

# Online Assessment Technologies and Future Trends: A Systematic Review

Abdul Cader Mohamed Nafrees  
Office of the Dean  
South Eastern University  
Sri Lanka  
nafrees@seu.ac.lk

S. R. Liyanage  
Faculty of Computing and Technology  
University of Kelaniya  
Kelaniya, Sri Lanka  
sidath@kln.ac.lk

N. G. J. Dias  
Faculty of Computing and Technology  
University of Kelaniya  
Kelaniya, Sri Lanka  
ngdias@kln.ac.lk

**Abstract**—A rapidly expanding method of continuing education in times of epidemic or conflict is online assessment (OA). Numerous tools are now available to perform OA more effectively and maintain the quality of e-learning (EL) as a result of the fast growth of new technologies. In order to analyse OA technologies and their future prospects, this study has conducted a systematic literature review (SLR). These publications were evaluated in light of the study issue, recent developments and future trends. It was shown that while few studies took into account automated feedback providing, the majority of studies concentrated on eradicating OA cheating. Few studies also concentrated on creating software for OA. Additionally, the bulk of studies have taken AI-based research into account. This research has downloaded articles only from 8 publishers and only open access articles. Future researches can be done about identifying techniques, how OA helps for the fair access to the quality education, and implications and considerations of implementing OA technologies.

**Keywords**—exam cheating, e-learning, emerging technologies, AI, Online assessment technologies

## I. INTRODUCTION

Digitalization and emerging technologies provide the education industry a variety of possibilities. In that sense, OA is a development resulting from the idea of e-learning (EL). For more than three decades, OA has been used to offer and promote a successful EL process in response to the pandemic's increase in EL [1]. This is done using a variety of techniques and learning management systems. OA, however, has a number of drawbacks as well. According to a research by [2], OA has certain advantages over traditional learning methods, including being cost-effective, up-to-date, and time-saving. However, it also has some drawbacks, including limits on the framework, a propensity for cheating, and unsuitability for collaborative projects.

Several solutions have been offered by educational institutions, academics, and policymakers to guarantee that OEs are comparable to face-to-face assessment methods. To perform OEs and lower examination misconduct, academic institutions have utilised a variety of software, including completely automated, semi-automated, and others. In order to choose new research directions, it is crucial to examine the various OA technologies and their patterns. According to a research study [3], the top 25 software tools for OE and upcoming technologies for OE were reviewed. These included machine learning (ML), artificial intelligence (AI), biometric methods, and a few other kinds of application development approaches. The study found that a few key obstacles such network infrastructure, costs, training requirements, and

implementation complexity prevent the usage of all these software tools and technologies in all nations. There were no study especially done for OA technologies and future trends.

As a result, this study concentrates on OA technologies and their developments by taking into account two important factors. In order to gather evidence from previously published studies from globally updated databases and publishers including IEEE, Springer, Science direct, Wiley, Taylor & Francis, and Sage, a detailed systematic literature review (SLR) procedure is being used. A systematic and explicit technique is used in a well-designed SLR to find, choose, and summarise the necessary data from previously published papers and research publications in order to address the research question (RQ) [4]. The article categorized as methodology, previous research, findings, discussion, and conclusion of this paper are all included. Most of the articles being compiled and summarised are from the recent five-year span of publications (2018–2023). The methodology section provides a brief explanation of the creation of RQ, article inclusion & exclusion criteria, the search procedure, and data gathering & extraction. The section on current research contains all the important elements that were discussed in the preceding sentence. Additionally, the results section includes the responses to the RQ and other necessary comparisons. The main conclusions, constraints, recommendations, and future study directions are all included in the discussion and conclusion section.

## II. METHODOLOGY

The main components for developing a research question (RQ), article inclusion and exclusion criteria, the search procedure, and data collection and extraction are summarised in this section. SLR guidelines have been used for this aim. The RQ was created following an initial examination of the literature, which has been published since 2018. These articles have been searched using the selected title 'Online Assessment Technologies and their trends'.

RQ: What are the most recent developments and trends in OA, and how do they affect academic results?

### A. Inclusion and exclusion criteria

In any SLR, the inclusion and exclusion criteria are a crucial step. We choose the papers from a variety of fields, including developing frameworks, traditional development, emerging technologies, and policy development. The articles chosen for this review study fall into the following categories. As a result, we must take into account the articles from reputable publishers that prove innovation and quality. [5].

