CHAPTER 5

AN ANALYSIS OF ONLINE ASSESSMENT TECHNOLOGIES AND THEIR FUTURE TRENDS

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Abstract

Online Assessment (OA) is a rapidly growing mechanism for continuing education during pandemics or war situations. Due to the rapid development of emerging technologies (ETs), several tools are available to conduct OA in a better way to maintain the quality of e-learning (EL). Therefore, this study focuses on analysing OA technologies and their future trends by conducting a systematic literature review (SLR). From 1525 downloaded research papers, 84 articles were selected. These articles were analysed based on four main research question themes: recent trends and developments in OA, techniques used in OA, how OA helps for fair access to quality education, and implications and considerations of implementing OA technologies. It was found that the majority of the research focused on eliminating OA cheating, while few studies considered automatic feedback provision. Additionally, few researches focused on software development for OA, while the majority of the articles focused on policy and theoretical development for OA. Further, the majority of the studies have considered AI-based research. This research has downloaded articles only from 8 publishers and only open-access articles. Future research can be done on OA tools development while considering low-bandwidth internet connections.

Introduction

Digitisation and ETs provide numerous solutions to the education sector. In that respect, OA is one of the advancements stemming from the concept of EL. Following the surge of EL during the pandemic, OA has become one of the ways to complete academic sessions without delays. Sisodia et al., 2022 pointed out that OA has both positive impacts (eco-friendly, cutting-edge, cost-effective, and saves time) and negative impacts (adaptability to the environment, framework limitations, prone to cheating, and unsuitability for group work). Additionally, OA faces some challenges, such as reliability of the OA software, development of questions, compatibility with the infrastructure, and validation system.

Educational institutes, researchers, and policymakers have been providing several solutions to ensure that OAs are equal to face-to-face examination methods. Academic centres have used both fully automated and semi-automated tools and techniques to conduct OAs. Therefore, it is important to study the limitations and negative aspects of different types of technologies and software that are being used to identify new research directions.

Muzaffar et al., 2021 said that the 25 most widely used software tools for OA and ETs for OA include machine learning (ML), artificial intelligence (AI), biometric techniques, and a few other types of application development techniques. The study confirmed that all these software tools and technologies cannot be used in all countries due to several major factors, such as network infrastructure, cost issues, training requirements, and implementation complexity.

Therefore, this review study is focused on the following research questions (RQs). These RQs have been created after conducting a preliminary literature review. The articles have been searched using the selected title "OA technologies and their impact on EL."

Therefore, a detailed SLR process is employed to collect evidence from world-renewed databases and publishers. This article is categorised into existing studies, methodology, results and discussion, and conclusion.

Table 1: RQs from the preliminary studies

S. No	RQs
1	What are the most recent developments and trends in OA, and how do they affect academic results?
2	What are the recent developments and groundbreaking techniques in the field of OA, and how do they advance both teaching and learning?
3	How can OA be used to provide fair access to high-quality education? What are the prospects and opportunities for the future of EL?
4	What are the implications and considerations of implementing OA technologies, and how can they be effectively managed to ensure fairness and validity in evaluation processes?

Related studies

This section provides a summary of previous studies based on the RQs. It is categorised into five subsections from 3.1 to 3.5.

Overview of OA

Basuony et al., 2020 mentioned that the most used OA methods were take-home assessments and shuffled quizzes, but students prefer online quizzes, project-based activities (Stoian et al., 2022), and online projects (Shehata et al., 2020) for their final examination. Bag et al., 2022 proposed a Technology Acceptance Model (TAM) to find students' acceptance of OA considering security, self-efficacy, reliability, and ease of new technologies. However, this study failed to include experience, service quality, and information quality. Nevertheless, students supported OA (Bag et al., 2022; Basuony et al., 2020) with the proper training (Tan et al., 2021), despite less awareness and a lack of training (Kundu & Bej, 2021).

In OA, Ilgaz & Afacan Adanır (2020) and Sánchez-Cabrero et al. (2021) identified an increase in students' academic performance, reduced stress levels (Alghamdi & Ali, 2021; Bisht et al., 2022), higher levels of focus and concentration, ease of attendance, quick paper marking, and proper digital training. However, Hou (2023) stated that open universities in Asia, Europe, and Africa satisfactorily conducted EL by utilising all the available technologies except OA, due to ICT infrastructure, network connectivity,

and plagiarism issues, as well as a lack of awareness about evaluation tools and a lack of training (Kamal & Illiyan, 2021).

