International Research Journal of MMC (IRJMMC)
ISSN 2717-4999 (Online) | 2717-4980 (Print)
Volume 6, Issue 5 | December 2025

Paradigms and Prospects of e-Assessment: A Scoping Review

Krishna Prasad Adhikari, M.Phil.[1] | Dirgha Raj Joshi, Ph.D.[2]
Lekhnath Sharma, Ph.D.[3]

[1]Assistant Professor
Central Department of Education, Tribhuvan University, Nepal

[2]Lecturer
Mahendra Ratna Campus Tahachal, Tribhuvan University, Nepal
Email: dirgharaj.joshi@mrc.tu.edu.np

[3]Professor
Central Department of Education, Tribhuvan University, Nepal
Email: sharmaln012@gmail.com

Corresponding Author
Krishna Prasad Adhikari
Email: krishna.adhikari@cded.tu.edu.np

To Cite this article: Adhikari, K. P., Joshi, D. R., & Sharma, L. (2025). Paradigms and prospects of e-Assessment: A scoping review. *International Research Journal of MMC, 6*(5), 77–93. https://doi.org/10.3126/irjmmc.v6i5.89056

Submitted: 1 November 2025 **Accepted:** 15 December 2025 **Published:** 31 December 2025

Abstract

E-Learning is becoming more popular as a result of technological advancement. The focus of the e-learning environment is inclusivity and accessibility for all learners with diverse geographical and cognitive backgrounds, where students get the opportunity to learn at their own pace, place, and time. The growing adoption of e-learning in education is not only creating a new platform for teaching and learning but also raising the issues of e-assessment. Cooper's (1988) method of organizing knowledge synthesis was used in this study. This review paper is focused on concretizing the existing knowledge in the e-assessment based on the findings of the research articles. The article published from 2012 to 2024, focusing on the concept of e-assessment, strategies of e-assessment and issues in the implementation of e-assessment were included in this study. The review revealed three major findings related to e-assessment conception and perception, e-assessment of, for, and as learning, and issues of authentication and authorship in e-assessment. Based on the findings of the reviewed literature, it can be concluded that e-assessment could be a firm alternative to existing paper-based traditional assessment. The findings imply that effective implementation of e-assessment requires well-designed feedback-rich and learner-centered assessment practices supported by improved teacher competencies, inclusive digital infrastructure, and reliable measures to ensure authenticity and academic integrity.

Keywords: e-Assessment, formative assessment, technology, feedback, e-authentication, peer assessment, elf-assessment

1. Introduction

Assessment is the "systematic collection of information about student learning, using the time, knowledge, expertise, and resources available to inform decisions that affect student learning" (Walvoored, 2010, p. 2). In reality, assessment not only monitors the students' learning but also provides opportunities for teachers and students to reflect and improve their teaching and learning activities (Cornard & Openo, 2018). Assessment could define the life chances and direction of individuals as well (Coats, 2018). Joughin (2009) explains three predominant functions of assessment these are supporting the learning process, evaluating the performance of students according to curriculum standards, and preparing the students for their future profession.

Generally, assessment has three approaches: assessment of learning, assessment for learning, and assessment as learning (Earl, 2013; Adhikari et al., 2023). Assessment of learning is typically done at the end of the teaching-learning activities in a summative format for certifying students' performance (Earl, 2013). Assessment for learning is primarily formative in nature and aims to modify existing teaching and learning activities for the betterment (Earl, 2013). The assessment as learning focuses on developing the metacognitive skills of students so that they are their own best assessors of the learning process (Earl & Katz, 2013). More importantly, the essence of assessment as learning is to make students active, engaged, and critical of their learning (Earl & Katz, 2013). All three approaches have their importance in the teaching and learning process. Assessment as and for learning is crucial to develop problem-solving, critical thinking, innovation and creativity, learning to learn, and metacognitive skills in learners, while assessment of learning can provide important information about the learners to the other stakeholders and job recruitment agencies. Technological development has opened up new promises for teaching (Joshi et al., 2025; Joshi, Adhikari, Chapai, et al., 2023), learning, and assessment practices in higher education (Clariana & Wallace, 2002)

Subsequently, an alternative form of assessment attracted the attention of academic institutions, pedagogues, and practitioners who are captivated by its benefits and advantages (Baleni, 2012; Deutsch et al., 2012). Teachers have become increasingly aware of the growing use of ICT in higher education (Deutsch et al. 2012; Khadka et al., 2024), and technology-supported educational systems have transformed the way students are assessed, enabling the acquisition and development of new knowledge and skills (Sampson et al, 2014). The revolution in technology has encouraged educational institutions worldwide to change assessment format, together with teaching and learning activities from paper-based to computer-based assessments, from summative to formative, from assessment of learning to assessment for/as learning (Brady et al., 2019; Khadka et al., 2024). Moreover, digital assessment and evaluation, as well as teachers' behavior, play a vital role in ensuring continuity of learning and evaluation during crises like the COVID-19 pandemic (Joshi et al., 2024; Khadka et al., 2023). Hence teachers of 21st century should have additional digital skills (Khanal et al., 2024) for its propar management (Joshi, Adhikari, Khanal, et al., 2023; Joshi & Rawal, 2021). It does not mean that the assessment of learning is disappearing with the development of technology, but it is embedded with the process of learning. For example, if we apply peer-assessment techniques to assess the work of peers, the assessment of learning and assessment as the learning go together. Where the assessor grades the work of peers and also develops his/her metacognitive skills through assessment (Earl & Katz, 2013).

We are in the transitioning phase of online learning from the physical model to the online model. Various studies have been done on the possibilities, challenges, and problems of online learning in the international context. In this context, subject teachers are also facing various digital skill-related challenges in their instruction (Khanal, Joshi, Adhikari, Khadka, et al., 2022; Adhikari et al., 2022; Khanal, Joshi, Adhikari, & Khanal, 2022), hence the institution should have a digital support system for them (Joshi et al., 2022). Our universities are starting

collaboration to exchange ideas and motivate faculty to adopt technology in teaching-learning activities to some extent after the outbreak of Covid-19. But the issues of the assessment in online mode have not been resolved yet. In this context, the need of a comprehensive e-assessment framework, which includes all the components of assessment, was realized.

In the process of searching the literature, separate reporting of the issues of assessment was found, some reported from the students' side and some from instructors or institutions, some focus only on teaching and learning activities, and some focus only on evaluation. So, we decided to conduct a narrative review, which would help to concretize the existing knowledge about e-assessment. Particularly, this paper is concentrated on how the different institutions of the developed world practice e-assessment, what the academics and students perceive about the process and prospects of e-assessment, and are these systems are also compatible with content like mathematics and science at the higher level.