- Area of research: Articles are select related to OA and OE that are in line with above mentioned domains.
- Publishers: We select eight reputed research article publishers. These are IEEE, ScienceDirect, Emerald, MDPI, Sage, Taylor & Francis, Wiley, and Springer and the majority of the articles publish by these publishers are indexing by Scopus and Web of science.
- Year of publications: This review study only considers articles published between January 2018 to June 2023 for the inclusion criteria.
- Type of research: We include all types of research works such as software development, theoretical formation, concept development, and review works.
- Article accessibility: We select articles that only with open access type. Because, we have not received any financial support to conduct this research.
- Language selection: We select article which are published only in the medium of English.

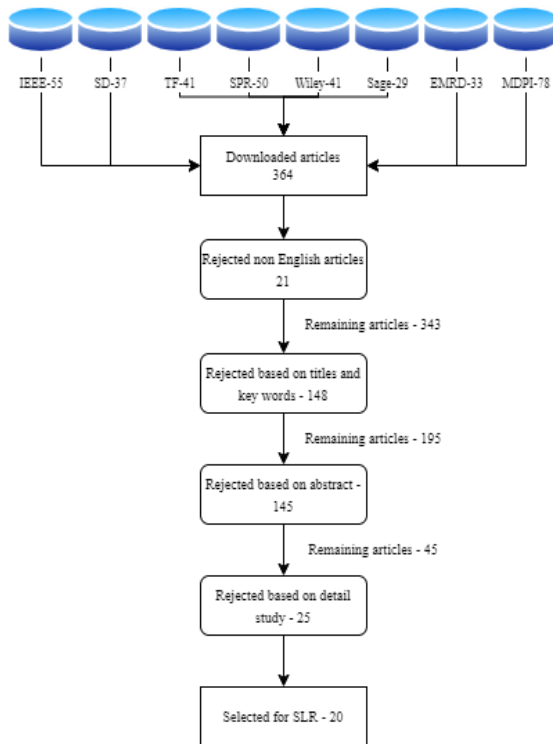


Fig. 1. Article finalize process

### B. Search process

We used the Google Scholar website to look for publications from the eight publishers listed in section 1. We have identified the necessary articles by using a number of key terms and phrases. For instance, we employed the key terms Online Exam, E-exam, Online Assessment, and E-assessment. Other terms like trend, technology, etc. that were connected to

our topic were also used. We then added the chosen publisher's name at the end of the keyword phrases. For instance, we may say E-exam technologies IEEE. It should be mentioned that we searched for articles using Boolean operators like AND and OR. For instance, articles have been chosen using the key term "online examination or online assessment technologies IEEE." We downloaded 364 articles from eight reputed publishing databases from 2018 to 2023.

### C. Data extraction and synthesis

This process has started after completed section 3.2 and selection of final articles according to the figure 2. This step mainly focused on answering the RQ defined in Section 2. There are 20 articles have finalized to answer the formulated RQ. The following section 3 provided answer to the RQ. These are included information about OA or OE related tools and techniques. It is noted that, all the selected articles are read in fully to find any single relevant information for answering the RQ. Similarly, scholars have conducted many researchers for the purpose examined emerging technologies. In that respect, table 1 represented number of publications in each year (2018 - 2023) for conducted researches for various purposes (Emerging technologies, traditional development, Policy development, and Framework development).

TABLE I. ARTICLE CATEGORIZATION BASED ON DEVELOPMENT METHODS AND YEAR OF PUBLICATION

Purpose	Publication year						Total
	2018	2019	2020	2021	2022	2023	
Emerging technologies	[6]		[7], [8], [9], [10]	[11], [12]	[13], [14]	[15], [16]	11
Traditional techniques	[17]	[18], [19]		[20]	[21]		5
Policy development		[22]	[23]		[24]		3
Theoretical development				[25]			1
Total	2	3	5	4	4	2	20

We have considered researches about 5G, AI, IoT, ML, Deep learning, Blockchain, and Big data as the emerging technologies. Then, any research work related to Moodle, VLE, ZOOM, MS Team, Google class room, MOOC, and other simple web based have considered as the traditional techniques. However, development of TAM, UTAUT, etc., have considered as the framework development, and the rest of the researches have considered as the policy development.