Ali et al. (2022) said that OA creates higher chances for measuring students' academic achievement, and at the same time, provides opportunities for academic dishonesty when there is no e-proctoring available. However, these issues can be eliminated by employing skill-based application-type questions and maintaining a good relationship between students and lecturers (Amzalag et al., 2022). Nevertheless, there were a few other challenges, such as instructors not being familiar with OA tools, inconsistent pass rates, the inability to monitor group assignments, and additional workload for both staff and students. Also, Hussain et al. (2020) said that less or no training in EL tools leads to unfair examination results, ethical issues with OA proctoring tools, and increased student anxiety.

Ismail et al. (2019) concluded that the online evaluation method is much better compared to traditional methods. Also, they pointed out that Natural Language Processes (NLP) and information extraction techniques can be used to reduce evaluation process errors. Further, Su, (2020) said that recent advancements in technological advancement supported the development of OA.

Recent trends and developments in OA

Sultana and Rao (2022) proposed a facial detection system to detect OA malpractices. It has used OpenCV for face identification with a HOG face detector. It was working through face detection, face recognition, and head pose detection. Similarly, Hu et al. (2018) developed a system using the Adaboost & haar algorithm and head pose estimation using CNN. Further, Garg et al. (2020) employed Viola Jones to eliminate impersonation. Also, Atoum et al. (2017) analysed students' eye movement, voice, prohibited material, and internet usage to identify impersonation. Likewise, Satre et al. (2023) proposed an AI-based OPS to detect face and object movement by analysing images/video through a webcam using YOLO. Similarly, A. K. Pandey et al. (2020) proposed an OA application called E-PARAKH using a live media streaming server, a real-time messaging protocol, a web real-time communication API, and face recognition using ML for effective live audio video management to eliminate examination malpractices (EM).

Labayen et al. (2021) proposed a deep learning system based on cloud computing to integrate with LMS using AI to detect EM by analysing face, voice, typing, eye movement, and head pose. Further, Kaddoura & Gumaei

(2022a) proposed an AI solution using CNN, a Gaussian-based Discrete Fourier Transform (DFT), and a soft voting technique for fuse cheating probability. In addition, Labayen et al. (2021) and Nigam et al. (2021) discussed several existing OPS for OA purposes, such as fully live online proctoring (ProctorU, Examity, Software Secure-PSI), recorded and reviewed proctoring (Kryterion, ProctorExam, Respondus, Remote Proctor, ProctorCam, B Virtual, Learner Verified), and fully automated proctoring (Protorrio, Proctor Track, Comprobo, Sumadi, ProctorFree, HonorLock, and ExamSoft). Similarly, Ciolacu et al. (2019) explored AI for fraud detection, biometrics for authentication, a learning lab for digital technologies used to do assignments for a small team of students, an AI-based chatbot for self-evaluation, WordVec for automatic essay correction using search phrases, and early recognition of students who are about to fail.

Nigam et al. (2021) summarised the typical features of OPS (authentication, browsing tolerance, remote authorisation, control, and report generation) and suggested considering the EEG machine and LIDAR to increase accuracy when developing new OPS. Further, Zhao et al. (2023) suggested the use of biometric authentication and blockchain-based invigilation mechanisms to detect malicious activities, provide data protection, and eliminate collusion in OA. Also, Siriwardhana et al. (2020) mentioned that blockchain helps to remove data security and privacy issues that may arise when developing AR and VR-based content through 5G MEC sever for uninterrupted indoor connectivity for live video streaming during OA. In addition, Sattar et al. (2022a) proposed a smart login (IP-based) using AI and blockchain for student identification, cheating reduction, and secure result release. This system creates and shuffles questions and distributes them to the student at fixed time intervals. Then, it will check for plagiarism and paraphrase, then forward the answer script to the database if it is not plagiarised, and block background applications during OA. Likewise, Al-Hawari et al. (2019) used the Single Sign (SSO) concept and proposed a system for report generation, automatic exam scheduling, question generation, and examination login security.

Zilles et al. (2019) proposed a semi-automated OA system called a Computer Test Facility to conduct exams asynchronously for large groups of students. This system generates different questions for different students at the same time. Also, students are allowed to complain about students who committed EM. However, invigilation was handled by humans and CCTV. Similarly, Roszak et al. (2021) proposed a computer-based exam (CBE). This provides questions for reuse, evaluation, feedback provided, and an exam results summary with proper human resources, finance, and technical

support. Also, this type of technological implementation motivates students for EL engagement and simulation technologies in the medical field. Likewise, Azis et al. (2022) proposed a system for online evaluation, reducing EM by eliminating shared answers with students. Further, Gamage et al. (2020) discussed virtual law clinics for law practice, audio-visual (Adobe Connect) tools for feedback assessment, online simulated-based tasks, and practical and viva through Zoom or Blackboard.