2. Methods and Procedures

This is a review-based paper. It has followed Cooper's (1988) methods of organizing knowledge synthesis. Methods and procedures have included article retrieving techniques, inclusion and exclusion criteria, article selection and final pooling, and article analyzing and synthesizing process. Based on the Cooper's idea we have reviewed the articles and generated the result.

2.1 Articles Retrieving Techniques

The initial pooling was done by exploring the recent information system journals, educational journals, and articles using different databases such as Google Scholar, Educational Resources Center [ERIC], PROQUEST and EBSCO HOST. The literature published online between 2012 and 2024 was searched and retrieved. The criteria of searching literature were set as ("e-Assessment" OR "Computer-based Assessment" OR "Online Assessment" OR "Technology in Assessment") AND ("Mathematics" OR "Mathematics Education" OR "Education" OR "Learning"). For the collection of data snowball method (Wohlin, 2014) in the literature review was applied to identify additional sources based on the reference list using backward snowballing and citation of the current literature using the forward snowballing method (Wohlin, 2014).

2.2 Inclusion and Exclusion Criteria

Inclusion and exclusion criteria in the review process should be based on research questions (Kitchenham & Charters, 2007). These criteria should be practicable in terms of classification, management, and interpretation (Kitchenham & Charters, 2007; Okoli & Schabram, 2010). Since this study is targeted to analyze the practices of e-assessment in education in a specific period, so some criteria are set for the selection of appropriate literature for the study. The peer-reviewed articles published after 2012 A.D., based on the perception and conception of students and instructors on e-assessment, practices on e-assessment, strategies applied to conduct e-assessment, the impact of e-assessment in learning, issues, and challenges while conducting e-assessment, were framed as the inclusion criteria for the review process. In the searching process, mathematics was considered as the central theme, but the articles closely related to the research questions of the study were included in the selection procedure.

2.3 Article Selection and Final Pooling

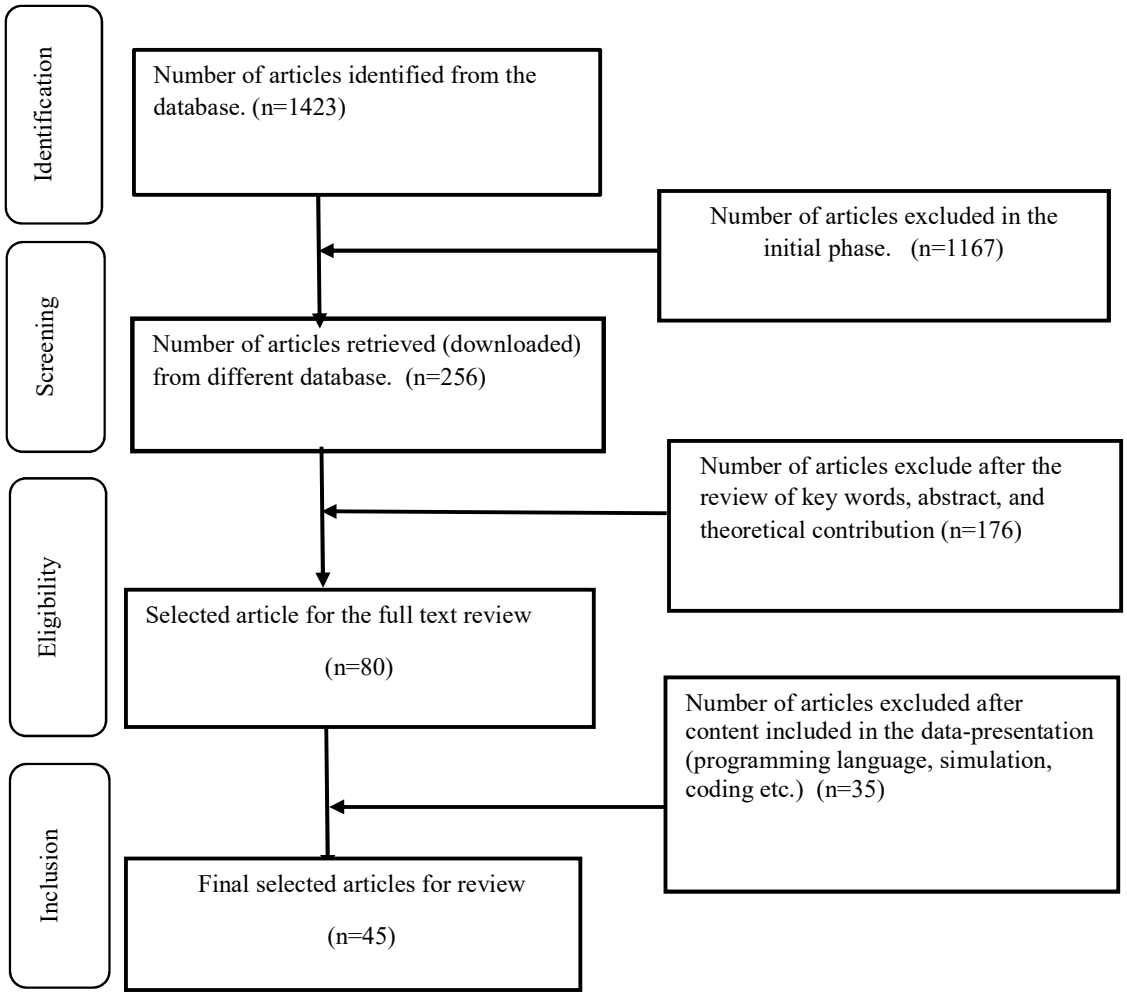
The retrieved articles, at first, were managed in Microsoft Excel sheets. In total, 1423 articles were retrieved as the initial pooling from the databases. In the screening phase, the reliability (submission history, publication process, and targeted area) and accessibility of

journals were analyzed and only 256 full-text articles were selected for the next process. In the second phase, the eligibility of resources was analyzed based on the inclusion/exclusion criteria. Particularly, abstracts, keywords, and methods, and theoretical contributions were studied thoroughly and only the 80 articles were selected for the full-text review. In the process of full-text review 35 articles that were more technical (including programming language, simulation, or customization of tools, etc.) and beyond the scope of this paper were excluded. At last, 45 articles were used in the process of analysis. The detail of the article selection procedure is presented in Figure 1.

2.4 Articles Analyzing and Synthesizing Process

The collected literature was analyzed by using the content analysis approach (Seuring & Gold, 2012) based on the topic of the study. At first, the collected literature was categorized based on the themes of the topic. Some already formulated themes were removed and some new themes were added based on the nature of literature and finally altogether four themes: e-Assessment conception and perception, e-assessment approaches, e-assessment strategies, and the issue of authentication and authorship in e-assessment were formulated and analyzed using these themes as headings.