## III. RESULTS

This section provides precise results by categorizing the literature reviews in two sub sections. That is, What are the most recent developments and trends in OA and how do they affect academic results, from the selected research articles.

### A. Recent development and trends in OA

A face recognition method was suggested in a paper by [14] to identify OE malpractices. It made use of the HOG face detector and OpenCV to identify faces. The three basic processes used by this system were head posture utilising facial landmark through head movement and angle, face recognition, and face detection using face landmark. Standard 3D coordinates of the facial features would be utilised in cases

when the head movement and angle can be determined by analysing the tip of the nose. Similarly, [6] constructed a system by integrating face detection methods using the Adaboost & Haar algorithm and head posture estimation using CNN. To distinguish mouth feature points from the identified facial region, it was used dlib. Authors have established that aberrant behaviour is evident when the lips move often and there is a yaw angle more than 15 degrees. This is how [9] used Viola Jones to get rid of impersonation. In the same, [17] analysing students' eye movement, speech, use of illegal content, internet activity, and impersonation. They created a hybrid two-stage approach using C++, with phase 1 extracting middle-level features and phase 2 extracting high-level features. Additionally, [15] developed an AI-based website for OPS to recognise pupils' aberrant behaviours and notify the guardian based on photos or videos taken using a camera. Python, HTML, CSS, and MySQL were used in the creation of this system. Face detection, anomaly detection, and object movement detection were all done using YOLO.

A method based on cloud computing technologies that integrates with LMS and uses AI approaches to identify test misconduct was developed in a study by [11]. This was done using a variety of techniques, including deep learning to recognise and identify faces, the Kaldi tool to detect and identify voices, type recognition, eye movement, head pose, impersonation, and computer monitoring. The user findings indicated that both students and staff supported the usage of the OE proctoring tools, although staff members expressed concerns regarding data security and privacy. Additionally, the tool created by the study team was compared against a number of currently available OE tools using the same research and [12]. These were divided into three categories: fully automated solution (Proctorio, Proctor track, Comprobo, Sumadi, ProctorFree, HonorLock, ExamSoft), recorded and reviewed proctoring (Kryterion, ProctorExam, Respondus, Remote Proctor, ProctorCam), and fully live online proctoring (ProctorU, Examity, Software Secure-PSI). In addition, [10] looked at a couple of the aforementioned technologies and their drawbacks (cost, difficulties, and features) and presented an AI solution using CNN, Gaussian-based Discrete Fourier Transform (DFT), soft voting approach for fusing cheating likelihood, and online test proctoring database. Three modules, including front camera, rear camera, and speech detection cheating modules, were used in the development of this system. Additionally, GAN augmentation was utilised to confirm the system's accuracy.

Furthermore, [12] investigated both AI-based and non-AI-based OPS to examine the advantages and disadvantages for OE monitoring purposes in the future. These features included a camera, mic, human proctor, screen share/recording, application lock, biometric, gaze tracking, and a random question bank. This study summarised the standard OPS features (authentication, browsing tolerance, remote authorization and control, report production). These were not the only topics this research looked at; it also looked at security, infrastructural, psychological, and socio-cultural concerns. Finally, this study recommended taking into account a few technologies, including an EEG machine and LIDAR, in order to improve accuracy and resolve the problems raised above.

Blockchain technology deployment in EL was the subject of a research by [16]. In that regard, this study included topics such as data protection strategies, biometric authentication,

block-chain based invigilation mechanisms to detect fraudulent behaviours, and removing collusion in OE. Additionally, blockchain helps to eliminate security and privacy concerns that can crop up while creating AR and VR-based content using a 5G MEC server for continuous indoor connectivity for live video streaming during OEs [7]. The aforementioned technique was combined with AI by [13] who also suggested smart login (IP-based) as a means of student identification, reducing cheating, and securely releasing test results. Additionally, the suggested method generates questions, shuffles them, and then distributes them to the students over a set period of time. When a student submits a response, it is checked for plagiarism and its paraphrased counterpart, and if neither is there, the answer script is delivered to the database. During the initial step of the login, students' devices' IP addresses and faces were collected for further usage. Preventing background programmes that were prohibited from usage during OE. The deployment of this system, however, was more expensive and required a reliable internet connection. Similar to [19], who employed the Single Sign On (SSO) idea and received functions like report production, automatic test scheduling, question generating, and examination login security (impersonation), SSO is a single sign-on system. The three-tier architecture of Java EE, Microsoft Active Directory, and the database notion were used to implement these. . Additionally, post-analysis showed that most of the staff and students approved of the system's functionality and usability enough to continue using it.