Alier et al. (2021) proposed the Moodle quiz module as a service using its IMS LTI interoperability features called the Atenea Exam Platform for a large number of students. It has used a private cloud server and DOJO code for the implementation. In addition, D. Pandey et al. (2022) analysed Tcexam, VirtualX, Moodle, FlexiQUiz, and EdBase for the OA but failed to discuss the OA process and invigilation process of these tools. Further, Ullah et al. (2019) compared two different types of quizzes, such as text-based and image-based, and confirmed that image-based questions are better than text-based questions. Additionally, image-based questions have removed spelling, system, formatting, and spacing issues that occurred in text-based questions. Also, Montenegro-rueda et al. (2021) confirmed that Moodle, Zoom, and Skype were the most used digital tools for OA purposes. It is mainly used for conducting quizzes and e-proctoring activities.

Alshurideh et al. (2021) proposed a TAM that confirmed the quality of the system, information quality, content quality, and service quality supported by perceived ease of use (PEU) and perceived usefulness (PU) of the mobile examination platform (MEP). However, MEP may create a chance for cheating in OA.

Techniques used in OA

Janke et al. (2021) mentioned a few EM mitigation techniques, such as open-ended questions over multiple choice, open book exams, collaborative exams, and providing constructive feedback and appreciation. Similarly, Golden and Kohlbeck (2020) concluded that paraphrasing with an honour code significantly reduced cheating compared to proctoring tools (ProctorU and HonorLock). Also, Mellar et al. (2018) said that the student's authorship and authentication checking system (TeSLA) provided access to e-assessment anywhere and satisfactorily reduced cheating.

Guangul et al. (2020) mentioned that students have supported open-ended exams (quizzes, take-home exams, online presentations, annotated

bibliographies, fact sheets, and e-portfolios) compared to remote-proctored exams (using Canvas, Sakai, and ProctorTrack). Further, online sessions and online presentations were conducted to reduce the issues of infrastructure and academic integrity related to OA.

Linden and Gonzalez (2021) confirmed that the OA can be effective as a face-to-face method. This was confirmed by utilising the security features of Zoom, such as disabling chat, screen sharing, annotation, enabling microphones, and video recording. Also, the breakout room feature was used for student identification and technical support. Similarly, Akimov and Malin (2020) mentioned that both students and staff were satisfied with oral OA using video conferencing to reduce contract cheating and technical issues. Further, Wuthisatian (2020a) confirmed that students who are familiar with online proctoring tools got higher marks. However, Gamage et al. (2020) mentioned that plagiarism detection tools may destroy teacher-student relationships and that virtual monitoring methods are expensive. Also, benchmark exams and viva methods have increased the chances of contract cheating.

Noorbehbahani et al. (2022) confirmed that the OPS is the most needed process during OA to maintain academic integrity. This can be done using continuous authentication (face, fingerprint, iris, keystroke, mouse dynamics, voice, and hand geometry were analysed, either single-modal or multi-modal) and online proctoring (IP detection, page focus detection, gesture-based detection, head pose, body movement, yaw angle, window change, lip movement, and time delay). Similarly, Asep & Bandung (2019) and Saba et al. (2021) proposed an android-based verification system using CNN. This system automatically logs out if the student fails to show face and detect multifaced.

Stadler et al. (2021) proposed time pressure techniques (fixed time with independently used time for each question, fixed time but different duration for each question, fixed time but equal duration for each question) without any proctoring to reduce EM. Similarly, Gupta et al. (2020) discussed asynchronous assessment methods (open-ended questions, modified essay questions, key featured questions, script concordance test, problem-based questions, virtual objective structured clinical examination, and oral examination) in the medical field. In contrast, Babbar and Gupta (2022) and Gamage et al. (2022) proposed a calculated average score of the assessments from the previously conducted examinations.

Table 6 presents different types of OA techniques to reduce EM developed by different researchers.

Table 6: Different types of OA techniques to reduce EM

By	OA techniques
Chiang et al. (2022)	Plagiarism detection project-based report submission, un-protected open-book exam project-based report submission, un-protected open-book exam, randomised question tools, automated feedback based on text mining analysis, profile-based student authentication, dynamic profile questions, and contract cheating.
Awad Ahmed et al. (2021a)	Cryptography for encryption and authentication, lotus notes for automatic processing, a website and web page for safe browsers, Multi-tier application architecture for reducing cheating, online protocol, and continuous authentication exam shield platform for multimodal biometric framework, firewall in server and proxy in client to avoid DDoS attack and SQL injection, COM technology for randomising exams and DCM technology for security control.
Ali et al. (2021)	VOS viewer
Manoharan & Ye (2020)	Developing multiple-answer questions, short-answer questions, and essay questions with individualised question technique.

How does OA ensure fair access to quality education?

Shang & Zhao (2020) concluded that the feedback process, marking process, data analysis from students' answers, and final score can be done much better compared to the traditional method via an intelligent examination system. Similarly, Mekterovic et al. (2020) proposed an automated programming assessment system. This system helps with course administration, content authoring, exam conduct, logging, problem mitigating, data analysis, and visualisation, data import and export, and rich question types and grading facilities.

