OPEN PRAXIS

A Systematic-Narrative Review of Online Proctoring Systems and a Case for Open Standards

RESEARCH ARTICLE

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ABSTRACT

Online proctoring systems are employed to monitor students during exams, safeguarding assessment integrity when in-person observation is not feasible. The systems leverage advanced technologies, including artificial intelligence (AI) and biometrics, to authenticate students and identify potential exam rule violations. However, concerns about data privacy and security, transparency in data processing and decision-making, and the ethical use of online proctoring systems have been raised. Following a surge in adoption during the COVID-19 pandemic, educational institutions are now critically evaluating the use of online proctoring systems. This research, based on a systematic-narrative hybrid literature review of publicly available descriptions of 33 online proctoring systems, highlights significant shortcomings in data privacy and security and the unspecified use of AI technologies, particularly regarding their role in decision-making on exam rule violations. Proprietary solutions dominate and open-source alternatives are not available. The article explains the dangers inherent in those shortcomings and provides educational institutions with criteria and data for the comparison of online proctoring systems, facilitating an informed system selection in line with educational contexts and values. Further, the article outlines how the introduction of open standards could address the significant shortcomings and the dominance of proprietary approaches. A proctoring profile identity standard is to include a variety of biometric and behavioural markers, created and updated across interactions with exam and generic learning technologies, stored securely, owned and controlled by the student. A proctoring flag standard is to provide a transparent basis for capturing data related to potential exam rule violations, to be evaluated for individual students and across cohorts. Key recommendations to the education sector are to demand more transparency from proctoring systems providers and to work together with students towards the goal of assessment integrity.

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INTRODUCTION

Online proctoring systems are used to monitor students taking exams in situations where direct in-person observation is not feasible. The aim of using online proctoring systems is to ensure assessment integrity (Hussein et al., 2020; Whitelock et al., 2020). Online proctoring systems employ powerful technologies to capture, create and process highly sensitive personal data. The systems create and store biometric authentication models consisting of physiological and behavioural data (Labayen et al., 2021; Okada et al., 2019) and utilize artificial intelligence (AI) technologies (Aurelia et al., 2023; Fidas et al., 2023). Among the concerns raised regarding the use of online proctoring systems are a lack of transparency and information, e.g., on how behaviours are classified as suspicious, and how proctoring companies meet ethical and legal requirements of data storage (Coghlan et al., 2021). My research explores the publicly available information on online proctoring systems to establish what details on data processing and storage are provided to assess if concerns voiced in the past are still relevant. My research goal is to facilitate a responsible use of online proctoring systems in the pursuit of assessment integrity.

To set the context, I provide an overview of the characteristics of online proctoring systems and contrast the data used in online proctoring with those of other assessment systems. I then report how prior literature reviews on online proctoring systems have addressed data privacy and security and detail efforts towards open-source solutions.

ONLINE PROCTORING SYSTEM FEATURES MAPPED AGAINST EXAMINATION STEPS

In the traditional approach to taking exams in higher education, students use pen and paper as tools and sit in large examination halls, supervised by human proctors. The proctors check student identities and monitor students to prevent access to unauthorized material and interactions with others. Computer-based proctoring systems were introduced in the early 2000s (Foster & Layman, 2013) with the aim of allowing students to take exams in their own environments using their own computers while still ensuring assessment integrity. Today's systems use a variety of technologies to address the tasks of identity checking and monitoring and combine automated steps with human intervention.

Before exam start, the identity of the student needs to be verified against pre-recorded or live evidence. This can be as simple as asking the student to present an identity card, such as a student id, to a camera, followed by live verification through the remote human proctor. Alternatively, pre-exam authentication can be based on sophisticated biometric models created before an exam session and used for automated authentication (Labayen et al., 2021; Okada et al., 2019). The physical environment of the student is inspected via a video room sweep to make certain that only the student is present. The computer system of the student is secured, e.g., with a lockdown browser, to ensure the student only has access to approved resources.

During the exam, proctoring monitors if the student complies with exam rules and does not receive external help. In a more traditional approach to online proctoring, a human proctor monitors the student via video feeds and decides if an intervention is required. In newer systems the monitoring task shifts to the computer system. Using technologies such as face or voice detection, the system checks if an additional person has entered the student's physical space or if the student engages in a conversation. Some automated systems intervene directly in the test process, alerting the student, e.g., to adjust their camera. Exam sessions are recorded, capturing data streams from video, audio, screen, keyboard and pointing devices for post-exam analysis. These different approaches are described as *live*, *automated*, and *recording* (e.g., see Arnò et al., 2021; Hussein et al., 2020; Labayen et al., 2021; Nigam et al., 2021) and work in combination. The proctoring data are analysed after the exam to determine if rule violations have taken place.

To strengthen authentication and monitoring further, suggestions have been made to combine data from multiple exam sessions. For example, Fidas et al. (2023) propose to store biometric data or handwriting samples from multiple exam sessions to be used for comparisons in subsequent exams. In addition, data derived from non-exam related student interaction with the learning management system can be used to strengthen model development (Fidas et al., 2023; Whitelock et al., 2020). This results in registration and profiling phases which relate to contexts and time periods outside specific exam sessions. Table 1 provides an overview and adds information on the involvement of human proctors and computer systems.

Table 1 An overview of online proctoring phase in relation to exam sessions.

CONTEXT AND TIMING		ONLINE PROCTORING PHASES	TYPICALLY CARRIED OUT BY
Before exam, to be used for multiple exams		**Registration** – Acquire identity documents or profiles to be used for authentication	Human or machine
Related to specific exam	Pre-exam	**Authentication** – Verifying the identity of student against pre-recorded or live evidence **System and room check** – Verification/restriction of student's computer system and physical environment to comply with exam conditions	Human or machine
	During exam	**Monitoring** – Checking that student complies with exam rules and does not access/receive external help; capturing data and raising flags indicating potential rule violations for immediate or post-exam intervention **Immediate intervention** – Dialog with student to address potential rule violations; potentially termination of exam session	Human or machine or combination (e.g., machine generated flags, human intervention)
	Post-exam	**Review** – Review of data recorded during exam guided by flags raised; decisions on impact on exam outcomes	Human
Longer term data collection, beyond specific exam		**Profiling** – Collection of data to build profile of student to be used in future exam proctoring	Machine

THE NATURE OF PROCTORING DATA

Compared to traditional assessment systems, proctoring changes the nature of data collected. While personal identifiers (name, date of birth, student id, …) are required for any online system, proctoring with new technologies adds physiological (face and voice characteristics, fingerprints, …) and behavioural (typing patterns, mouse movement patterns, eye movements, …) biometrics. While student images are already commonly used, e.g., as profile pictures in learning management systems, registration and authentication require higher resolution images. During the monitoring and review phases, online proctoring creates data on potential rule violations and on the decisions made in response. While there are some parallels to plagiarism detection, online proctoring data do not focus on the assessment material but on physical and behavioural characteristics of the student. As discussed by Whitelock et al. (2020) and Laamanen et al. (2021), students are concerned about the use of such personal data. Compared to manual proctoring, using automated and AI processing creates the capacity for near endless data collection and analysis, and large datasets are required for the training of AI systems (Aurelia et al., 2023; Fidas et al., 2023). While AI-enabled or AI-based proctoring is now common, many authors (e.g., see Khanna et al., 2021; Motwani et al., 2021; Nigam et al., 2021; Slusky, 2020; Tweissi et al., 2022) do not describe how AI is used. Table 2 compares the data used by advanced proctoring technologies to those traditionally used with assessment technologies.