According to a case study by [18], the Computer Based Test Facility (CBTF) offers a semiautomated OA system to conduct exams asynchronously for large groups of students. Students can choose the timing of their exam through an exam web page at any point in time. It was claimed that this technique simultaneously creates various questions for various students. However, the human proctor was primarily in charge of this OE invigilation to verify each student's identification. Additionally, the test security was improved by installing CCTVs within the CBTF to identify students who engaged in examination malpractices. Students were also given the opportunity to report students who committed offences via the exam portal. Similar, [26] who investigated computer-based exams (CBE) and determined that CBE can offer more benefits when taking future test decisions into account in terms of reuse, assessment, providing feedback, and summarising exam findings overall. However, this achievement is only feasible if the organisation provides the necessary amount of technical, financial, and human resources. Additionally, this study noted that the use of such technology encourages students to engage in EL, and simulation technologies strongly enhance risk-free learning in the medical profession.

A study by [20] presented the Atenea Exam platform, an IMS LTI interoperability feature-based high performance system built on the Moodle quiz module. This method was utilised to administer exams online to a sizable group of students, and it was determined that the suggested technique can be used to administer exams online to large groups of students. For the purpose of implementation, a private cloud data server and DOJO code were utilised with an already-existing Moodle application. Similarly, [22] examined two distinct formats, including text-based and image-based shuffled quizzes. A small sample of EL students were surveyed to determine the study's efficacy, efficiency, and memorability. The usefulness of an online course and a

collusion abuse instance were two parts of this examination. According to the study's findings, image-based questions outperform text-based ones. Additionally, concerns with spelling, systems, formatting, and space that existed in text-based questions have been eliminated in image-based questions. In addition, employing a challenge question might help to decrease impersonation. However, it was stated that adding more difficulty questions would improve imitation accuracy.

A research by [24] examined a number of the OE tools that were employed. Tcexam, VirtualX, Moodle, FlexiQUIz, and EdBase were among them. These resources are all publicly accessible and usable via an internet connection. The OE process and invigilation process of these tools, however, were not covered by the authors. Additionally, an SLR by [23] discussed a few tools and techniques for OA purposes, including a virtual law clinic for legal practise, an audio-visual tool (Adobe Connect) for feedback assessment, an online simulation-based task, practical and viva exams conducted using Zoom or Blackboard, and no-detriment policies to reduce the failing rate of students as a result of pandemics. However, [8] suggested a brand-new OE programme named E-PARAKH that made use of a live media streaming server, a real-time messaging protocol, a web real-time communication API, and facial recognition made possible by machine learning for the purpose of managing live audio and video in a way that effectively weeded out examination fraud. A system with features including online evaluation, minimising test cheating on websites, and eliminating sharing answers with students in real-time was also presented by [21]. Additionally, they wanted to minimise using paper for exams in order to lessen deforestation.

According to a TAM created by [25], the system quality, information quality, content quality, and service quality supported the mobile examination platform's (MEP) perceived utility and ease of use (PEU). However, authors noted that the MEP may increase the possibility of cheating in OE and might display technical issues when OE is taking place.

#### IV. DISCUSSION AND CONCLUSION

Due of the worldwide shutdown that followed the outbreak, EL bloomed. The education sectors have to adopt a new standard as a result. To maintain the standard of education on the virtual platform, managing evaluations equitably is therefore of utmost importance. As a result, the majority of educational sectors decided to provide tests and evaluations online. It is crucial that OA continues to expand quickly in EL, offering various benefits such eco-friendliness, adaptability, and cost-effectiveness. On the other hand, this approach presents a number of difficulties, including examination dishonesty, technological difficulties, and problems with internet access.

By examining a few crucial factors, this study aims to understand OA technologies and their potential future developments. In order to filter the necessary information from previously published papers, an SLR approach was used. 364 papers from internationally renowned publications were downloaded, and 20 of the articles were finalised. 14 search keywords with the words "e-exam," "e-assessment," "online exam," or "online assessment" were used for this. IEEE was the source of the vast majority of the technical papers.

RQ: What are the most recent developments and trends in OA, and how do they affect academic results?