Ngqondi et al. (2021a) proposed a framework considering technical and social sub-systems to focus on proctoring. Likewise, Fluck (2019) proposed an internet-based architecture to access assessment tools and proctoring (a lock-down browser and remote proctoring). Further, students were allowed

to use BYOD, wireless networking, and wireless power connections to reduce students' stress levels.

Z. H. Khan & Abid (2021) mentioned that open-book exams based on real-world design scenarios can enhance student skills. Also, Gamage et al. (2022) said that a blackboard, video proctoring tools, viva after the exam, awareness about the honor code, warnings, and penalties can be used to maintain OA integrity. Therefore, González-González et al. (2020) confirmed that the most decisive factor was trust, which referred to the security and privacy of e-proctoring tools, meanwhile, attitude and intention were the most dependable factors for e-proctoring implementation.

Elzainy et al. (2020a) mentioned that problem-based learning, online presentations, personalised questions, a combination of different assessment methods, and pre-defined quizzes (Argyriou et al. (2022a) increased academic integrity and students' learning skills. Similarly, Guerrero-Roldán & Noguera (2018) mentioned that online technologies support effective learning as ICT handles the entire OA process, from design to result release. Also, OA positively affects competency-based learning, student-centered learning, and e-assessment.

Implications and considerations of implementing OA technologies

M. A. Khan et al. (2021) mentioned that the student who had better computer skills did OA with ease. Also, the automatic marking system eliminated bias. However, generally, students prefer formative assessment for OA (Meccawy et al., 2021). Further, Fluck (2019) said that open-book and open-web examinations motivate students to study not only for a degree but also for their future and working lives.

Gudiño Paredes et al. (2021) confirmed that remote protected exams motivate students to be honest during OA, with fewer technical issues, no anxiety, and no data privacy issues. Further, S. Khan and Khan (2019) mentioned that the advantages of OA are editing answers, spelling checks, zooming in, and checking for missed questions.

Meccawy et al. (2021) mentioned that incomprehensibility during EL was the reason to engage with EM and increase workload despite its many advantages. Also, Elsalem et al. (2021a) said that the practical contents cannot be evaluated as it is impossible to hold a supervised interactive experience. Further, Fuller et al. (2020) mentioned that BYOD has

increased the chances of cheating. It was also mentioned that implementing simulated patient technology leads to high costs and is not suitable for busy clinical schedules. Also, Muzaffar et al. (2021) said that the inaccessibility of software tools, less software development, lack of economic analysis, and MCQs in MOOCs were flawed (Costello et al., 2018). Further, Lee & Fanguy (2022) concluded that despite the many positives of AI and ML applications, these tools may destroy the relationship between students and staff. Also, faculty may lose their examination evaluation skills in the long term.

Babbar and Gupta (2022), Bashitialshaaer et al. (2021), and Montenegro-rueda et al. (2021) discussed some issues such as the effects of mental health, lack of technological training and device access, technical issues, cyber-attacks, cyberbullying, home environment, EM, power interruption, and financial issues. Further, M. A. Khan et al. (2021) discussed the initial cost, device compatibility, selection of questions, cheating, and suitability of different course types. In addition, Awad Ahmed et al. (2021a) discussed authenticity and internet speed, and S. Khan & Khan (2019) discussed sudden transition.

Coghlan et al. (2021a) studied the morals and values of OPS, such as academic integrity, fairness, non-maleficence, privacy, liberty, transparency, autonomy, trust, and accountability. Further, many companies did not reveal the transparency of their OPS. Also, the privacy of third-party or inter-developed OPS is still controversial. Therefore, it was suggested to take students' acceptance agreement into consideration and consider the environmental and psychological factors of Yandug et al. (2023) when using OPS.

Methodology

This section provides research questions (RQ), article inclusion and exclusion criteria (IEC), the search process (SP), and data extraction and synthesis (DES), which are explained in detail. For this purpose, SLR guidelines have been utilised.

IEC

IEC is an important process for any SLR. We select articles from various domains, such as ETs, traditional development, policy development, and theoretical formation. The selection of articles for this review follows the below categories (Boote & Baile, 2005).

1. Area of research: Articles are mainly related to OA and are in line with the above-mentioned domains.
2. Publishers: IEEE, ScienceDirect, Emerald, MDPI, Sage, Taylor & Francis, Wiley, and Springer.
3. Year of publications (YoP): Articles published between January 2018 and June 2023 meet the inclusion criteria.
4. Types of research: Software development, theoretical formation, concept development, and review works.
5. Article accessibility: Articles that allow open access.
6. Language selection: Articles that are published in the medium of English.