Table 2 Data used by advanced proctoring technologies compared to those traditionally used with assessment technologies.

DATA TRADITIONALLY USED WITH LEARNING TECHNOLOGIES	DATA ADDED VIA THE USE OF ADVANCED PROCTORING TECHNOLOGIES
Personal data Name, DoB, id number, … Still images of faces, not necessarily in high resolution Data based on the assessment content Exam answers, plagiarism similarity indices	Physiological and behavioural biometrics High resolution images of faces and students' physical environments Flags (indicating potential exam rule violations) supported by personal data (e.g., video recordings) instead of assessment data Profiles based on biometric data

DATA PRIVACY AND SECURITY IN THE ONLINE PROCTORING LITERATURE

While several reviews of online proctoring systems have been published over the last years, the coverage of data privacy and security is limited (see Table 3). Arnò et al. (2021) and Labayen et al. (2021) comment on the GDPR (General Data Protection Regulation) compliance of the systems investigated yet provide little detail on how such compliance is addressed or what it means in the context on online proctoring. While Nigam et al. (2021) write about the importance of data privacy they do not address privacy concerns in their descriptions of proctoring systems. Aurelia et al. (2023) take a cheating prevention perspective and do not address potential student concerns. While some authors (Hussein et al., 2020; Whitelock et al., 2020) write about trust, they focus on establishing trust into the integrity of exams conducted online and not on the trust a student can have into the system chosen by their education provider.

Table 3 Discussion of data privacy and security in proctoring system reviews.

ARTICLE	FOCUS	DETAILS ON DATA HANDLING, PRIVACY AND SECURITY
Foster and Layman (2013)	Comparison of eight proctoring systems, looking at features built into the systems, technical requirements, and support for proctoring modes	Not addressed
Hussein et al. (2020)	Looked at eight systems, trialled one; costs and licencing are part of the review criteria; concerned with selecting an online proctoring system during the COVID-19 pandemic	Not addressed
Arnò et al. (2021)	Review of 29 proctoring systems looking at system functionality, open-source status and cost-free access; concerned with selecting an online proctoring system during the COVID-19 pandemic	Investigate compliance with data protection regulations (in particular GDPR), user-friendliness and need for client-side software installation yet provide little detail
Labayan et al. (2021)	Review of 16 proctoring systems, looking at service characteristics, technical features and hosting location	Address GDPR compliance, yet do not provided details
Nigam et al. (2021)	A literature-based review of 15 AI-based proctoring systems which provides limited system details	Not addressed No insights regarding threats of AI technologies despite specific reference to AI
Aurelia et al. (2023)	Provide a brief overview of features, advantages, and disadvantages of 13 proctoring systems; no details on assessment criteria are provided	Not addressed
Fidas et al. (2023)	Briefly introduce six proctoring systems	Not addressed

OPEN-SOURCE PROCTORING SYSTEMS

As stated by Foster and Layman (2013) and more recently Arnò et al. (2021), it is challenging to uncover details of online proctoring systems. Most systems are commercial products with proprietary licencing, preventing access to details on system architecture and code. The two system reviews that addressed licencing found one open-source system (Hussein et al., 2020) which is no longer available and an open-source lockdown browser (Arnò et al., 2021) which is still available but does not constitute a full proctoring system.

The TeSLA system discussed by Okada et al. (2019) and Whitelock et al. (2020) promises valuable features, including e-authentication instruments based on biometric and textual analysis tools. After initial research funding from the European Commission, the development into a commercially available system was envisaged. Yet, current details could not be found at the time of writing. Labayan et al.'s (2021) online proctoring systems review serves as justification for development of the SMOWL system. The authors refer to SMOWL's data privacy policy that separates biometric data from identity data when creating the biometric model for a student by indirection via a separate identification code. SMOWL has since been developed into a commercial system. Fidas et al.'s (2023) TRUSTID system is described as 'online student identity management system' (p16), available open source in the TRUSTID code repository as proof-of-concept version. The system uses a client server architecture with a server-side backend and two client applications. A smartphone app is used to capture face and voice data for the creation of biometric user profiles. A desktop application is used during exams to verify the student's identity and monitor for exam rule violations. The TRUSTID architecture puts strong emphasis on the protection of student data across storage, retrieval and processing and the authors discuss mechanisms such as encryption, distributed ledger technologies (often referred to as blockchain technologies) and digital wallets. TRUSTID aims at providing students with control over their data following principles of self-sovereignty. For example, students control access to the biometric models stored in the smartphone app to which they grant their university access on request. The last activity on the TRUSTID code repository occurred in July 2023 and a video system demonstration created around the same time is available.

RESEARCH OBJECTIVES AND QUESTIONS

The review presented in this introduction shows that online proctoring draws on physiological and behavioural student characteristics that are compiled into sophisticated data models, created and accessed by AI tools. Information on the treatment of data privacy and security is limited as is the insight into the AI algorithms employed. This situation is concerning for many reasons. Swauger (2020) points to the potential for discrimination against non-traditional students and a pedagogy of punishment based on allegations of cheating, propagated by technology companies who are in line for big profits. Coghlan et al. (2021) outline challenges regarding transparency, the reliance on companies meeting legal and ethical requirements, and the lack of real choice for students. Students have no alternative to consenting to proctoring (McKenna, 2022) regardless of concerns about the invasive nature of online proctoring. Institutional policies have not kept pace with new forms of technologies and data collections (Brown & Klein, 2023).