##### A. *What are the most recent developments and trends in Online Assessment (OA)?*

Numerous methods and techniques for performing OA have been developed and put to use by institutions and scholars. Recent development work has demonstrated that mobile-based OA platforms and tools may be effectively utilised to fulfil OA in this regard. Students may take OEs using their smartphones and tablets with to these digital tools. This makes OA more accessible and handy for students. A research [25], for instance, suggested using a mobile examination platform (MEP) for OE purposes and validated its PEU and PU. Institutions may also encourage and promote OA involvement by utilising gamification strategies and its component parts (badges, leaderboards, and awards). Similar to this, a variety of digital tools, including web-based, desktop-based, and AI-based tools, are available for conducting OA. However, since the epidemic in 2019, AI-based OEP technologies have grown in popularity for OE monitoring and lowering academic dishonesty. However, these OA methods have the potential to cause technological issues as well as the development of new OE cheating methods.

As was already noted, these AI systems employ a variety of methods to conduct OA and identify student cheating behaviours. These methods include face recognition, eye tracking, head position identification, suspicious communication detection, and voice analysis. Although AI OEP technologies are potentially useful, they can present issues with data security and privacy. However, new advancements in blockchain technology are offering a solution to lessen the security and data privacy concerns associated with digital tools. In this way, this technique may be used to develop safe and unbreakable OA tools. As a result, it can aid in safeguarding student and staff data and preventing fraud. For example, study [14] showed how AI-based tools can be used to conduct OA, while study [16] showed how blockchain help to reduced data security and privacy issues.

To construct OA tools, several emerging technologies can be used. To advance towards a completely automated OA process, current trends and developments have mostly focused on ML approaches. Although conventional development approaches, such computer- or web-based OE procedures with human invigilation, have been employed to generate OA tools, industries and research specialists are primarily focused on fully automated solutions, like ProctorU, Proctorio, and others. For instance, research [8] provided a system named E-PARAKH, while study [11] proposed an AI-based solution through an LMS employing cloud technologies. The bulk of these tools and studies have utilised webcams and microphones in this regard.

Many emerging technologies can be employed to create OA tools. However, recent developments and trends are mainly focusing on ML concepts to move towards a fully automated OA process. Although traditional development techniques, such as web-based or computer-based OE methods with human invigilation, have been used to create OA tools, industries and research experts mainly focusing on fully automated solutions, such as ProctorU, Proctorio, and etc. For example, study [11] proposed an AI-based solution through LMS using cloud technologies, and [8] proposed a

solution called E-PARAKH. In this respect, the majority of these tools and researches have used mic and webcam. In conclusion, whereas the bulk of other tools have concentrated on eliminating OE cheating through online tools, a small number of solutions have focused on automatic feedback and labelling of OEs. However, very few systems take into account both user input and internet monitoring, and they ignore concerns about data security and privacy.

### B. How do they affect academic results?

Academic performance is inconsistently impacted by OA. While some research has shown a link between OA and improved academic achievement, other studies have revealed little to no difference between OA and traditional paper-based testing. However, a growing body of research suggests that OA could occasionally be even more helpful than traditional assessments. For instance, a research by [22] found that image-based shuffled quizzes performed better than text-based quizzes in terms of student attention and learning outcomes. Computer-based examinations (CBEs) can be more advantageous than traditional paper-based assessments in terms of reusing, assessing, obtaining feedback, and summarising the entire exam results, according to a different research by [26]. But it's important to keep in mind that the efficiency of OA systems, the design of exams, and student motivation can all affect how OA impacts academic achievements.

Aside from speeding up the OE process in terms of marking and feedback delivery, the introduction of different digital OA systems raises certain ethical and privacy concerns because they capture students' private information. However, the solution to these problems is already in place because to the quick growth of new technologies like ML and blockchain. In order to do future study on these types of technologies while creating OA tools.

Overall, due to recent developments and trends, OA is becoming more secure, useful, and engaging for students. The outcome could be improved academic achievement. It is essential to carefully develop and implement the design of OA assessments to ensure that they are as effective as possible. In addition to the aforementioned, we also wish to emphasise how the COVID-19 outbreak has recently increased the prevalence of OA usage. As a result, a lot of study has been done on the impact of OA on academic achievements. As a lot of this research is still in its infancy, further study is required to fully comprehend the long-term effects of OA on academic achievement.