Figure 1. *The Selection of Articles for the Review Process*



3. Result and Discussion

This section provides a detailed analysis of the results of the selected literature. The results of the literature are categorized into different thematic headings as e-assessment conception and perception, e-assessment of, for, and as learning, and issues of authenticity and authorship in e-assessment.

3.1 e-Assessment Conception and Perception

Students' conception of assessment also determines the learning performance in mathematics. Brown & Hirschfeld (2007) explained that those students who conceived assessment as a tool to make accountable for learning and assessment as useful had higher mathematics achievement compared to the students who ignored assessment. It also argued that the assessment makes students and instructors accountable for teaching and learning activities. In this review, how students and teachers have conceived the concept of assessment and their perception regarding the use of e-assessment in the teaching-learning process are discussed. Table 1 gives a summary of issues and observations found from the review of articles dealing on conceptions and perceptions of students and instructors on e-assessment.

Table 1: *Perception and Conception on e-Assessment*

Authors	Perception and Conception
van der Kleij et al. (2012)	e-Assessment positively influence attitude and motivation, provide immediate correct response and feedback.
Broughton et al. (2013)	Free-up time Effective to provide feedback Can test the students' conceptual understanding of mathematics.
Timmers et al. (2013)	Positive motivation on task value that predicts formative assessment. Increase feedback-seeking behavior.
Cheng and Hou (2015)	Students offer more affective feedback in the initial stage Cognitive or metacognitive feedback in the later stage.
Holmes (2015)	Low-stakes continuous assessment in summative format is beneficial than high stake assessment.
Adesemowo et al. (2016)	e-Assessment extending the scholarship of teaching and learning to the scholarship of teaching, learning, and assessment.
Debuse and Lawley (2016)	Feel beneficial regarding reducing time, improving efficiency, and immediate feedback.
Martínez-Sierra et al. (2016)	Conception on students' representations about assessment in mathematics is closely linked to their representations of mathematics itself.
Pattalitan (2016)	Feedback and feed-forward mechanisms and model situations for the learners to engage in appropriate activities which lead them to the closure of the gap between current and good performance
Noor Davids (2017)	The ICT solution with TPCK model is beneficial for their present and future professional careers.
Wang and Jeffrey (2017)	Positive about e-portfolio assessment rather than traditional paper-based examination.
Acosta-Gonzaga and Walet (2018)	Students enjoy on feedback system in e-assessment, perceive ease of use.
Alruwais et al. (2018).	e-Assessment provides feedback for students, enhance higher-order thinking, and reduce the burdens of teacher

Bahar and Asil (2018)	Male students have a significantly positive attitude than their female counterparts.
Bloom et al. (2018)	Perceive benefits of the online exam on data gathering and feedback.
Brown and Lally (2018)	Students perceive a lack of knowledge and hurdles in online assessment
Demir (2018)	Social media seemed effective to provide feedback and enhance peer engagement.
Faniran and Ajayi (2018)	Student preference is on computer-based assessment than paper-based assessment.
Brady et al. (2019)	Students and instructors perceive lacking competencies in design, set-up, and ongoing maintenance, time, and resources.
Helfaya (2019)	Participants appreciated the use and benefits of computer-based assessment.
Khan and Khan (2019)	Lack of confidence in the transition towards online
Patronis et al. (2019)	Perceived difficulties in grading
Reedy et al. (2021)	Perceive as efficiently managing and streamlining the assessment process, facilitating dialogue and engagement, enhance learning, develop digital identity and academic integrity needs for a digital world.
Snekalatha et al. (2021)	Perceived positively towards the online formative e-assessment.

E-assessment is considered as the process of accommodating different learning styles and learning preferences, a focus on convenience, flexibility, ease of access, and choice rather than on awareness (Reedy et al., 2021). Students' social representations of assessment in mathematics are closely linked to their social representations of mathematics and the teaching and learning thereof (Martínez-Sierra et al., 2016).

The perception of students and instructors on computer-based assessment was found to be positive (Bahar & Asil, 2018; Broughton et al., 2013; Debuse & Lawley, 2016; Snekalatha et al., 2021; Wang & Jeffrey, 2017). A study by Bahar & Asil (2018) found that male students had significantly positive attitudes than their female counterparts on e-assessment, duration of computer usage is also a significant determinant in attitudes, in which user who had a long history of computer usage, while education level didn't significantly matter on attitude. But the single research finding is not sufficient to conclude that female students are less satisfied with the process of e-assessment. The research showed that the instructors' and students' perception about the computer-based assessment and feedback production, namely SuperMarkIt (SMI) was positive regarding the quality, efficiency, and versatility. Mostly, it is beneficial regarding time as it reduces repetition, improving efficiency, and providing immediate feedback, consistency, legibility, and ecological benefits (Debuse & Lawley, 2016).

Teachers' perspectives on the use of computer-aided assessment were its free up time in compiling, distributing, and marking assessments, convenient, provide opportunities, provide immediate feedback and motivate the students. The process of computer-based assessment is efficient and time-saving for teachers but the feedback-providing system can make students too much dependent on problem-solving and complete the assessment (Broughton et al., 2013). The study of medical students on non-proctored online formative assessment regarding the reliability, usefulness, and feasibility suggests that viva-voce exam through video conferencing is reliable, the multiple-choice examination is done through online practically feasible, having faster feedback than classroom assessment and online test helps substantially to learn the subject matter; however, there are challenges regarding the connectivity and digital devices (Snekalatha et al., 2021).

Low-stakes continuous assessment in a summative format influence positively on the engagement of students in learning. Students opined that they improved their understanding of the content through the use of continuous assessment. This study suggests that the students' engagement and learning can be improved through carefully designed assessments (Holmes, 2015). Response of students on ICT-Based e-assessment with technology, pedagogy, and content knowledge (TPCK) model found positive for present and future professional careers because the lifelong learning can be promoted through the development of assessment through ICT (Noor Davids, 2017), however, the knowledge of continuous assessment process and possible hurdles during online assessment process should be clearly explained to the students. For that, an alternative approach to curriculum and pedagogical design is necessary (Brown & Lally, 2018).