The years of the COVID-19 pandemic have seen a rushed adoption of online proctoring technologies (Selwyn et al., 2023). Having experienced many challenges (e.g., concerns about privacy and equity, tests marked as zero) universities are switching to a more thoughtful adoption of online proctoring and system selection (e.g., my university has suspended the use of online proctoring for a year to carefully evaluate). While this includes deliberation on the need for exams, prominent researchers continue to see exams and online proctoring as important components of university education (e.g., see Coghlan et al., 2021; Dawson, 2020; Najar & Ahmad, 2024; Nicola-Richmond et al., 2024; Selwyn et al., 2023). To contribute to a responsible adoption of online proctoring and system selection, I am undertaking a new review of online proctoring systems focused on data privacy and security and AI. My research questions are:

1. Who are the providers of online proctoring systems, are open-source systems available?
2. How do online proctoring system providers address data privacy and security?
3. How do online proctoring system providers address AI use?
4. How might higher education institutions select online proctoring systems responsibly?

METHOD

Breitkreuz (2022) asks for epistemological and ecologically informed research for addressing complex social problems. Epistemologically informed research focusses on intentional pre-research exploration. It asks the researcher to be mindful in the development of the research questions and aware of the knowledge paradigms that frame the research. Ecologically informed research means to acknowledge and critically consider the complex real-life settings of our research contexts. Online proctoring is part of a complex social setting. While technology plays an important role in online proctoring, it cannot be studied in isolation from the social, political, and economic aspects of education. I have approached my research from an interpretivist perspective as an intentional exploration, following the arguments outlined by Breitkreuz (2022).

My research method is a systematic-narrative hybrid literature review as conceptualized by Turnbull et al. (2023). This method combines strengths from both systematic and narrative review approaches by addressing specific research questions, providing specific search and inclusion criteria, drawing on both quantitative and qualitative elements, and arguing from an evidence base (Turnbull et al., 2023). Narrative reviews support exploration of emerging research areas, are suitable for new interpretations and identification of gaps (Hecker & Kalpokas, n.d.). The narrative aspects of the hybrid approach facilitate the intentional explorations while the systematic aspects provide the rigour.

I attempted to identify all online proctoring systems with publicly available descriptions in English, focusing on the web home pages provided by the system creators/vendors. I started with the Capterra listing on proctoring software, and added additional systems following a snowballing approach (e.g., learning about systems in the literature or conversations with colleagues). I also conducted a literature search using Google web search, Google Scholar, and my university's library system that draws on several content providers, combining variations of 'online proctoring system' with terms such as review, assessment integrity, privacy, security, self-sovereignty, trust, biometric, cheating, dishonesty, plagiarism, students as partners, open-source, or open educational resources.

My search timeframe was from September 2023 to December 2024, and I revisited sites multiple times. In mid-December 2024 Capterra listed 36 online proctoring systems. Table 4 names the 33 systems included (from the Capterra listing and other sources) and the eight systems excluded (from the Capterra listing). The websites of several systems became unavailable, and some systems merged over the timeframe of my research. I have retained the notes I had collected on those systems.

Table 4 Systems included in and excluded from review.

Systems included in review (from Capterra listing and other sources)
BRISO; CONSTRUCTOR PROCTOR; DIGIEXAM; DIGIPROCTOR; DUGGA; EVALART; EXAMITY; EXAMONLINE; HIREPRO PROCTORING; HONORLOCK; INSPERA PROCTORING; INTEGRITY ADVOCATE; IRIS INVIGILATION; METTLE; MOODLE PROCTORING AND PROCTORING PRO; PROCTOREDU; PROCTORIO; PROCTORSTONE; PROCTORTRACK; PROCTORU; PSI BRIDGE; ROSALYN; RPNOW; SMOWL; SUMADI; SURPASS; SYNAP; TALVIEW; TESTWE; UXPERTISE XP; WISE PROCTOR; WITWISER; YOUTESTME
Systems excluded from review (from Capterra listing)
CAMPUS 365 ERP PLATFORM (school management software); ELYSA GRADE (could not locate website); EVALART (test provision for candidate selection); EVERCERT (certification consulting); FORM PRESENTER (software to control time available for filling out forms); HIREPRO VIDEO INTERVIEWS (video interview software); PROCTORIZER (website in Spanish only); ULEARN (website not available)

My data consisted of the information available on the publicly available websites for the systems. I was not able to test the systems and did not have access to any insider information. I went through multiple iterations of reading the system descriptions, taking notes, developing and refining categories. I read all sections of the websites, watched any videos available, followed links, paid attention to menus and footnotes and revisited the sites many times.

I recorded notes on the systems in several categories which evolved over time based on finding new information and my growing understanding of the relevance towards answering my research questions. Notes on the company backgrounds, references to company locations, the focus of service provision (e.g., test centre or exam proctoring services), and claims on uptake or business volumes, provided information I later summarized under 'company background'. A particular challenge lay in working out how to describe the proctoring approaches followed by the systems in a coherent way. After initially taking notes guided by the language used by the system providers, I developed my own categories (see Table 5). I revisited the websites several times to correctly map system features against categories. My initial data collection included notes on learning management system integrations and student-side tools (e.g., mobile apps related to the proctoring systems or web browser extensions). I decided to not draw on these notes as they had limited relevance for answering my research questions. Initially I did not have a clear approach to collecting notes regarding AI, e.g., covering AI under the proctoring approach or under a generic category for details foregrounded on the websites. As the research evolved, I decided on a separate AI category and again revisited all system descriptions to extract the relevant data. After initially recording details on data privacy and security separately I later combined both categories. This was triggered by inconsistent use of the terms and gaps for many of the systems. From start to finish I focused both on the information and on how or where this information was made available. For example, I looked if the language used

	CRITERION	EXPLANATION
Timing of human proctor engagement	Human-live	Live observation by human proctor (optionally supported by machine generated flags) with the potential of live interaction with student, setting of flags for later analysis, or immediate decision making
	Human-recorded	Post exam analysis by human proctor based on recordings (optionally supported by human set or machine generated flags)
Level of machine-generated input in the proctoring process	Automated flags	Machine-generated flags to be used for immediate or post-exam attention
	Automated alerts	Machine-generated alerts to students during exam (aimed at improving proctoring processes with minimal interruption of exam taking)
	Automated decisions	Machine-generated decision making that affects exam outcomes (by denying student access to the exam, by substantially interrupting the exam taking, or by ending the exam session prematurely)

Table 5 Criteria used for analysis of proctoring features.

addressed students directly, if details were foregrounded on the webpage or hidden in small print in footnotes or accessible only via following several links. This data collection and analysis approach resulted in five coding categories named company background, proctoring approach, privacy and security, AI details, and notes. Appendix A provides summary notes for each system under these categories.

I did not seek ethics approval for the research. I did not involve human participants, and I only drew on publicly available data for this research.