SP

We searched articles using the Google Scholar website from eight publishers mentioned in Section 1. We have used several keywords and phrases to identify the required articles. For example, we used online assessment or e-assessment as the keywords. We used several other words related to our title, such as trend, technology, etc. With that, we joined the publisher's name at the end of the key phrases. For example, online assessment technologies (IEEE, and e-assessment trends) in Figure 1 show the sample search results from 2018 to date. Also, we have used boolean operators (AND, OR) to join different keywords.

We downloaded 1525 articles (Table 2) from eight publishers from 2018 to 2023, with the majority of the articles downloaded from MDPI (325) and the minimum articles downloaded from Sage (121).

Table 2: Article categorisation based on publication type and database

Publication Type / Database	Journal	Conference	Total
IEEE	78	52	130
ScienceDirect	140	17	157
Taylor & Francis	171	0	171
Springer	172	39	211
Wiley	170	0	170
Sage	121	0	121
Emerald	140	0	140
MDPI	325	0	325
Total	1417	108	1525

The following paragraph contains all the search terms that we have used to download articles.

Online examination or online assessment or e-exam or e-assessment methods, Online examination or online assessment or e-exam or e-assessment exam technologies, Online examination or online assessment or e-exam or e-assessment Innovations, Impact of Online examination or online assessment or e-exam or e-assessment in E-Learning, Challenges of Online examination or online assessment or e-exam or e-assessment, Online examination or online assessment or e-exam or e-assessment implementation issues, Advancement in Online examination or online assessment or e-exam or e-assessment, Strategies for improving Online examination or online assessment or e-exam or e-assessment, Cutting-edge techniques in Online examination or online assessment or e-exam or e-assessment, Online examination or online assessment or e-exam or e-assessment for quality education, New approaches for Online examination or online assessment or e-exam or e-assessment, Overcoming barriers in Online examination or online assessment or e-exam or e-assessment, E-learning challenges and opportunities, Future prospects of Online examination or online assessment or e-exam or e-assessment and E-learning.

After Figure 2, Table 3 presents the number of publications in different years, and it has been confirmed that after the pandemic, there was a sudden increase in research related to OA.

Table 3: Article categorisation according to YoP and database

Publication year / Database	2018	2019	2020	2021	2022	2023	Total
IEEE	Atoum et al. (2017), Ciolacu et al. (2019), Hu et al. (2018)	Zilles et al. (2019), Asep and Bandung (2019)	Siriwardhana et al. (2020), A. K. Pandey et al. (2020), Garg et al. (2020), (Shang and Zhao (2020), Manoharan and Ye (2020), Hussain et al. (2020), Mekterovic et al. (2020)	Labayen et al. (2021), Saba et al. (2021), Muzaffar et al. (2021)		Satre et al. (2023)	16
ScienceDirect	Guerrero-Roldán & Noguera (2018)	Fluck (2019), Backes & Cowan (2019)	Elzainy et al. (2020b), Wuthisatian (2020b), Kaddoura & Gumaei (2022b), Golden & Kohlbeck (2020)	Elsalem et al. (2021b), Awad Ahmed et al. (2021b), Ngqondi et al. (2021b), Janke et al. (2021)	Sattar et al. (2022b)		12
Taylor & Francis			Fuller et al. (2020), Akimov & Malin (2020)	Gudiño Paredes et al. (2021), Stadler et al. (2021), Ali et al. (2021)		Slack & Priestley (2023)	6

Springer	(Mellar et al. (2018), Costello et al. (2018)	(Ullah et al. (2019), Ilgaz & Afacan Adanır (2020), S. Khan & Khan (2019)	(Guangul et al. (2020)	(Nigam et al. (2021), Kharbat & Abu Daabes (2021), Coghlan et al. (2021b), Meccawy et al. (2021)	(Sultana & Rao (2022), Noorbehbahani et al. (2022), Flores et al. (2022), Amzalag et al. (2022), D. Pandey et al. (2022)		15
Wiley		Al-Hawari et al. (2019)	Su (2020), Shehata et al. (2020), Linden & Gonzalez (2021)		Lee & Fanguy (2022), Chiang et al. (2022)		6
Sage				Z. H. Khan & Abid (2021)	Azis et al. (2022), Argyriou et al. (2022b), Babbar & Gupta (2022)		4

Emerald	Ismail et al. (2019)		Bisht et al. (2022), Basuony et al. (2020), Bag et al. (2022)	Kamal & Illiyan (2021), Kundu & Bej, (2021), Tan et al. (2021)	Ali et al. (2022)	Hou (2023), Koswatte et al. (2023)	10
MDPI			Montenegro-rueda et al. (2021), Gupta et al. (2020), González-González et al. (2020), Gamage et al. (2020)	Alier et al. (2021), Sánchez-Cabrero et al. (2021), Bashitialshaaer et al. (2021), M. A. Khan et al. (2021), Roszak et al. (2021), Alshurideh et al. (2021), Alghamdi & Ali (2021)	Gamage et al. (2022), Stoian et al. (2022)	Yandug et al. (2023), Zhao et al. (2023)	15
Total	7	8	24	25	14	6	84