Due to time limits, this review study only took into account studies from a few select publications, despite the fact that several publishers provide reliable and high-quality research papers. Due to budgetary restrictions, closed access papers were not included in the study. Additionally, just the top five pages of Google Scholar search results were collected for publications.

In order to fully comprehend how an OA tool may develop in the future, it has also been advised that further research be done on the approaches employed in OA, how OA supports equitable access to high-quality education, and the ramifications and concerns of applying OA technology.

### ACKNOWLEDGMENT

We would want to express our profound gratitude to Faculty of Graduate Studies, University of Kelaniya, Sri

Lanka, for kindly offering us the opportunity to publish our review article at ICATC 2023 with free of cost.

### REFERENCES

- [1] C. McCoy, A. Yu, and S. Ramazanov, "An author co-citation analysis: Examining the intellectual structure of e-learning from 1981 to 2014," *Proc. Assoc. Inf. Sci. Technol.*, vol. 52, no. 1, pp. 1–3, 2015, doi: 10.1002/pr2.2015.145052010090.
- [2] A. Sisodia, S. Vishnoi, M. Khenwar, T. Mehrotra, S. Agrawal, and S. Upadhyay, "Online or Offline Exam in Covid-19 Pandemic: Analysis and Assessment in the Context of Students/ Staff and its Impacts," *Cent. Eur. Manag. J.*, vol. 30, no. 4, pp. 2120–2128, 2022, doi: 10.57030/23364890.cemj.30.4.219.
- [3] A. W. Muzaffar, M. Tahir, M. W. Anwar, Q. Chaudry, S. R. Mir, and Y. Rasheed, "A systematic review of online exams solutions in e-learning: Techniques, tools, and global adoption," *IEEE Access*, vol. 9, pp. 32689–32712, 2021, doi: 10.1109/ACCESS.2021.3060192.
- [4] E. T. Rother, "Systematic literature review X narrative review," *ACTA Paul. Enferm.*, vol. 20, no. 2, pp. 7–8, 2007, doi: 10.1590/s0103-21002007000200001.
- [5] Boote and Baile, "Literature Review in Research Writing," *elsevier*, 2005. <https://scientific-publishing.webshop.elsevier.com/research-process/importance-literature-review-research-writing/> (accessed Sep. 23, 2023).
- [6] S. Hu, X. Jia, and Y. Fu, "Research on Abnormal Behavior Detection of Online Examination Based on Image Information," in *Proceedings - 2018 10th International Conference on Intelligent Human-Machine Systems and Cybernetics, IHMSC 2018, IEEE, 2018*, pp. 88–91. doi: 10.1109/IHMSC.2018.10127.
- [7] Y. Siriwardhana, C. De Alwis, G. Gur, M. Ylianttila, and M. Liyanage, "The Fight against the COVID-19 Pandemic with 5G Technologies," *IEEE Eng. Manag. Rev.*, vol. 48, no. 3, pp. 72–84, 2020, doi: 10.1109/EMR.2020.3017451.
- [8] A. K. Pandey, S. Kumar, B. Rajendran, and B. B. S, "E-parakh: Unsupervised online examination system," in *IEEE Region 10 Annual International Conference, Proceedings/TENCON, 2020*, pp. 667–671. doi: 10.1109/TENCON50793.2020.9293792.
- [9] K. Garg, K. Verma, K. Patidar, N. Tejra, and K. Petidar, "Convolutional Neural Network based Virtual Exam Controller," in *Proceedings of the International Conference on Intelligent Computing and Control Systems, ICICCS 2020, 2020*, pp. 895–899. doi: 10.1109/ICICCS48265.2020.9120966.
- [10] S. Kaddoura and A. Gumaei, "Towards effective and efficient online exam systems using deep learning-based cheating detection approach," *Intell. Syst. with Appl.*, vol. 16, no. November, p. 200153, 2022, doi: 10.1016/j.iswa.2022.200153.
- [11] M. Labayen, R. Veja, J. Florez, N. Aginako, and B. Sierra, "Online Student Authentication and Proctoring System Based on Multimodal Biometrics Technology," *IEEE Access*, vol. 9, pp. 72398–72411, 2021, doi: 10.1109/ACCESS.2021.3079375.
- [12] A. Nigam, R. Pasricha, T. Singh, and P. Churi, "A Systematic Review on AI-based Proctoring Systems: Past, Present and Future," *Educ. Inf. Technol.*, vol. 26, no. 5, pp. 6421–6445, Sep. 2021, doi: 10.1007/s10639-021-10597-x.
- [13] M. R. I. Sattar et al., "An advanced and secure framework for conducting online examination using blockchain method," *Cyber Secur. Appl.*, vol. 1, no. June, p. 100005, 2022, doi: 10.1016/j.csa.2022.100005.
- [14] M. Sultana and M. K. Rao, "A Novel Framework for Malpractice Detection in Online Proctoring," in *Advanced Computing and Intelligent Technologies, Lecture Notes in Electrical Engineering, 2022*, pp. 81–88.
- [15] S. Satre, S. Patil, T. Mane, V. Molawade, T. Gawand, and A. Mishra, "Online Exam Proctoring System Based on Artificial Intelligence," in *Proceedings of 2023 International Conference on Signal Processing, Computation, Electronics, Power and Telecommunication, IConSCEPT 2023, 2023*. doi: 10.1109/IConSCEPT57958.2023.10170577.
- [16] M. Zhao et al., "Blockchain in Online Learning: A Systematic Review and Bibliographic Visualization," *Sustain.*, vol. 15, no. 2, 2023, doi: 10.3390/su15021470.
- [17] Y. Atoum, L. Chen, A. X. Liu, S. D. H. Hsu, and X. Liu, "Automated Online Exam Proctoring," *IEEE Trans. Multimed.*, vol. 19, no. 7, pp. 1609–1624, 2017, doi: 10.1109/TMM.2017.2656064.