FINDINGS AND DISCUSSION

The online proctoring systems reviewed align with the features related to specific exams (pre-, during, and post-exam) outlined in Table 1. Pre-exam authentication approaches are typically based on an ID card and/or a live photo. Verification is carried out by a human proctor or is automated and recorded for later confirmation. Most systems facilitate room checks and monitor the activities on the student's computer, typically using technologies such as specialized web browsers (e.g., PROCTERU) with some using more invasive approaches such as 'deep proctoring' that monitors activity on operating systems level (DIGIPROCTOR).

Most systems offer several proctoring modes, combining human and machine tasks in monitoring and intervention phases as indicated in Table 1. The terminologies vary and, in many cases, not enough detail is provided to gain a clear understanding. Table 5 shows the criteria I have created to compare the systems and extract the features I regard as important for understanding current proctoring approaches (Appendix A presents the respective values for the systems analysed). The first two criteria focus on when – during or after the exam – the human proctor is engaged. 'Live' provides the opportunity to interact with the student to address issues during the exam; 'recorded' means that any decisions are made in hindsight. Most systems provide both modes. Exceptions are ROSALYN and RPNOW which provide the 'live' but not the 'recorded' mode. For RPNOW this seems to be related to the focus on providing test centre services. In the case of ROSALYN, the focus is on 'immediate human intervention [that] stops most violations in its tracks'. In contrast, WITWEISER offers the 'recorded' but not the 'live' mode with service costs being a factor: 'Big data technology for exceptional scalability at low cost'.

The three remaining criteria displayed in Table 5 focus on the level of machine-generated input into the proctoring process. Most systems include some form of 'automated flag' setting, based on events such as the student switching between browser windows, moving out of camera focus, or detection of voices in the student's exam environment. The criteria 'automated alerts' and 'automated decisions' assess if the proctoring system intervenes in the exam process solely based on machine-generated insights without supervision of a human proctor. With alerts I refer to interventions relating to technical factors that hinder the proctoring and should be addressed immediately, hopefully without affecting the student's exam focus too much. In contrast, automated decisions would substantially impact the exam outcome (to the extreme of stopping the exam progressing), comparable to decisions possible by human proctors in live proctoring. This would indicate that a computer algorithm has been given the authority to decide that a violation of exam rules has occurred, without verification via a human proctor.

As Appendix A shows, I noted some form of automated flag setting for most systems (21 out of 24; for nine systems I could not apply this analysis, e.g., due to an overall lack of detail in descriptions or the system being no longer available). I concluded that ten systems clearly do not enable automated alerts and decisions, with some of those emphasising the importance of review by the human proctor. For example, HONORLOCK explicitly writes about referring potential incidents identified by automated processes to a human proctor for decision making. In contrast, three systems (HIREPRO, IRIS INVIGILATION, PROCTORSTONE) feature some form of automated decision-making, as underlined by a statement by HIREPRO: 'Eliminate manual reviews with AI-powered auto-detection of fraudulent behaviour'. I suggest that three systems (CONSTRUCTOR PROCTOR, DIGIPROCTOR, HIREPRO) use some form of automated alerts. Most system description are not explicit on the level of autonomy given to automated processing.

My online proctoring systems review confirms the prevalence of data as outlined in Table 2. The systems routinely draw on image, video, and audio data. The use of two video cameras to gain a 360-degree view of the student's physical environment is commonplace. Data are processed to assist with the detection of potential exam rule violations, such as in the analysis of gaze direction (e.g., PROCTERIO), voice or speech detection to distinguish general background noise from conversations with potential proctoring implications (e.g., CONSTRUCTOR PROTECTOR, HONORLOCK), the extraction of lip and eye movements (EXAMONLINE), or the use of knuckle scans in the context of authentication (PROCTORTRACK). Most systems set flags (by automated processing or human proctor created) and link those to video recordings. Some systems highlight how they are restricting data processing. For example, HONORLOCK and PROCTERIO highlight the use of face detection only, meaning that no additional processing is applied to determine the identity of the person detected; INTEGRITY ADVOCATE and SMOWL emphasize that they are not using biometrics to support user identification. Despite these restrictions, the examples show that online proctoring data use far exceeds what we are accustomed to from conventional learning support systems. The post-exam reviews rely on the recorded data and some of the system descriptions contain images showing lists of potential exam rule violation flags. Yet, there are no details on how decisions are recorded or how or for how long the preliminary data are kept.

Only a few systems refer to the registration and profiling steps displayed in Table 1. Some identify the data the automated authentication draws on (PROCTORTRACK – biometric profile, SUMADI – registered facial profile, TALVIEW – voice matching) and allude to a registration step proceeding a specific exam session. Features such as the continuous identity checking carried out by DIGIPROCTOR imply that identifying data are stored beyond authentication. SMOWL refers to building a student profile over the duration of courses, implying a longer-term data collection and storage approach.

ONLINE PROCTORING SYSTEMS PROVIDERS

As noted in previous reviews, online proctoring is dominated by commercial providers. All 33 systems reviewed are commercial services (the open-source version of MOODLE PROCTORING is an incomplete solution). As explained in the introduction, I have not been able to locate current versions of the TeSLA and TRUSTID systems. Despite substantial research funding and cooperation across universities, it seems challenging to develop full systems. The systems with a recent higher education research context (DUGGA, SMOWL, SYNAP) are all commercial services. With company locations in Asia, Australia, Europe and North America, providers are spread across many geographical areas. This aligns with the challenges in securing assessment integrity felt globally.

While several systems primarily focus on the provision of proctoring services, others foreground testing and certification services (e.g., SURPASS and YOUTESTME). The focus of some system websites is less on explaining the online proctoring options than promoting wider assessment services (e.g., INSPERA PROCTORING), switching to online versus on-site exams (e.g., DIGIEXAM), or learning management system adoption (e.g., UXEPERTISE XP). The varied company foci add to the challenges of determining the level of uptake of a proctoring system in the higher education context, something I attempted based on the clients named on the websites.

The answer to my first research question is therefore that online proctoring is firmly in the hands of commercial providers from education/assessment and testing/test centre backgrounds. I could not locate a comprehensive open source online proctoring solution.

DATA PRIVACY AND SECURITY

The system websites vary widely in how they address data privacy and security. While DUGGA and MOODLE PROCTORING/PRO do not address the topics at all, some proctoring companies build on a pedagogy of punishment and allegations of cheating as described by Swauger (2020). For example, DIGIPROCTOR foregrounds students' sophistication in cheating, and TALVIEW writes about cheating and impersonation to emphasize the need for proctoring services. Others (e.g., CONSTRUCTOR PROCTOR, PROCTORU, SURPASS) provide access to generic policies that do not mention proctoring specific data, are written in legal language, and are not displayed prominently. On the other hand, several providers follow the values plauded by Coghlan et al. (2021) by addressing students, explaining data privacy and security in accessible language, making it easy to find this information, and showing concern for the needs of students. For example, EXAMITY, HONORLOCK, INTEGRITY ADVOCATE, PROCTORIO and ROSALYN write in a style that addresses students directly. ROSALYN and TALVIEW foreground the information in easily accessible trust sections. PROCTORTRACK provides access to a dashboard showing what data have been collected and when those are scheduled for deletion and facilitate data deletion requests.