DES

This step mainly focused on answering the RQs defined in Section 3.1. There are 84 articles that have been finalised to answer the formulated RQs. Section 4 has included answers to the RQs from the selected articles. These include information about OA or related tools, techniques, and limitations. It is noted that a few articles have provided answers to more than one RQ. For example, RQ 3 and RQ 4 were answered by Babbar & Gupta (2022).

It is confirmed that scholars have conducted more research by conducting statistical analysis (52) followed by developing software tools (15) for purposes of OA. Table 3 shows the number of publications for each year for different scholarly endeavours (software development, concept paper, review article, and statistical analysis).

Table 4: Article categorisation according to scholarly endeavours and YoP

Publication year Scholarly endeavors	2018	2019	2020	2021	2022	2023	Total
Software Development	3	2	4	2	3	1	15
Concept paper	0	0	1	2	0	0	3
Review works	1	1	6	3	2	1	14
Statistical analytics	3	5	13	18	9	4	52
Total	7	8	24	25	14	6	84

Similarly, scholars have conducted much research on policy development (52), followed by ETs (16). In that respect, Table 4 represents the number of publications in each year (2018–2023) for conducted research for various purposes.

Table 5: Article categorisation based on development methods and YoP

Publication year / Purpose	2018	2019	2020	2021	2022	2023	Total
ETs	3	1	5	3	2	2	16
Traditional techniques	1	2	2	3	1	0	9
Policy development	2	5	16	15	11	4	52
Theoretical development	1	0	2	4	0	0	7
Total	7	8	25	25	14	6	84

We have considered research about 5G, AI, IoT, ML, deep learning, blockchain, and big data as the ETs. Research work related to Moodle, VLE, Zoom, MS Team, Google Classroom, MOOCs, and other simple web-based techniques has been considered traditional. The development of TAM, UTAUT, etc. has been considered as the framework development, and the rest of the research has been considered as the policy development.

Discussion and Conclusion

EL boomed after the pandemic due to lockdowns around the world. This forced a new normal in the education sector. Therefore, it is the most important priority to manage assessments as fairly as possible to maintain the quality of education on the virtual platform. OA must be rapidly growing in EL, presenting several advantages such as eco-friendliness, flexibility, and cost-effectiveness. However, EM, technical issues, and internet connectivity are a few of the challenges.

This study focuses on OA technologies and their future by analysing a few key aspects from sections 3.2 to 3.5. Therefore, an SLR method was employed to filter the required data from 84 previously published articles from 1525 downloaded papers. For this purpose, 14 search terms were used. Therefore, this section provides relevant answers to the RQs.

Overview of OA

According to Section 3, we can say that students generally accept OA. However, several matters restrict its continued use. These are: no proper training and awareness from the university, unstable internet connectivity, difficulty in monitoring group assignments, workload for both students and staff, increase in students' anxiety, ethical issues with OAS, and unbiased examination results due to a lack of OPS. It is noted that the OA reduces students' stress levels and helps to increase their academic performance. However, a few researchers found that long examinations increased their stress level. For example, Slack & Priestley (2023) concluded that online 24-hour exams affect students' well-being, while they are satisfied with online open book exams. Also, students' stress level increased due to exam software unfamiliarity and technical difficulty.

However, a few studies provided solutions to these issues, such as spending higher investment on network and ICT infrastructure at the beginning of the OA, providing proper training to the users, developing skill-based questions, implementing NLP and information extraction for the evaluation process, and maintaining a good relationship between staff and students.

RQ1

What are the most recent developments and trends in OA?

Institutions and researchers have proposed several methods and techniques for conducting OA. In this respect, recent work has proven that mobile-based platforms can be used efficiently to complete OA. These types of digital tools allow students to take OAs through their smartphones and tablet devices with more convenient and easy access. For example, Alshurideh et al. (2021) proposed a mobile examination platform (MEP) for OA purposes, confirming its PEU and PU towards MEP and increasing OA engagement through gamification techniques. Similarly, several digital tools are available to conduct OA, such as web-based, desktop-based, and AI-based.

AI-based tools use facial recognition, eye tracking, head pose identification, suspicious communication identification, and voice analysis to detect EM. Even though these tools can be effective, they also raise concerns about data privacy and security. However, recent developments in blockchain technology are providing a way to reduce data privacy and security issues. In this respect, this technology can be employed to create secure and tamper-proof OA tools. Therefore, it can help protect data and prevent any fraudulent

activities. For example, Zhao et al. (2023) showed how blockchain helps reduce data security and privacy issues.