- [18] C. Zilles, M. West, D. Mussulman, and T. Bretl, "Making testing less trying: Lessons learned from operating a computer-based testing facility," in *Proceedings - Frontiers in Education Conference, FIE, IEEE*, 2019, pp. 1–9. doi: 10.1109/FIE.2018.8658551.
- [19] F. Al-Hawari, M. Alshawabkeh, H. Althawbih, and O. Abu Nawas, "Integrated and secure web-based examination management system," *Comput. Appl. Eng. Educ.*, vol. 27, no. 4, pp. 994–1014, 2019, doi: 10.1002/cae.9.
- [20] M. Alier, M. J. Casany, A. Llorens, J. Alcober, and J. D. Prat, "Atenea exams, an IMS LTI application to solve scalability problems: A study case," *Appl. Sci.*, vol. 11, no. 1, pp. 1–17, 2021, doi: 10.3390/app11010080.
- [21] A. Azis, R. Abou-Samra, and A. Aprilianto, "Online Assessment of Islamic Religious Education Learning," *Tafkir Interdiscip. J. Islam. Educ.*, vol. 3, no. 1, pp. 60–76, 2022, doi: 10.31538/tijie.v3i1.114.
- [22] A. Ullah, H. Xiao, and T. Barker, "A study into the usability and security implications of text and image based challenge questions in the context of online examination," *Educ. Inf. Technol.*, vol. 24, no. 1, pp. 13–39, 2019, doi: 10.1007/s10639-018-9758-7.
- [23] K. A. A. Gamage, E. K. de Silva, and N. Gunawardhana, "Online delivery and assessment during COVID-19: Safeguarding academic integrity," *Educ. Sci.*, vol. 10, no. 11, pp. 1–24, 2020, doi: 10.3390/educsci10110301.
- [24] D. Pandey, G. A. Ogunmola, W. Enbeyle, M. Abdullahi, B. K. Pandey, and S. Pramanik, "COVID-19: A Framework for Effective Delivering of Online Classes During Lockdown," *Hum. Arenas*, vol. 5, no. 2, pp. 322–336, 2022, doi: 10.1007/s42087-020-00175-x.
- [25] M. T. Alshurideh et al., "Factors affecting the use of smart mobile examination platforms by universities' postgraduate students during the COVID-19 pandemic: An empirical study," *Informatics*, vol. 8, no. 2, 2021, doi: 10.3390/informatics8020032.
- [26] M. Roszak, B. Sawik, J. Stańdo, and E. Baum, "E-learning as a factor optimizing the amount of work time devoted to preparing an exam for medical program students during the covid-19 epidemic situation," *Healthc.*, vol. 9, no. 9, 2021, doi: 10.3390/healthcare9091147.