Twelve systems address GDPR compliance at various levels. This reaches from brief references and generic information (e.g., DIGIEXAM, PROCTOREDU) to meaningful explanations of the concepts of data controller and data processor in the context of online proctoring (KRYTERION). Some systems provide information on the location of the data centres used and the implications regarding country specific regulations (e.g., HIREPRO, HONORLOCK), the length of data storage (e.g., IRIS INVIGILATION), or the range of individuals who can access student data (e.g., PROCTORIO). Most systems address data security to some degree in the information provided via their websites. Topics include encryption (e.g., EXAMONLINE), hardware and operational security (e.g., TALVIEW), backup and disaster recovery (e.g., INSPERA), auditing (e.g., SYNAP), ethical hacking (e.g., PROCOTORIO) and security features integrated into cloud service provisions (e.g., TESTWE).

These observations lead to a two-level answer for my second research question. First, some system providers demonstrate little care for data privacy and security. Education institutions should carefully evaluate if choosing these providers aligns with their values. Second, despite the care for data privacy and security demonstrated by several providers, many questions remain unanswered. One area of concern relates to the types of data related to online proctoring. Systems construct student profiles to strengthen pre-exam authentication and confirm student identity throughout the exam session. This raises questions about consent and ownership. Students should be active participants in contributing to the development of their proctoring profile, for example in choosing when they permit the extraction of biometrics for their identity profile. Students should have access to this profile, be able to facilitate additional data collection, and control its use. We should draw on the concept of data sovereignty, described as 'meaningful control, ownership, and other claims to data or data infrastructures' (Hummel et al., 2021, p12) and discussed by Grech et al. (2021) as self-sovereign student identities in the context of academic records.

The meaningful application of GDPR is another area of concern. GDPR contains the concepts of data controller and data processor. The data controller decides the purposes, the 'why', and the means, the 'how', of the collection and processing of personal data; the data processor carries out the instructions of the data controller (European Commission, n.d.). In proctoring, the educational institution is the data controller and the proctoring company the data processor. Yet, as Giannopoulou et al. (2023) conclude in their review of legal decisions regarding online proctoring and GDPR, those lines are blurred, e.g., regarding the processing the proctoring companies perform on the data collected. I question if educational institutions in their role as data controller have enough insight into the processing steps to control the 'how' aspects.

AI USE

Following the earlier discussion on automated processing and decision making (automated flags, alerts, decisions), my focus now shifts to the use of AI. Of the 24 systems with descriptions comprehensive enough for closer inspection, two thirds refer to the use of AI in supporting data processing and decision-making tasks (some, e.g., INTEGRITY ADVOCATE and IRIS INVIGILATION, instead talk about detecting student use of generative AI to compose answers). There are references to the use of AI in analysing data to assist with authentication and alerting to potential rule violations, yet little detail on specifics is provided. Some statements are difficult to assess without further explanation (e.g., CONSTRUCTOR PROCTOR's '1,000,000+ Video & audio in AI-trained datasets'). On some websites it appears that references to AI are included to create the impression of advanced system capabilities. Others refer to the increasing importance of AI technologies and their 'sharp awareness of its evolution' (KRYTERION).

Two systems stand out from the others. TALVIEW offer a new AI proctoring mode based on Alvy, a 'dedicated AI Proctoring Agent, revolutionizing how exams are monitored'. TALVIEW claim that 'Alvy can identify nearly 90% of the events recognized by both human proctors and the traditional AI model.' The difference between Alvy and TALVIEW's automated proctoring mode seems to lie in Alvy's direct interaction with students. Differences in terms of data analysis are not outlined. ROSALYN stands out by the level of detail provided in language accessible to the end user, e.g., on candidate profiling, gaze and speech analysis (see this blog entry as example). ROSALYN also emphasizes the need for the continuous development of AI models and explicitly references the use of proctoring data for the training of those models.

The answer to my third research question is that we are lacking meaningful insights into the use of AI in online proctoring systems. As Selwyn et al. (2023) state, education institutions have little insight into the functioning of proctoring systems. It is questionable if institutions can look 'under the hood of the software' and undertake 'due diligence' as necessary according to New Zealand's past Privacy Commissioner (Walters, 2021, no page number). A recent systematic review on the use of AI in education by Forero-Corba and Negre Bennasar (2023) lauds the potential of AI techniques to improve education. The challenge is to find a way forward that fulfils Giannopoulou et al.'s (2023) demand for educational technologies that reflect the ethos of education institutions.

One question to be addressed is how much technical detail should be available to give adequate insights. Somavarapu et al. (2024) provide a review of AI technologies used in research projects focussed on online proctoring solutions. The authors name the attributes (e.g., face detection, face alignment, head pose estimation) and the specific AI technologies used (e.g., SURF, Viola-Jones and SIFT algorithms for face detection). Details on attributes are valuable to a more general audience such as educators and students. Among the systems I have reviewed only ROSALYN provides comparable details. While restricted of interest to a technical audience, details on algorithms and machine learning approaches should be available and could build on 'model cards', introduced to increase transparency on machine learning and AI technologies (Mitchell et al., 2019).

Beyond the level of technical detail, I also seek more clarity on the level of autonomy AI has in proctoring. While AI is already widely used for analysing data, building models and making predictions, it appears that most systems do not yet allow for autonomous decisions without human supervision. This needs to be clarified, especially considering the rapid technological advances in AI technologies and their increasing levels of adoption. This also applies to generative AI. For now, TALVIEW's AI proctoring agent Alvy appears to be the only generative AI component. Undoubtedly other systems will follow.

TOWARDS THE RESPONSIBLE SELECTION OF ONLINE PROCTORING SYSTEMS

My fourth research question asks how education institutions might select online proctoring systems responsibly. As demonstrated by the information provided in this article, there are big differences in how system providers see issues around data privacy and security and attitudes towards assessment integrity. After pre-selecting a system provider who values the protection of student data and foregrounds student interests, institutions can use the overviews on the proctoring steps, data and systems (Tables 1 and 2, Appendix A) to seek further clarifications.