Many ETs can be employed to create OA tools. However, recent developments and trends are mainly focusing on ML-based, fully automated OA processes. Although traditional development techniques, such as web-based or computer-based methods with human invigilation, have been used to create OA tools, industries and research experts mainly focus on fully automated solutions, such as ProctorU, Protorrio, etc. For example, Labayen et al. (2021) proposed an AI-based solution through LMS using cloud technologies with a microphone and webcam. In summary, a few tools focused on automatic feedback and marking of OAs, while the majority of other tools focused on reducing EM. However, very few tools consider both feedback provided and online invigilation, and they fail to consider data privacy and security issues.

How do they affect academic results?

The effects of OA on academic performance are inconsistent. While some studies have identified a correlation between OA and better academic performance, others have found little to no difference. An increasing amount of evidence, however, points to the possibility that OA may occasionally be even more beneficial than conventional tests. For instance, Ullah et al. (2019) discovered that in terms of student interest and learning results, image-based shuffled quizzes outperformed text-based quizzes. According to Roszak et al. (2021), CBEs can offer more benefits than conventional paper-based tests in terms of reusing, evaluating, receiving feedback, and summarising the overall exam findings. However, it is crucial to remember that the effectiveness of OA systems, the way assessments are created, and student motivation can all have an impact on how OA affects academic outcomes. Furthermore, the development of various digital tools speeds up the OA processes in terms of marking and feedback provided.

Overall, OA is becoming more safe, practical, and interesting for students as a result of current advances and trends. This might result in better academic performance. To ensure that OA assessments are as successful as possible, it is crucial to thoroughly plan and carry out their design. In addition, the effect of OA on academic outcomes has been the subject of extensive research. To properly understand the long-term impacts of OA on academic achievement, further research is necessary, as a lot of this research is still in its infancy.

RQ2

What are the ground-breaking techniques in the field of OA?

Several techniques have been discussed in previous studies to study the groundbreaking techniques used in OA. These studies have included e-proctoring tools, open-ended exams, plagiarism detection tools, randomised question tools, automated feedback based on text mining analysis, profile-based student authentication, dynamic profile questions, contract cheating identification software, cryptography for encryption and authentication, lotus notes for automatic processing, a safe browser, a multi-tier application architecture, online continues authentication, a multimodal biometric framework, firewall protection, randomised security control, mobile-based continues verification, time pressure technique, and asynchronous assessment methods.

Universities conduct examinations through various online platforms. However, instructors complain that OAs increase the chances of academic dishonesty. Therefore, the majority of the techniques and methods are used to reduce EM, while few tools are used to provide real-time feedback on assessment. Some of these tools are used for both. There are several software programs used for e-proctoring purposes, such as ProtorU, Honorlock, TeSLA, and Turnitin. For example, Awad Ahmed et al. (2021a) and Chiang et al. (2022) confirmed how different techniques and tools help to conduct OAs successively. Furthermore, quizzes, fact sheets, online presentations, e-portfolios, and take-home exams are used in OAs. Additionally, problem-based questions, oral examinations, and virtual objective clinical examinations are also discussed. Furthermore, different types of student authentication methods are employed. Several studies have suggested and tested randomisation techniques to reduce EM.

The majority of tools use biometric parameters for student verification and authentication purposes. A few tradition-based tools still use typical username and password login techniques to verify students' identities. In addition, institutions' and students' digital devices and exam-related data can be protected from cyberattacks using cryptography, firewalls, and proxy servers.

How do they advance both teaching and learning?

The above-discussed techniques are used by various digital tools and methods to increase the quality of EL by reducing academic dishonesty, providing quick feedback, and increasing security. Therefore, it is confirmed

that these ground-breaking techniques can help to improve academic integrity, increase flexibility, enhance personalised learning, and provide immediate feedback and authentic assessments. These techniques help to assess students' skills in a much better way. For example, Guangul et al. (2020) confirmed that students prefer project-based report submission for their OA purposes.

Overall, all these techniques significantly reduce EM and increase the quality of EL with the help of ETs. However, these tools and techniques create some other issues, such as data privacy and security, initial cost, user training, and student concerns.

RQ3

How can OA be used to provide fair access to high-quality education?

The studies about OA from the last five years provide several pieces of evidence to support the claim that digital platforms can provide high-quality education. For example, EL can help remove financial barriers by providing students with easy access to thousands of textbooks and video tutorials across the internet without any subscription or payment, at anytime and anywhere via internet connection using students' mobile devices. This is highly advantageous for low-income students and developing countries. For example, Costello et al. (2018) discussed how MOOCs offer a wide range of free courses. This is also helpful for students with disabilities who live in remote areas. Additionally, OA motivates teachers to share the resources online. This can help to develop new and enhanced educational resources for learners. For example, Argyriou et al. (2022a) confirmed that students' performance increased after they practiced pre-quizzes online.