Feedback is a major component for the acceptance of e-assessment. Feedback and feed-forward mechanisms are the forearms of assessment that draw creativity in tracking student's improvement. Owing to theories of learning, systematic incorporation of feedback and feed-forward mechanisms to teachers' instructional scaffolding techniques is highly wanting if teaching is to be effective (Pattalitan, 2016). Students seem positive about computer-based assessment due to the feedback system provided in online mode(Acosta-Gonzaga & Walet, 2018; Adesemowo et al., 2016; Bloom et al., 2018; Cheng & Hou, 2015; Debuse & Lawley, 2016; Demir, 2018; Fyfe et al., 2014). Students can become self-reflective and self-regulated learners through the use of e-assessment, feedback moderation and visualizing all activities (Debuse & Lawley, 2016; Fyfe et al., 2014) and develop as an independent learner and promote higher-order thinking (Alruwais et al., 2018). In particular, students appreciate the timely given constructive feedback and the feedforward system of e-assessment (Helfaya, 2019). But, it should be noted that the effectiveness of feedback relies on the students' expectations and the use of feedback in the learning process (Timmers et al., 2013). It is also found that students expect and offer more affective feedback from their instructor and peers than cognitive and metacognitive feedback in the initial stage, but in the progress, peers offer cognitive and metacognitive feedback and change the pattern of affective feedback as well (Cheng & Hou, 2015). In a nutshell, feedback is the contributing factor for learning outcomes as well. Immediate feedback to the students can attract their attention of students. Students perceived that immediate knowledge of correct response and elaborated feedback is much more supportive than knowledge of the result of summative assessment in learning (van der Kleij et al., 2012).

Issues related to a lack of appropriate theoretical framework, academics' competencies in designing e-assessment, set-up and maintenance, and time and resources are major existing challenges (Brady et al., 2019). In particular, the challenges of e-assessment are associated with the free writing test, screen display, and built-in timer (Patronis et al., 2019). Some other challenges include internet connectivity and the mode of presentation of items when undertaking computer-based assessments (Faniran & Ajayi, 2018; Snekalatha et al., 2021). Convincing students about the usefulness of e-assessment is important before applying it. The transition from traditional assessment to e-assessment is gradual but important. The concerns and preferences of students should also be emphasized (Khan & Khan, 2019) in the transition process.

3.2 Assessment Approaches

Generally, assessment has three approaches these are assessment of learning, assessment for learning, and assessment as learning (Earl, 2013). Assessment as and for learning is crucial to develop problem-solving, critical thinking, innovation and creativity, learning to learn, and metacognitive skills in learners. Assessment of learning, on the other hand, is also important to provide essential information about the learners to the other

stakeholders and job recruitment agencies. Table 2 presents the focus of e-assessment and the findings derived from the review of listed literature are discussed in the subsequent paragraphs.

Table 2: *Focuses of e-assessment*

Authors	e-Assessment (of, for, and as learning)
Lu and Law (2012	Peer grading Peer feedback, Predictor of the performance
Spivey and McMillan (2014)	Effort and performance
Lafuente Martínez et al. (2015)	Transparency in assessment
Adesemowo et al. (2016)	Scholarship of teaching and learning to the scholarship of teaching, learning, and assessment
Lin and Wang (2017)	Improve learning and clarify the misconception.
Petrović et al. (2017)	Formative assessment
Appiah and Tonder (2018)	Credibility of e-assessment
Holmes (2018)	e-Assessment in the virtual learning environment and students' activity.
Liu et al. (2019)	Voluntary assessment vs. compulsory assessment.
Veenman and van Cleef (2019)	Online instrument over off-line for the assessment for metacognitive skills in mathematics
Aldon, and Panero, (2020)	Technology and posture of formative assessment.
Ukobizaba et al. (2021)	Students' problem-solving skills in mathematics Structure of the Observed Learning Outcome taxonomy, Higher-Order Thinking etc.
Wafubwa and Csíkos (2021), Yin et al. (2022)	Learning intentions, Peer assessment Teachers' evaluation skills.

Studies have shown that properly designed e-assessment improves students' learning engagement (Holmes, 2018) and reduce the workload of teachers in administration, marking, and feedback (Adesemowo et al., 2016). Even the higher-order assessment tasks can also be assessed in an e-assessment system (Appiah & Tonder, 2018) and strengthen students' problem-solving abilities through different approaches of assessments within learner-centered teaching approaches (Ukobizaba et al., 2021). The development of digital technology has significantly changed the assessment pattern of mathematical skills. Particularly, the didactic nature of the formative assessment is proposed in recent days, which can transform the principles of formative assessment into an instrument of formative assessment (Aldon & Panero, 2020). From these findings, it can be said that an appropriately designed e-assessment is useful to assess the higher-order thinking skills, but the literature is silent on referring to the appropriate design of assessment, issues of the digital divide, appropriate use of tools, and approaches for the assessment.

Most of the literature on e-assessment focuses on assessment for and as learning, which focuses on students' learning improvement and teachers' evaluation skills. In particular, the peer assessment and success criteria have a significant effect on the metacognitive skills of teachers (Wafubwa & Csíkos, 2021; Yin et al., 2022), while online instruments are preferable over offline instruments for the assessment of metacognitive skills of students in mathematics (Veenman & van Cleef, 2019). Web-based dynamic assessment models can improve student learning achievement and overcome the misconceptions about the content (Lin & Wang, 2017)

and e-assessment promotes transparency in virtual and blended learning environments through different assessment tools like discussion forums, quizzes, assignments, and others (Lafuente Martínez et al., 2015). Online formative assessment strategies are very efficient interventions to improve the performance of students and provide potential for gaining insight into students' learning habits (Petrović et al., 2017), and the peer feedback, particularly in the process of peer assessment, enhances both assessor and students' performance (Lu & Law, 2012). Students' learning outcomes can be enhanced from both compulsory and voluntary online peer assessment systems, but voluntary peer assessment seemed more effective than compulsory assessment in learning outcomes and accuracy of assessment as well because the motivational level of students in the voluntary group is good and can provide a high-quality draft for peer-review (Liu et al., 2019).

Overall findings of the research showed that the formative assessment strategies applied in the process of e-assessment seemed more effective in learning progress. The focus on assessment is not only to assess the students' performance but also to develop the problem-solving and metacognitive skills of students. More interestingly, the process of e-assessment not only supports reflecting on students' learning process but also adapts teacher's instructional strategies according to students' level of learning.

3.3 Issues of Authenticity and Authorship

Maintaining the authorship and authenticity of online assessments and submission is a challenge because of the increasing rate of plagiarism and cheating (Mellar et al., 2018; Okada, Noguera, et al., 2019; Okada, Whitelock, et al., 2019a; Reedy et al., 2021). An Adaptive Trust-based e-Assessment System (TeSLA) is crucial to maintain authenticity and authorship in the digital age (Mellar et al., 2018; Okada, Noguera, et al., 2019). Some issues explored in the research papers are mentioned in Table 3 and the discussion on findings based on these issues is presented in this section.