Somavarapu et al. (2024) review advanced technologies (e.g., face alignment, face spoofing detection, eye gaze estimation, open mouth detection) and the underlying algorithms. While I agree with the authors that online proctoring systems should draw on technological advances, we need to focus on how those technologies are used in responsible ways. Models supporting the selection of educational technologies and their implementation in complex higher education environments, as discussed by Chugh (2023), provide valuable guidance that can be adopted for the proctoring system context. AI policy frameworks highlight the pedagogical, operational, and governance dimensions to be considered (Chan, 2023). Selecting the right system will go a long way towards responsible use of online proctoring in the immediate future.

Considering the dominance of proprietary proctoring systems and the challenges observed in maintaining and further developing open-source approaches, a potential path forward lies in the creation of open standards for data collection, management and exchange.

An open standard for proctoring identity built on data sovereignty principles

Proctoring relies on determining the identity of the student at the start and throughout the exam. Identity verification builds on increasingly sophisticated biometrical and behavioural models. An open standard for proctoring identity built on data sovereignty principles would facilitate the responsible and effective use of authentication technologies while at the same time addressing data privacy, security and agency issues.

I envisage a proctoring landscape where students control their online proctoring profiles. Students actively work towards creating and maintaining these profiles via specific setup sessions and authorized data collection, e.g., during learning management system use as suggested by Fidas et al. (2023) and Whitelock et al. (2020). The identity profiles can be used across learning institutions and proctoring system providers and are used following explicit student consent that details which features of biometrical and behavioural profiles are made available.

Portugal et al. (2023) discuss the need for continuous user identification technologies applied across higher education technology settings, working towards an 'innovative framework for student identity management' (p25) based on open-source policies. An open standard for proctoring profiles would be an important component of such framework. Following data sovereignty principles, as outlined by Grech et al. (2021) and Hummel et al. (2021) would provide the foundation for building the systems around the standard.

An open standard for proctoring flags to underpin decision making and analysis

Online proctoring relies on the setting of flags for alerting to potential rule violations. By and large, the flags are created by automated processes and saved for human decision making. As rule violations are not easily identifiable (e.g., did the student look up in contemplation or did they look at someone providing information), the raising of flags needs to be overcautious, necessitating a large proportion of false positives. This results in the danger of profiling students based on flagged suspicious behaviours (Zeide, 2023), exacerbated by the lack of transparency of online proctoring systems (Giannopoulou et al., 2023). False positives and negatives are seen as one of the open problems in existing systems (Paul et al., 2024).

Creating an open standard for proctoring flags would be an important step towards creating transparency. First, the standard could be used to create an access point across proctoring systems to provide students with insights into the flags reported against them. Besides increasing transparency, this could be extended into a commenting and communication feature allowing students and staff to work together in resolving flags. Second, the standard could serve as basis for the large-scale anonymized reporting of flags, allowing institutions and researchers to study the accuracy of online proctoring, something currently not possible (Dawson, 2023).

In summary, I am arguing for automated proctoring that takes advantage of advanced technologies to undertake monitoring, serve in-exam alerts, and raise flags for post-exam human decision making, equivalent to the current 'recorded' approach. The adherence to open standards would enable the construction of vendor-independent functionalities to strengthen the position of both students and institutions. Using automation for data gathering and monitoring would allow for the frequent use of online proctoring, e.g., in practice tests, creating familiarity with online proctoring and reducing the fear of the unknown (Nicola-Richmond et al., 2024). Table 6 overviews the resulting proctoring steps.

Table 6 Suggested proctoring approach based on automated monitoring and human decision-making.

PRE-EXAM	DURING EXAM	POST-EXAM
Automated identity and environment (physical, student's devices) checking based on student proctoring identity profile Automated testing of input devices (e.g., camera, microphone) for data collection	Student is automatically alerted to system issues (e.g., need to adjust lighting to improve image quality) Flags indicating potential exam rule violations are created based on automated real-time monitoring	Student and proctor review flags and associated data Communication between proctor and student to resolve issues Decision making by exam review board as required

CONCLUSION

The rushed adoption of online proctoring during the COVID-19 years has led to a proliferation of online proctoring systems that take advantage of advanced computing technologies. My research, conducted as a systematic-narrative hybrid literature review, examined 33 online proctoring systems with specific focus on data privacy and security, AI processing, system providers and licence status. My research aim was to contribute to a responsible adoption of online proctoring system selection.

My findings show clear differences between the attitudes of the system providers as expressed in the descriptions of their products, ranging from a focus on catching cheats to a more considerate view of preserving assessment integrity. The level of detail provided on data privacy and security and the use of AI technologies varies widely. As Giannopoulou et al. (2023, p301) write, 'All in all, the adoption of an e-proctoring system requires the universities to perform a careful assessment of the characteristics of the software, the concrete modalities of deployment in the specific context, and the guarantees offered by the provider.' As shown in my research, the publicly available information on current proctoring systems does not provide sufficient detail for such careful assessment. Henry and Oliver (2022, p348) conclude, 'it is the responsibility of university staff and students to be vigilant and engaged, so as to ensure the algorithms and platforms we chose to live with are shaped to our needs, rather than the other way around'. Following this directive is challenging for university staff and near impossibly for students in the online proctoring space. While the information available on online proctoring system is insufficient, the data I have provided in my review nevertheless can guide universities in their system selections.

LIMITATIONS OF THIS RESEARCH

The review of the proctoring systems presented in this research is based on the descriptions provided by the companies offering those systems. This was appropriate as the research design included looking at the perspectives on data privacy and security as portrayed by the companies. Yet, it is a limitation as an independent test of the systems could have provided better insights into their functionalities. Exploring all systems hands-on would have been challenging as independent access is not available and their proprietary nature prevents studying the algorithms and technologies used. Staff at the educational institutions conversing with system providers might gain additional information. Yet, given the proprietary settings, the depth of the new insights is likely to be limited. Students are unlikely to gain access to the more detailed information.

FUTURE WORK

In their explorations of a right to digital education Celeste and Gregorio (2023, p250) conclude that 'digital education has been left in the hands of private actors whose main objective is the pursuit of economic gains'. This sentiment rings true for the online proctoring space where system provision is dominated by commercial providers. I call on educational institutions to regain control and to work with students on finding just solutions. While the ultimate goal would be to create leading edge open-source proctoring systems, the history of the systems such as

TeSLA and TRUSTID (no longer available despite substantial research efforts) as well as MOODLE PROCTORING and SMOWL (transition from research-based to commercial systems) demonstrate the challenges in achieving this. Having commercial systems adhere to open standards would go a long way in building solutions that facilitate transparency and interactivity.