Further, ETs help students self-evaluate their learned knowledge. For example, Ciolacu et al. (2019) discussed an AI-based chatbot for self-evaluation and early recognition of students who were about to fail in their subject. Also, these tools are used for automatic assessment corrections, automatic feedback provision, and student comparisons based on their latest and previous exam marks. In this regard, Shang and Zhao (2020) proposed an intelligent examination system for this purpose. Therefore, these different types of ETs help to conduct a good OA, which increases the chance of higher-quality education.

What are the prospects and opportunities for the future of EL?

Despite a few negative aspects of the EL, such as quality assurance, digital literacy of participating students, and equity and inclusion of students, the future of the EL is very bright. With the swift improvements in ETs, the availability of online resources, and the fastest-growing popularity of OAs, EL is much more affordable and accessible to students at all levels around the world. The following prospects and opportunities for the future of EL include increased access and affordability, greater personalisation and flexibility, and new and innovative educational practices. Therefore, these prospects and opportunities help more students secure high-quality education, allow students to learn at their own pace, especially benefit students who have some other prioritised commitments (work, family, disability, geographical, and network issues), and recently introduced online technologies greatly help to continue the education anywhere and anytime.

Overall, EL has a very bright future. EL is becoming more accessible and inexpensive for students all around the world thanks to the expansion of internet technology and the rising popularity of OA.

RQ4

What are the implications and considerations of implementing OA technologies?

These several implications and considerations include higher chances for improved learning outcomes, reduced cost, increased flexibility and convenience for students and instructors, higher chances for EM, technical issues and challenges, and the possibility that students may face inequality.

The majority of the studies confirmed that the OA helps to improve students' learning outcomes. OA technologies can be implemented to develop interactive and engaging assessment sessions that positively support students in using their knowledge productively. Further, these technologies can be used to reduce the costs of exam paper printing and human invigilation; for example, asynchronous OA reduces students' anxiety levels and reduces time and cost (Bashitialshaaer et al., 2021). Importantly, OA technologies provide easy access to OA.

On the other hand, there are several negative sides to OA technologies. For example, EM cannot be prevented because technologies provide a wider range of accessibility for subject materials during an examination, continuous human invigilation is difficult, and students can cheat technological tools. Additionally, OA is more difficult to implement and monitor than traditional

face-to-face examinations due to unfamiliarity with the tools and methods. Also, OA increases the workload of the instructors. For example, students prefer traditional exams over OA as it is needed for longer exam preparation (Elsalem et al., 2021a). In addition, not all the students have the required digital tools and a good internet connection.

How can they be effectively managed to ensure fairness and validity in evaluation processes?

Regardless, we have to adapt to the EL environment to continue our education. Therefore, fairness and validity in the evaluation process are the most influential factors in confirming the quality of EL. So, the following steps can increase our aims, such as good question design, selecting different types of questions and different types of assessments, implementing globally accepted e-proctoring tools, providing clear instructions and awareness to the students, arranging swift technical assistance, and having a proper backup plan. For example, providing additional time to complete the OA, allowing students to retake the OA, and providing guidance on how to troubleshoot software or hardware issues.

Instructors must design questions that cover all the intended learning outcomes and cannot be easily found through direct answers on the internet. Also, these questions should be multiple-choice, short-answer, problem-based, and essay questions. This will significantly reduce the risk of EM and confirm that students are evaluated on their thinking and problem-solving skills, as well as their ability to apply their learned knowledge. Additionally, the choice of different assessment techniques will provide a comprehensive evaluation of students' learning. This includes presentations, assignments, and group projects.

Furthermore, institutions can employ e-proctoring to monitor students' activities and prevent EM. However, it is noted that these tools are not purely accurate and may flag legitimate activities as EM. For example, OPS may flag false positives and false negatives that lead to incorrect decisions about students' activities (Coghlan et al., 2021a). Therefore, clear instructions and awareness about OA and e-proctoring tools must be provided to students, such as what is allowed and not allowed, punishments, and how OA tools work.

Limitations and future directions

This SLR considered studies only from selected publishers, even though many publishers are publishing high-quality research articles, and articles were downloaded from the first five pages of Google Scholar search results due to time constraints. Closed-access articles were not included in the study due to financial constraints.

This SLR has suggested considering research-related development of OA tools rather than theoretical or policy development because the majority of the articles published have been related to theoretical or policy development in the past. Additionally, the rapid development of ETs provides a good platform for software development. Furthermore, any tools developed must be designed to support low-bandwidth internet connections.

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