcity of publications has greatly conditioned the analysis of other levels of education. For example, the combination of compulsory schooling (primary and secondary) accounted for barely 10% of the total number of studies ($n=17$), meaning that this was almost a new field in e-assessment and its development. Therefore, these fields still require more research and, as an example, can model the research carried out in higher education because the few studies have focused on the study

of attitudes toward e-assessment (7 of the 17) and on the results of e-assessment processes (5).

Additionally, this review has tried to synthesize the sample sizes of the current research to reflect the trend in the number of participants for each study and for each of the research areas. These sample sizes presented a large variability for each technique in the different groupings carried out, and factors such as the capacity of each research, the personnel available, and the funding largely conditioned the sample sizes of the research analyzed. On the other hand, polls and tests were the most used instruments used (91.8%) because of their rapid deployment and application among students and the ease of collecting and analyzing the results obtained in the digital environment (Pozzo et al., 2018).

7.3 Technological support: A key factor in the development of e-assessments

The review has shown a high variability in the tools used for e-assessment, which makes it difficult to synthesize and group some of them. The results have also shown the LMS as the predominant tool, approached in a generic way or through built-in tools such as Stack or WIRIS. At the same time, mobile technologies can be a new avenue of research at all educational levels (already reflected in higher education), given their possibilities and scarce research addressing them (Nikou & Economides, 2017a, b 2018, 2019).

As for the technological systems used for e-assessment in higher education, 79 of the 130 studies in this category analyzed the LMS systems of the institutions (60.8%), 37 on available tools and software (28.5%), and only 15 on mobile technologies (11.5%); thus, new research should focus on the study of mobile technologies (Alkiş & Coşkunçay, 2018; Sánchez-Prieto et al., 2017). This indicates the importance and widespread use of LMSs in education, which is also consistent with their key role during the pandemic as the main method of continuity and assurance of education (Dascalu et al., 2021; Grigoryeva et al., 2021; Raza et al., 2021).

Finally, the present review has confirmed the greater development of e-assessment research for formative assessments (McCallum & Milner, 2021; Mimirinis, 2019), as represented by the 42.8% of the studies included, compared with summative (19.6%) and mixed (18.8%). Therefore, the current research has focused on formative e-assessment developments, opening a new avenue for research in overcoming the limitations of these processes for summative assessments and expanding the field in this direction.

7.4 Postpandemic trends, limitations, and future avenues for research

The mapping has shown a clear trend and continuity of prepandemic research with research carried out during the pandemic, maintaining the same trends. It is important that future studies, once the pandemic has ended and full normality has been achieved, provide comparative frameworks for evaluation in virtual environments pre- and postpandemic and that they can analyze changes in publications, systems used, and study populations in the two sets of research.

Looking to the future, three lines of research stand out: innovation in terms of technology and means for online assessment (1), consolidation of the findings achieved so far through the replication of the study in different populations and platforms (2), and studies focused on technology adoption among educational agents (3).

In addition, the fact that only two studies in the past five years have proposed extending the theoretical justification of e-assessment shows that the research on e-assessment is no longer in its initial state but transitioning to a new phase and, hence, is starting to be a more consolidated practice in the educational fields, especially in higher education (Mastan et al., 2022). Also, it has been shown that the pedagogical design, innovation, and development of e-assessments are more important today than the theoretical explanation of it, so these must be the main lines and future challenges that this field must address in the coming years for the transformation of teaching in this new educational reality.

The mapping has also shown the importance of progressing in the research field to support this e-learning assessment modality. A recommendation is developing more specific systematic literature reviews in the future (e.g., a review for each technology detected here), in which a smaller number of publications would be included and a more thorough analysis of them could be carried out, thus obtaining more in-depth methods of advancing.

8 Limitations

It is essential to note the limitations. First, the number of databases selected (two in this case) should be highlighted because, although they are two of the most relevant in the field of research, they do not bring together all the existing publications on the subject in other databases, a limitation derived from the high volume of publications available in the field (García-Peñalvo, 2022).

Second, the time limit of the mapping (five years) does not clearly represent the evolution of the field. However, the high volume of publications indicates this time period was sufficient. Third, to reflect on the field's heterogeneity, the few classifications available on e-assessment to date and volume of publications analyzed may have generated problems in interpreting the data, for which the authors have generated specific analysis categories.

9 Conclusion

The current mapping has underlined the importance of the e-assessment field, trying to focus on the current state of research and synthesize the trends and lines currently addressed in the literature. In addition, this mapping has proposed analyzing the e-assessment transition during the pandemic and before, comprising years of normal education (2017–2019) and technology-mediated education (2020–2021). The present review sets the future direction of the field and advances in the return to educational normality, so it is recommended future

studies verify the progress of the e-assessment. Thus, to conclude, we would like to propose some possible research areas:

- **Higher education teachers:** The present review has shown the high volume of publications focused on higher education, but most focused on students. Therefore, future research can address the assessment from the perspective of university professors because studies in this population were quite scarce.
- **Other educational levels:** Similarly, the lower levels of education (secondary and primary education) or nonformal contexts were the focus of fewer studies, so future investigations may seek to explore these fields and their relationship with e-assessments.
- **Mobile technologies:** Currently, the research has mostly dealt with evaluation studies on Moodle and LMS platforms, as well as different software and educational tools based on the web. In contrast, far fewer studies have focused on assessment through mobile devices and electronic tablets (m-assessment) and through the specific applications for these devices. Therefore, the use of mobile technologies in electronic assessments opens a new avenue of research.
- **Acceptance, efficacy, and quality studies:** Most published studies on e-assessment have focused on the motivation, attitude, and results of students in these processes. The authors of the present research consider relevant to open new lines of research focused on technological acceptance models and the quality of these new assessment designs in this new educational reality.

Data availability The datasets generated during and/or analysed during the current study are available in the Google Sheets repository: bit.ly/3N8xBXf.

Declarations

Competing interests The authors have no relevant financial or nonfinancial interests to disclose.

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