The importance of open standards in ensuring quality and interoperability of learning technology products and services has been acknowledged (Koper, 2008). Yet, there are many challenges in definition and pathway to adoption (Duval & Verbert, 2008). While online proctoring has its specific challenges, there is common ground with other learning technologies in areas such as continuous authentication, which is tasked with providing 'unobtrusive and continuous user authentication, behind the scene, and without inconveniencing the users' (Soltani et al., 2021, p6), or the work on decentralized self-sovereign digital identities that provide verifiable credentials (e.g., see Sedlmeir et al., 2021). The work towards open standards in the online proctoring space needs to link to such initiatives.

DATA ACCESSIBILITY STATEMENT

All data generated or analysed during this study are included in this published article.

ADDITIONAL FILE

The additional file for this article can be found as follows:

- **Appendix A.** Proctoring systems overview. DOI: https://doi.org/10.55982/openpraxis.17.3.836.s1

COMPETING INTERESTS

The author has no competing interests to declare.

AUTHOR CONTRIBUTIONS (CRediT)

Eva Heinrich: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. The author has read and agreed to the published version of the manuscript.

SUSTAINABLE DEVELOPMENT GOALS (SDGs)

This study is linked to the following SDG(s): Quality education (SDG 4).

AUTHOR NOTES

Based on Academic Integrity and Transparency in AI-assisted Research and Specification Framework (Bozkurt, 2024), the author of this paper used CoPilot (Versions as of January 2025) to assist with complementing the human editorial process. The human author critically assessed and validated the content to maintain academic rigor. The author also assessed and addressed potential biases inherent in the AI-generated content. The final version of the paper is the sole responsibility of the human author.

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REFERENCES

Arnò, S., Galassi, A., Tommasi, M., Saggino, A., & **Vittorini, P.** (2021). State-of-the-Art of Commercial Proctoring Systems and Their Use in Academic Online Exams: *International Journal of Distance Education Technologies*, *19*(2), 55–76. https://doi.org/10.4018/IJDET.20210401.oa3

Aurelia, S., Thanuja, R., Chowdhury, S., & **Hu, Y.-C.** (2023). AI-based online proctoring: A review of the state-of-the-art techniques and open challenges. *Multimedia Tools and Applications*. https://doi.org/10.1007/s11042-023-16714-x

Bozkurt, A. (2024). GenAI et al.: Cocreation, Authorship, Ownership, Academic Ethics and Integrity in a Time of Generative AI. *Open Praxis*, *16*(1), 1–10. https://doi.org/10.55982/openpraxis.16.1.654

Breitkreuz, R. (2022). The gold standard: Epistemologically, ecologically informed research. *Social Sciences & Humanities Open*, *6*(1), 100345. https://doi.org/10.1016/j.ssaho.2022.100345

Brown, M., & **Klein, C.** (2023). Data Justice Now: Why We Need Technologies Built for Care and How You Can Advocate for Change. *About Campus: Enriching the Student Learning Experience*, 10864822231195579. https://doi.org/10.1177/10864822231195579

Celeste, E., & **Gregorio, G. D.** (2023). *Towards a Right to Digital Education? Constitutional Challenges of Edtech*. http://hdl.handle.net/10400.14/42312

Chan, C. K. Y. (2023). A comprehensive AI policy education framework for university teaching and learning. *International Journal of Educational Technology in Higher Education*, *20*(1), 38. https://doi.org/10.1186/s41239-023-00408-3

Chugh, R., Turnbull, D., Cowling, M. A., Vanderburg, R., & **Vanderburg, M. A.** (2023). Implementing educational technology in Higher Education Institutions: A review of technologies, stakeholder perceptions, frameworks and metrics. *Education and Information Technologies*, *28*(12), 16403–16429. https://doi.org/10.1007/s10639-023-11846-x

Coghlan, S., Miller, T., & **Paterson, J.** (2021). Good Proctor or "Big Brother"? Ethics of Online Exam Supervision Technologies. *Philosophy & Technology*, *34*(4), 1581–1606. https://doi.org/10.1007/s13347-021-00476-1

Dawson, P. (2020). Assessment security. In P. Dawson (Ed.), *Defending Assessment Security in a Digital World* (1st ed., pp. 19–37). Routledge. https://doi.org/10.4324/9780429324178-2

Dawson, P. (2023). Remote Proctoring: Understanding the Debate. In S. E. Eaton (Ed.), *Handbook of Academic Integrity* (pp. 1–16). Springer Nature Singapore. https://doi.org/10.1007/978-981-287-079-7_150-1

Duval, E., & **Verbert, K.** (2008). On the Role of Technical Standards for Learning Technologies. *IEEE Transactions on Learning Technologies*, *1*(4), 229–234. https://doi.org/10.1109/TLT.2009.6

European Commission (n.d.). What is a data controller or data processor? https://commission.europa.eu/law/law-topic/data-protection/reform/rules-business-and-organisations/obligations/controllerprocessor/what-data-controller-or-data-processor_en, accessed 12/02/2024

Fidas, C. A., Belk, M., Constantinides, A., Portugal, D., Martins, P., Pietron, A. M., Pitsillides, A., & **Avouris, N.** (2023). Ensuring Academic Integrity and Trust in Online Learning Environments: A Longitudinal Study of an AI-Centered Proctoring System in Tertiary Educational Institutions. *Education Sciences*, *13*(6), 566. https://doi.org/10.3390/educsci13060566

Forero-Corba, W., & **Negre Bennasar, F.** (2023). Techniques and applications of Machine Learning and Artificial Intelligence in education: A systematic review. *RIED-Revista Iberoamericana de Educación a Distancia*, *27*(1), 209–253. https://doi.org/10.5944/ried.27.1.37491

Foster, D., & **Layman, H.** (2013). *Online Proctoring Systems Compared*. https://caveon.com/wp-content/uploads/2013/03/Online-Proctoring-Systems-Compared-Mar-13-2013.pdf

Giannopoulou, A., Ducato, R., Angiolini, C., & **Schneider, G.** (2023). From data subjects to data suspects: Challenging e-proctoring systems as a university practice. *Journal of Intellectual Property, Information Technology and E-Commerce Law*, *14*(2), 278–306. https://ssrn.com/abstract=4498632

Grech, A., Sood, I., & **Ariño, L.** (2021). Blockchain, Self-Sovereign Identity and Digital Credentials: Promise Versus Praxis in Education. *Frontiers in Blockchain*, *4*, 616779. https://doi.org/10.3389/fbloc.2021.616779

Hecker, J., & **Kalpokas, N.** (n.d.). The Guide to Literature Reviews: What is a Narrative Literature Review? Retrieved April 17, 2025, from https://atlasti.com/guides/literature-review/narrative-literature-review

Henry, J. V., & **Oliver, M.** (2022). Who Will Watch the Watchmen? The Ethico-political Arrangements of Algorithmic Proctoring for Academic Integrity. *Postdigital Science and Education*, *4*(2), 330–353. https://doi.org/10.1007/s42438-021-00273-1

Hummel, P., Braun, M., Tretter, M., & **Dabrock, P.** (2021). Data sovereignty: A review. *Big Data & Society*, *8*(1). https://doi.org/10.1177/2053951720982012

Hussein, M. J., Yusuf, J., Deb, A. S., Fong, L., & **Naidu, S.** (2020). An Evaluation of Online Proctoring Tools. *Open Praxis*, *12*(4), 509. https://doi.org/10.5944/openpraxis.12.4.1113

Khanna, V., Brodiya, S., & **Chaudhary, D.** (2021). Artificial intelligence based automated exam proctoring system. *08*(12).