Table 3: *Issues of e-assessment*

Authors	Issues and challenges for authenticity and e-authorship
Callan et al. (2016)	Knowledge, skills, and confidence on time, effort, and resources.
Mellar et al. (2018)	Cheating, plagiarism, Adaptive Trust-based e-Assessment System (TeSLA)
Okada et al. (2019)	Technical, organizational, and pedagogical, TeSLA,
Okada et al. (2019a)	Acceptance and trust in e-authentication tools.
Nguyen et al. (2020)	Design activities for higher-order thinking and academic integrity pledge, online proctoring
Laamanen et al. (2021)	Disabilities and e-authentication.
Reedy et al., (2021)	Academic integrity, proctored or not-proctored examination, cheating

Cheating is the major problem in all forms of exams, whether face-to-face or online, proctored or non-proctored (Mellar et al., 2018; Reedy et al., 2021). But teacher experiences that the case of cheating in distance education is low due to the use of the e-assessment system. The issue of authorship checking is also a major problem in all contexts, as copying and pasting from the e-resources, ghostwriting, and plagiarism. Another category of cheating was accessing the information from the other students (Mellar et al., 2018). Interestingly, students perceived that cheating is harder in online examinations than in face-to-face exams (Reedy et al., 2021) Students' perceptions about cheating differ with age, and staff and students are confused about what constitutes cheating in online examinations (Reedy et al., 2021).

In addition to that, technical, organizational, and pedagogical issues related to accessibility, security, privacy, and e-assessment design and feedback on e-authentication of e-assessment are also identified. The technical issue contains system interface, TeSLA instruments, feedback and usability, the organizational issue contains accessibility, security and privacy, fraud detection, prevention and trust, and the pedagogy and assessment issue is under the pedagogical issue (Okada, Noguera, et al., 2019). Knowledge, skills, and confidence in time, effort, and resources needed to design standard assessments to capture the required evidence are the challenges of e-assessment found by Callan et al. (2016). Although online quizzes with randomized questions in an adaptive form are common, many are poorly designed; hence, the training for flexible, customized, and cost-effective assessment with clear guidelines is recommended (Callan et al., 2016). Teachers and students have positive acceptance and trust in e-authentication tools (Okada, Noguera, et al., 2019; Okada, Whitelock, et al., 2019a; Laamanen et al., 2021), because it can increase the students' awareness of cheating and plagiarism and maintain the trustworthiness of e-assessment (Okada, Noguera, et al., 2019) and student accept e-authentication tool because it provides opportunities to prove the originality of the work (Laamanen et al., 2021). Women and mature students show higher trust than men and younger participants, while students with disabilities have mixed perception because of a lack of essential technological competencies, clarity on the assessment procedures, accessibility and inclusiveness (Okada, Whitelock, et al., 2019a). On the other hand, gender, age, experience, and adaptability issues make more difference.

The technologies for the authentication, such as "face recognition, voice recognition, and Keystroke Dynamism" (Mellar et al., 2018, p. 5) and authorship checking from forensic analysis, plagiarism detection are in use. In learning management systems such as Moodle, TeSLA plug-in can be integrated into activities such as assignments, forums, quizzes, etc. The main reason found in the study was students' unwillingness to work hard and the weakness of sanctions, lack of knowledge about the plagiarism issue (Mellar et al., 2018). In the case of the unavailability of online proctoring and other additional software, modifications in the assessment format can minimize cheating. For example, higher-order thinking multiple-choice questions, higher-order thinking short answer questions, increasing assessment frequency, academic integrity pledge, etc., could be effective techniques (Nguyen et al., 2020).

4. Conclusion

This study is concerned with the process, practices, effect, and strategies of e-assessment in education based on the 45 articles from 2012-2024. The research on this duration mostly focused on how students and teachers perceive the adoption of different strategies of e-assessment, what the challenges are in adopting e-assessment (computer-based assessment), and how the strategies of assessment influence the learning process. Despite some issues of designing and conducting the assessment, e-assessment seems benefited to students as well as teachers. Students perceived positively the process of e-assessment as it is transparent and progressive for learning. Particularly, the feedback mechanism adopted in the e-assessment design has helped to reflect and improve the learning process. For teachers, the e-assessment system reduces the burden on marking and grading the students and also provides input to improve, change or refine the self-teaching styles.

The design of e-assessment is mostly based on the formative approach, where the parameters of assessment for and as learning is ensured. Instructor-led assessment, peer-assessment, self-assessment, e-portfolio, and analytics to some extent, are the major strategies applied in the process of e-assessment. However, some research findings are based on summative e-assessment also and some are on alternative tools for e-assessment, for instance, smartphones. The findings showed that a properly designed e-assessment technique is beneficial for the enhancement of students' learning and furnishing the skills of teachers in

assessment. Very little research has been found in the use of e-assessment in the area of higher mathematics. But, the findings in such research are motivating for future research. Particularly, the formative assessment model of e-assessment assists students in enhancing the problem-solving skills in mathematics and teachers for the development of metacognitive skills of assessment.

In the last section of the review paper, some issues of authentication and authorship are explored. The research findings showed that both face-to-face and online systems of assessment have the problem of cheating if we are solely following the process of summative evaluation. But, the issues of authentication and authorship can be mitigated through the process of formative assessment, particularly in the e-assessment system. TeSLA is the most recommended system for e-authentication and authorship. Face recognition, voice recognition, and Keystroke Dynamism are for e-authentication and forensic analysis, plagiarism detection tools are for authorship checking are also recommended to maintain the validity of the e-assessment process.

This study has several implications for the implementation of e-assessment in higher and school education, the use of assessment strategies to assess students' learning and learning processes, and the maintenance of the trustworthiness of the online assessment process. The perceptions of the teachers and students regarding e-assessment were positive. So, educational institutions should develop online assessment policies and guidelines, establish robust infrastructure, and strengthen staff and faculty skills to execute online assessment. The authenticity and credibility of online assessments depend on the assessment procedures. Online assessment focuses on assessment for and as learning rather than of learning, so professional development programs should be conducted for teachers to enhance their skills in formative assessment design, feedback design, and higher-order task creation. The findings of the study also provide sufficient evidence on adopting trusted authentication systems and redesigning assessments to maintain academic integrity.

5. Limitations of the Study

The field of education is expanding as the advancement of science and technology. These technologies also broadening the area of research in education. In the process of database searching, thousands of research papers were found based on the assessment and e-assessment but we only reviewed very limited papers that are firmly concerned with e-assessment. All the dimensions of curriculum, instruction, and assessment which are interconnected cannot be covered here. This single review paper could not answer all the issues related to education, assessment, and technology, but it could open the new door of research in the area of e-assessment.