Koper, R. (2008). Open source and open standards. In *Handbook of Research on Educational Communications and Technology* (3rd ed).

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), 4. https://doi.org/10.1186/s41239-020-00236-9

Labayen, M., Vea, R., Florez, J., Aginako, N., & **Sierra, B.** (2021). Online Student Authentication and Proctoring System Based on Multimodal Biometrics Technology. *IEEE Access*, *9*, 72398–72411. https://doi.org/10.1109/ACCESS.2021.3079375

McKenna, S. (2022). Neoliberalism's conditioning effects on the university and the example of proctoring during COVID-19 and since. *Journal of Critical Realism*, *21*(5), 502–515. https://doi.org/10.1080/14767430.2022.2100612

Mitchell, M., Wu, S., Zaldivar, A., Barnes, P., Vasserman, L., Hutchinson, B., Spitzer, E., Raji, I. D., & **Gebru, T.** (2019). Model Cards for Model Reporting. *Proceedings of the Conference on Fairness, Accountability, and Transparency*, 220–229. https://doi.org/10.1145/3287560.3287596

Motwani, S., Nagpal, C., Motwani, M., Nagdev, N., & **Yeole, A.** (2021). AI-Based Proctoring System for Online Tests. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3866446

Najar, G. A., & **Ahmad, M. N.** (2024). *A Review on Factors Affecting the Success of Online Proctoring System. Journal of Information Systems Research and Practice, 2(2), 56–70.* Retrieved from https://ijie.um.edu.my/index.php/JISRP/article/view/53561

Nicola-Richmond, K., Dawson, P., & **Partridge, H.** (2024). Online proctored exams: Rhetoric vs reality. *Higher Education Research & Development*, *43*(2), 392–405. https://doi.org/10.1080/07294360.2023.2234310

Nigam, A., Pasricha, R., Singh, T., & **Churi, P.** (2021). A Systematic Review on AI-based Proctoring Systems: Past, Present and Future. *Education and Information Technologies*, *26*(5), 6421–6445. https://doi.org/10.1007/s10639-021-10597-x

Okada, A., Noguera, I., Alexieva, L., Rozeva, A., Kocdar, S., Brouns, F., Ladonlahti, T., Whitelock, D., & **Guerrero-Roldán, A.** (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

Paul, J. S., Farhath, O., & **Selvan, M. P.** (2024). AI based Proctoring System – A Review. *2024 International Conference on Inventive Computation Technologies (ICICT)*, 1–5. https://doi.org/10.1109/ICICT60155.2024.10544779

Portugal, D., Faria, J. N., Belk, M., Martins, P., Constantinides, A., Pietron, A., Pitsillides, A., Avouris, N., & **Fidas, C. A.** (2023). Continuous user identification in distance learning: A recent technology perspective. *Smart Learning Environments*, *10*(1), 38. https://doi.org/10.1186/s40561-023-00255-9

Sedlmeir, J., Smethurst, R., Rieger, A., & **Fridgen, G.** (2021). Digital Identities and Verifiable Credentials. *Business & Information Systems Engineering*, *63*(5), 603–613. https://doi.org/10.1007/s12599-021-00722-y

Selwyn, N., O'Neill, C., Smith, G., Andrejevic, M., & **Gu, X.** (2023). A necessary evil? The rise of online exam proctoring in Australian universities. *Media International Australia*, *186*(1), 149–164. https://doi.org/10.1177/1329878X211005862

Slusky, L. (2020). Cybersecurity of Online Proctoring Systems. *Journal of International Technology and Information Management*, *29*(1), 56–83. https://doi.org/10.58729/1941-6679.1445

Soltani, R., Nguyen, U. T., & **An, A.** (2021). A Survey of Self-Sovereign Identity Ecosystem. *Security and Communication Networks*, 1–26. https://doi.org/10.1155/2021/8873429

Somavarapu, J., Biswas, S. Kr., Purkayastha, B., Abhisheka, B., & **Potluri, T.** (2024). Advancements and Challenges in Fully Automated Online Proctoring Systems: A Comprehensive Survey of AI-Driven Solutions. In T. Senjyu, C. So–In, & A. Joshi (Eds.), *Smart Trends in Computing and Communications* (Vol. 947, pp. 199–212). Springer Nature Singapore. https://doi.org/10.1007/978-981-97-1326-4_17

Swauger, S. (2020). Our Bodies Encoded: Algorithmic Test Proctoring in Higher Education. *Hybrid Pedagogy*. https://hybridpedagogy.org/our-bodies-encoded-algorithmic-test-proctoring-in-higher-education/

Turnbull, D., Chugh, R., & **Luck, J.** (2023). Systematic-narrative hybrid literature review: A strategy for integrating a concise methodology into a manuscript. *Social Sciences & Humanities Open*, *7*(1), 100381. https://doi.org/10.1016/j.ssaho.2022.100381

Tweissi, A., Al Etaiwi, W., & **Al Eisawi, D.** (2022). The Accuracy of AI-Based Automatic Proctoring in Online Exams. *Electronic Journal of E-Learning*, *20*(4), 419–435. https://doi.org/10.34190/ejel.20.4.2600

Walters, L. (2021, November 6). Universities expand controversial AI monitoring of students taking online exams. *Stuff*. https://www.stuff.co.nz/national/education/126908715/universities-expand-controversial-ai-monitoring-of-students-taking-online-exams

Whitelock, D., Edwards, C., & **Okada, A.** (2020). Can e-Authentication Raise the Confidence of Both Students and Teachers in Qualifications Granted Through the e-Assessment Process? *Journal of Learning for Development*, *7*(1), 46–60. https://doi.org/10.56059/jl4d.v7i1.384

Zeide, E. (2023). Big proctor: Online proctoring problems and how FERPA can promote student data due process. *Notre Dame Journal on Emerging Technologies*, *3*(1). https://ssrn.com/abstract=4336557

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