6. Funding

The research is part of a PhD grant (Award No. PhD-79/80-EDU-01) from the University Grants Commission (UGC) Nepal. However, the authors received no financial support for the publication of this article.

7. Declaration of conflicting interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

References

1. Acosta-Gonzaga, E., & Walet, N. R. (2018). The role of attitudinal factors in mathematical on-line assessments: A study of undergraduate STEM students. *Assessment*

and Evaluation in Higher Education, *43*(5), 710–726. https://doi.org/10.1080/02602938.2017.1401976

2. Adesemowo, A. K., Johannes, H., Goldstone, S., & Terblanche, K. (2016). The experience of introducing secure e-assessment in a South African university first-year foundational ICT networking course. *Africa Education Review*, *13*(1), 67–86. https://doi.org/10.1080/18146627.2016.1186922
3. Adhikari, K. P., Joshi, D. R., Belbase, S., Sharma, L., & Khanal, B. (2023). Mathematics teachers' self-reported practices of formative assessments in teaching mathematics online. *International Journal of Online Pedagogy and Course Design*, *13*(1), 1–19. https://doi.org/10.4018/IJOPCD.324603
4. Adhikari, K. P., Joshi, D. R., Khadka, J., & Khanal, B. (2024). Effect of preference and management of e-assessment system on its quality assurance process. *Journal of Educators Online*, *21*(3). https://doi.org/10.9743/JEO.2024.21.3.9
5. Adhikari, K. P., Joshi, D. R., & Sharma, K. P. (2022). Factors associated with the challenges in teaching mathematics online during COVID-19 pandemic. *Contemporary Mathematics and Science Education*, *3*(2), ep22014. https://doi.org/10.30935/conmaths/12225
6. Aldon, G., & Panero, M. (2020). Can digital technology change the way mathematics skills are assessed? *ZDM - Mathematics Education*, *52*(7), 1333–1348. https://doi.org/10.1007/s11858-020-01172-8
7. Alruwais, N., Wills, G., & Wald, M. (2018). Advantages and challenges of using e-assessment. *International Journal of Information and Education Technology*, *8*(1), 34–37. https://doi.org/10.18178/ijiet.2018.8.1.1008
8. Appiah, M., & Tonder, F. (2018). E-assessment in higher education: A review. *International Journal of Business Management and Economics Research*, *9*(6), 1454–1460.
9. Bahar, M., & Asil, M. (2018). Attitude towards e-assessment: influence of gender, computer usage and level of education. *Open Learning*, *33*(3), 221–237. https://doi.org/10.1080/02680513.2018.1503529
10. Baleni, Z. G. (2012). Why and how academic staff adopt e-assessment in a higher education institution (HEI). In H. Beldhuis (Ed.), *11th European Conference on e-Learning* (Vol. 28, pp. 28–36). Academic Publishing International Limited.
11. Bloom, T. J., Rich, W. D., Olson, S. M., & Adams, M. L. (2018). Perceptions and performance using computer-based testing: One institution's experience. *Currents in Pharmacy Teaching and Learning*, *10*(2), 235–242. https://doi.org/10.1016/j.cptl.2017.10.015
12. Brady, M., Devitt, A., & Kiersey, R. A. (2019). Academic staff perspectives on technology for assessment (TfA) in higher education: A systematic literature review. *British Journal of Educational Technology*, *50*(6), 3080–3098. https://doi.org/10.1111/bjet.12742
13. Broughton, S. S., Robinson, C. C., & hernandez-martinez, P. (2013). Lecturers' perspectives on the use of a mathematics-based computer-aided assessment system. *Teaching Mathematics and Its Applications*, *32*(2), 88–94. https://doi.org/10.1093/teamat/hrt008
14. Brown, G. T. L., & Hirschfeld, G. H. F. (2007). Students' conceptions of assessment and mathematics: Self-regulation raises achievement. *Australian Journal of Educational & Developmental Psychology*, *7*, 63–74. https://eric.ed.gov/?id=EJ815623
15. Brown, K., & Lally, V. (2018). Rhetorical relationships with students: A higher education case study of perceptions of online assessment in mathematics. *Research in Comparative and International Education*, *13*(1), 7–26. https://doi.org/10.1177/1745499918761938

16. Callan, V. J., Johnston, M. A., Clayton, B., & Poulsen, A. L. (2016). E-assessment: challenges to the legitimacy of VET practitioners and auditors. *Journal of Vocational Education and Training*, *68*(4), 416–435. https://doi.org/10.1080/13636820.2016.1231214
17. Cheng, K. H., & Hou, H. T. (2015). Exploring students' behavioural patterns during online peer assessment from the affective, cognitive, and metacognitive perspectives: a progressive sequential analysis. *Technology, Pedagogy and Education*, *24*(2), 171–188. https://doi.org/10.1080/1475939X.2013.822416
18. Coats, H. (2018). Research and governance architectures to develop the field of learning outcomes assessment. In O. Zlatkin-Troitschanskaia, M. Toepper, H. A. Pant, C. Lautenbach, & C. Kuhn (Eds.), *Assessment of learning outcomes in higher education Cross-National comparisons and perspectives* (pp. 3–18). Springer.
19. Cooper, H. M. (1988). Organizing knowledge syntheses: A taxonomy of literature reviews. *Knowledge in Society*, *1*(1), 104–126. https://doi.org/10.1007/BF03177550
20. Cornard, D., & Openo, J. (2018). *Assessment strategies for online learning: Engagement and authenticy*. AU Press.
21. Debuse, J. C. W., & Lawley, M. (2016). Benefits and drawbacks of computer-based assessment and feedback systems: Student and educator perspectives. *British Journal of Educational Technology*, *47*(2), 294–301. https://doi.org/10.1111/bjet.12232
22. Demir, M. (2018). Using online peer assessment in an Instructional Technology and Material Design course through social media. *Higher Education*, *75*(3), 399–414. https://doi.org/10.1007/s10734-017-0146-9
23. Deutsch, T., Herrmann, K., Frese, T., & Sandholzer, H. (2012). Implementing computer-based assessment – A web-based mock examination changes attitudes. *Computers & Education*, *58*(4), 1068–1075. https://doi.org/10.1016/j.compedu.2011.11.013
24. Earl, L., & Katz, S. (2013). Getting to the core of learning: Using assessment for self-monitoring and self-regulation. In M. Mok (Ed.), *Self-Directed Learning Oriented Assessments in the Asia-Pacific* (pp. 123–137). Springer Netherlands. https://doi.org/10.1007/978-94-007-4507-0_7
25. Earl, L. M. (2013). *Assessment as learning*. Sage Publishing. http://uk.sagepub.com/en-gb/eur/book/assessment-learning-1
26. Faniran, V. T., & Ajayi, N. A. (2018). Understanding students' perceptions and challenges of computer-based assessments: a case of UKZN. *Africa Education Review*, *15*(1), 207–223. https://doi.org/10.1080/18146627.2017.1292112
27. Fyfe, G., Fyfe, S., Meyer, J., Ziman, M., Sanders, K., & Hill, J. (2014). Students reflecting on test performance and feedback: An on-line approach. *Assessment and Evaluation in Higher Education*, *39*(2), 179–194. https://doi.org/10.1080/02602938.2013.801063
28. Helfaya, A. (2019). Assessing the use of computer-based assessment-feedback in teaching digital accountants. *Accounting Education*, *28*(1), 69–99. https://doi.org/10.1080/09639284.2018.1501716
29. Holmes, N. (2015). Student perceptions of their learning and engagement in response to the use of a continuous e-assessment in an undergraduate module. *Assessment and Evaluation in Higher Education*, *40*(1), 1–14. https://doi.org/10.1080/02602938.2014.881978
30. Holmes, N. (2018). Engaging with assessment: Increasing student engagement through continuous assessment. *Active Learning in Higher Education*, *19*(1), 23–34. https://doi.org/10.1177/1469787417723230
31. Joshi, D. R., Adhikari, K. P., Chapai, K. P. S., & Bhattarai, A. R. (2023). Effectiveness of online training on digital pedagogical skills of remote area teachers in Nepal. *International Journal of Professional Development, Learners and Learning*, *5*(2),

ep2311. https://doi.org/10.30935/ijpdll/13666
32. Joshi, D. R., Adhikari, K. P., Khanal, J., & Belbase, S. (2023). Impact of digital skills of mathematics teachers to promote students' communication behavior in the classroom. *Contemporary Educational Technology*, *15*(4). https://doi.org/10.30935/cedtech/13495
33. Joshi, D. R., Khanal, B., & Adhikari, K. P. (2025). Effects of digital pedagogical skills of mathematics teachers on academic performance. *International Journal of Educational Reform*, *34*(4), 665–688. https://doi.org/10.1177/10567879231164615
34. Joshi, D. R., Khanal, B., & Belbase, S. (2022). Teachers' perceptions toward student support in using information and communication technology in mathematics learning. *The International Journal of Technologies in Learning*, *29*(2), 57–73. https://doi.org/10.18848/2327-0144/CGP/v29i02/57-73
35. Joshi, D. R., Neupane, U., Singh, J. K., Khanal, B., & Belbase, S. (2024). Impact of COVID-19 pandemic on academic activities of academicians in Nepal. *Journal of Education*, *204*(2), 439–454. https://doi.org/10.1177/00220574231153183
36. Joshi, D. R., & Rawal, M. (2021). Mathematics teachers standing on the utilization of digital resources in Kathmandu, Nepal. *Contemporary Mathematics and Science Education*, *2*(1), 1–7. https://doi.org/10.30935/conmaths/9679
37. Joughin, G. (2009). Introduction: Refocusing assessment. In G. Joughin (Ed.), *Assessment, Learning and Judgement in Higher Education* (pp. 1–11). Springer Netherlands. https://doi.org/10.1007/978-1-4020-8905-3_1
38. Khadka, J., Acharya, D., Joshi, D. R., & Adhikari, K. P. (2024). Digital assessment in higher education of Nepal: preference and practice. *International Journal of Technology Enhanced Learning*, *16*(3), 297–312. https://doi.org/10.1504/ijtel.2024.10064317
39. Khadka, J., Joshi, D. R., Adhikari, K. P., & Khanal, B. (2023). Teachers' humanistic role in teaching mathematics online during the COVID-19 pandemic in Nepal. *International Journal of Distance Education Technologies*, *21*(1), 1–19. https://doi.org/10.4018/IJDET.324951
40. Khan, S., & Khan, R. A. (2019). Online assessments: Exploring perspectives of university students. *Education and Information Technologies*, *24*(1), 661–677. https://doi.org/10.1007/s10639-018-9797-0
41. Khanal, B., Devkota, K. R., Acharya, K. P., Chapai, K. P. S., & Joshi, D. R. (2024). Evaluating the competencies of university teachers in content, pedagogical, and technological knowledge. *Cogent Education*, *11*(1). https://doi.org/10.1080/2331186X.2024.2360854
42. Khanal, B., Joshi, D. R., Adhikari, K. P., Khadka, J., & Bishowkarma, A. (2022). Factors associated with the problems in teaching mathematics through online mode: A context of Nepal. *International Journal of Education and Practice*, *10*(3), 237–254. https://doi.org/10.18488/61.v10i3.3097
43. Khanal, B., Joshi, D. R., Adhikari, K. P., & Khanal, J. (2022). Problems of mathematics teachers in teaching mathematical content online in Nepal. *International Journal of Virtual and Personal Learning Environments*, *12*(1), 1–17. https://doi.org/10.4018/ijvple.312845
44. Kitchenham, B., & Charters, S. (2007). *Guidelines for performing Systematic Literature Reviews in Software Engineering*. http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.117.471
45. Laamanen, M., Ladonlahti, T., Uotinen, S., Okada, A., Bañeres, D., & Koçdar, S. (2021). Acceptability of the e-authentication in higher education studies: Views of students with special educational needs and disabilities. *International Journal of Educational Technology in Higher Education*, *18*(1). https://doi.org/10.1186/s41239-020-00236-9
46. Lafuente Martínez, M., Álvarez Valdivia, I. M., & Remesal Ortiz, A. (2015). Making

learning more visible through e-assessment: implications for feedback. *Journal of Computing in Higher Education*, *27*(1), 10–27. https://doi.org/10.1007/s12528-015-9091-8

47. Lin, C. Y., & Wang, T. H. (2017). Implementation of personalized e-assessment for remedial teaching in an e-learning environment. *Eurasia Journal of Mathematics, Science and Technology Education*, *13*(4), 1045–1058. https://doi.org/10.12973/eurasia.2017.00657a
48. Liu, J., Guo, X., Gao, R., Fram, P., Ling, Y., Zhang, H., & Wang, J. (2019). Students' learning outcomes and peer rating accuracy in compulsory and voluntary online peer assessment. *Assessment and Evaluation in Higher Education*, *44*(6), 835–847. https://doi.org/10.1080/02602938.2018.1542659
49. Lu, J., & Law, N. (2012). Online peer assessment: Effects of cognitive and affective feedback. *Instructional Science*, *40*(2), 257–275. https://doi.org/10.1007/s11251-011-9177-2
50. Martínez-Sierra, G., Valle-Zequeida, M. E., Miranda-Tirado, M., & Dolores-Flores, C. (2016). Social representations of high school students about mathematics assessment. *Canadian Journal of Science, Mathematics and Technology Education*, *16*(3), 247–258. https://doi.org/10.1080/14926156.2015.1119336
51. Mellar, H., Peytcheva-Forsyth, R., Kocdar, S., Karadeniz, A., & Yovkova, B. (2018). Addressing cheating in e-assessment using student authentication and authorship checking systems: Teachers' perspectives. *International Journal for Educational Integrity*, *14*(1). https://doi.org/10.1007/s40979-018-0025-x
52. Nguyen, J. G., Keuseman, K. J., & Humston, J. J. (2020). Minimize online cheating for online assessments during covid-19 pandemic. *Journal of Chemical Education*, *97*(9), 3429–3435. https://doi.org/10.1021/acs.jchemed.0c00790
53. Noor Davids, M. (2017). Student responses to an ICT-based e-assessment application for the teaching practicum/ teaching practice module. *International Journal of Information and Communication Technology Education*, *13*(3), 15–26. https://doi.org/10.4018/IJICTE.2017070102
54. Okada, A., Noguera, I., Alexieva, L., Rozeva, A., Kocdar, S., Brouns, F., Ladonlahti, T., Whitelock, D., & Guerrero-Roldán, A. E. (2019). Pedagogical approaches for e-assessment with authentication and authorship verification in higher education. *British Journal of Educational Technology*, *50*(6), 3264–3282. https://doi.org/10.1111/bjet.12733
55. Okada, A., Whitelock, D., Holmes, W., & Edwards, C. (2019a). e-Authentication for online assessment: A mixed-method study. *British Journal of Educational Technology*, *50*(2), 861–875. https://doi.org/10.1111/bjet.12608
56. Okada, A., Whitelock, D., Holmes, W., & Edwards, C. (2019b). e-Authentication for online assessment: A mixed-method study. *British Journal of Educational Technology*, *50*(2), 861–875. https://doi.org/10.1111/bjet.12608
57. Okoli, C., & Schabram, K. (2010). A Guide to Conducting a Systematic Literature Review of Information Systems Research. *Sprouts: Working Papers on Information Systems*, *10*(26). https://www.academia.edu/download/3250666/OkoliSchabram2010SproutsLitReviewGuide.pdf
58. Patronis, M., Ishtaiwa-Dweikat, F. F., Al Awad, M., & Aburezeq, I. M. (2019). Attitudes and perceptions towards summative e-assessment for free-text responses: A case study of a UAE university. *International Journal of Information and Communication Technology Education*, *15*(1), 13–28. https://doi.org/10.4018/IJICTE.2019010102
59. Pattalitan, A. P. (2016). The implications of learning theories to assessment and

instructional scaffolding techniques. *American Journal of Educational Research*, *4*(9), 695–700. https://doi.org/10.12691/education-4-9-9

60. Petrović, J., Pale, P., & Jeren, B. (2017). Online formative assessments in a digital signal processing course: Effects of feedback type and content difficulty on students learning achievements. *Education and Information Technologies*, *22*(6), 3047–3061. https://doi.org/10.1007/s10639-016-9571-0
61. Reedy, A., Pfitzner, D., Rook, L., & Ellis, L. (2021). Responding to the COVID-19 emergency: student and academic staff perceptions of academic integrity in the transition to online exams at three Australian universities. *International Journal for Educational Integrity*, *17*(1). https://doi.org/10.1007/s40979-021-00075-9
62. Seuring, S., & Gold, S. (2012). Conducting content-analysis based literature reviews in supply chain management. *Supply Chain Management*, *17*(5), 544–555. https://doi.org/10.1108/13598541211258609
63. Snekalatha, S., Marzuk, M., Meshram, S. A., Uma Maheswari, K., Sugapriya, G., & Sivasharan, K. (2021). Medical students' perception of the reliability, usefulness and feasibility of unproctored online formative assessment tests. *Advances in Physiology Education*, *45*(1), 84–88. https://doi.org/10.1152/ADVAN.00178.2020
64. Timmers, C. F., Braber-Van Den Broek, J., & Van Den Berg, S. M. (2013). Motivational beliefs, student effort, and feedback behaviour in computer-based formative assessment. *Computers and Education*, *60*(1), 25–31. https://doi.org/10.1016/j.compedu.2012.07.007
65. Ukobizaba, F., Nizeyimana, G., & Mukuka, A. (2021). Assessment strategies for enhancing students' mathematical problem-solving skills: A review of literature. *EURASIA Journal of Mathematics, Science and Technology Education*, *17*(3), 1945. https://doi.org/10.29333/ejmste/9728
66. van der Kleij, F. M., Eggen, T. J. H. M., Timmers, C. F., & Veldkamp, B. P. (2012). Effects of feedback in a computer-based assessment for learning. *Computers and Education*, *58*(1), 263–272. https://doi.org/10.1016/j.compedu.2011.07.020
67. Veenman, M. V. J., & van Cleef, D. (2019). Measuring metacognitive skills for mathematics: students' self-reports versus on-line assessment methods. *ZDM - Mathematics Education*, *51*(4), 691–701. https://doi.org/10.1007/s11858-018-1006-5
68. Wafubwa, R. N., & Csíkos, C. (2021). Formative assessment as a predictor of mathematics teachers' levels of metacognitive regulation. *International Journal of Instruction*, *14*(1), 983–998. https://doi.org/10.29333/iji.2021.14158a
69. Walvoored, B. E. (2010). *Assessment clear and simple: A practical guide for institution, departments, and general education*. CA: Jossey-Bass.
70. Wang, P., & Jeffrey, R. (2017). Listening to learners: An investigation into college students' attitudes towards the adoption of e-portfolios in English assessment and learning. *British Journal of Educational Technology*, *48*(6), 1451–1463. https://doi.org/10.1111/bjet.12513
71. Wohlin, C. (2014). Guidelines for snowballing in systematic literature studies and a replication in software engineering. *ACM International Conference Proceeding Series*, 1–10. https://doi.org/10.1145/2601248.2601268
72. Yin, S., Chen, F., & Chang, H. (2022). Assessment as learning: How does peer assessment function in students' learning? *Frontiers in Psychology*, *13*(June), 1–14. https://doi.org/10.3389/fpsyg.2022.912568