

# Fairness in Tech-Driven Assessment: Strategies to Safeguard Academic Integrity and Security in Virtual Environment

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**Abstract**—Advanced technology can provide vital tools to promote authentic, meaningful, and efficient assessments that measure students' achievement of learning objectives in higher education. However, it also brings several challenges in the learning process. This literature review-based paper describes the challenges in ensuring academic integrity and cybersecurity when students' knowledge and performance are assessed in a digital environment. The paper also reviews the strategies that can be implemented to address these challenges. Using students' authentication and authorship verification of their classwork, designing and developing e-assessments, technology accessibility and instructor training are probable solutions to address these challenges. Given the increasing adoption of digital technology in assessing students' effective learning achievement, this paper will help enhance knowledge and in-depth understanding of measures needed in using technology in academic assessment.

**Keywords**—Fairness, cybersecurity, e-authentication, academic integrity, e-assessment.

## I. INTRODUCTION

WITH the ubiquitous presence of digital technology in the modern world, the higher education environment is undergoing sweeping changes with the use of technology, which has transformed not only the students-instructor interaction method but also the assessment design, development, and application [1]. The assessment of students' learning achievement progresses with technological advances [2]. The e-assessment, which applies digital technology for assessment, is increasingly used in various academic disciplines in higher education [3]. As digital technology is now interlinked with what and how students learn, incorporating technology in different assessment levels is inevitable in most academic disciplines, especially cybersecurity and engineering programs [1]. Higher education institutions strive to improve the effectiveness and efficiency of students' learning process using e-assessment, especially when dealing with large groups of students with limited instructors [4]. With the augmented efficiency of technology, increasingly more exams are now computerized. The emergence of affordable digital devices allows students to write directly on the device screen using technology such as a stylus [1].

Existing literature shows that students prefer the e-assessment to the traditional paper-based assessment [3]. This

perceived willingness to adopt e-assessment indicates that e-assessment, with tools that can measure student competencies [2], is a viable mode of evaluating students' learning outcome [1]. Especially after the COVID-19 pandemic, e-assessment has become a reality in higher education [5]. The advanced technology offers significant advantages in different types of assessment. However, concerns about academic integrity and cybersecurity issues in e-assessment have also been raised [6]. Consequently, this paper focuses on the academic integrity and cybersecurity challenges in ensuring fairness when students' knowledge and performance are assessed digitally. Also, strategies can be adopted as probable solutions to address those challenges.

## II. EMBRACING E-ASSESSMENT IN ACADEMIC LEARNING

Assessment is a fundamental component of students' learning process that should advance knowledge by measuring the results [5]. Assessment, which obtains evidence of students' learning outcomes, is vital to learning [7], [8]. Assessment is a measurable set of standards to determine students' achieved knowledge, proficiency, and skill levels compared to the planned learning objectives of learning content at the end of a chapter, a module, or a learning period such as a semester or term. Assessments may include standardized testing, exams, writing, presentation, etc. [9]. Assessment is not only for checking if students have learned and understood the learning content but is also an integral part of students' learning process [10].

E-assessment is a computerized exam for practical, unbiased assessment of students' learning achievement. E-assessment includes the entire cycle of the assessment process, from designing and developing the assessment to managing the assessment outcome [11]. It is an effective method for objectively evaluating students' knowledge level, academic performance, and problem-solving skills [8]. E-assessment means using technology to manage and deliver assessments, which can be summative or formative [5]. The e-assessment uses digital technologies for formative and summative assessment of learning in higher education institutions [11].

Numerous advanced technologies help with learning assessment. These include touch screens with drag and drop and multi-touch features, augmented reality, virtual reality, mixed

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reality, robots, and behavioral monitoring such as voice recognition, eye gaze, face recognition, touchless user interface, etc. [6]. Advancements in technology have created new possibilities and promises for better assessment in higher education. The technological advances offer opportunities to design active assessments that measure complex student knowledge and learning. For example, innovative technology allows the simulation of scientific instruments, virtual experimentation, simulated collaboration, and adaptive responses to students' choices that can be captured and recorded in data streams [12]. All these strategies are adopted for assessments in different academic programs, including computer technology and engineering.

### III. BENEFITS OF ADOPTING E-ASSESSMENT

E-assessment, a powerful tool for evaluating students' learning achievement, can help enhance efficient and effective learning processes for students. Innovative technologies can deliver better assessments that benefit students' learning [13]. E-assessments are more practical, cost-effective, valid, and reliable than traditional paper-based assessments [12]. Technology can provide essential tools to promote authentic, meaningful, and efficient assessments. It is especially effective in formative assessment [14]. Various digital tools, such as wikis, blogs, e-forums, e-portfolios, learning management systems, etc., can create a virtual learning environment that can add value to the learning process [5].

#### A. Efficiently Manage and Streamline Assessment Process

E-assessments enhance accessibility, transparency, and clarity, ensure fairness and consistency, assign value to student class work, test the accuracy of their acquired knowledge, and track, monitor, and detect plagiarism [11]. E-assessment has advantages over traditional paper-based assessments because of its simplification. Compared to paper-based assessment, e-assessment is substantially efficient in data management, reducing instructors' workload, especially when dealing with many students [8]. That is why large-scale, high-stakes standardized tests increasingly use e-assessments that can be more authentic, engaging, and demanding [15]. The traditional paper-based assessment in higher education is increasingly being replaced by e-assessment, which has valuable tools and features that allow online submissions of assignments, taking exams, completing labs using simulation software, etc. [15].

#### B. Interactive Student-Instructor Engagement with Instant Feedback

E-assessment can provide constructive and instant interactive feedback, develop ideas and gain skills, improve the class experience, enhance clarity, monitor and ensure transparency of communication, and encourage students' active participation [11]. The provided instant feedback can help students understand the subject matter better and thus improve their class performance [3]. The e-assessment's advanced features allow students to receive faster feedback and computer-generated real-time data-driven decisions to change instructional strategy [6]. The instant feedback students receive can help them to

improve their learning [5], as there is a significant positive relationship between learning effort and learning success [3].

Feedback in e-assessment can enhance the quality of students' effective learning process with interactive techniques using multimedia such as audio, video, image, animation, etc., increasing students' motivation. In e-assessments such as multiple choice, true-false, matching tests, etc., students receive feedback instantly, allowing them to improve their learning by fixing their mistakes [16]. Instant feedback positively impacts students' learning performance by increasing their motivation to participate in the learning process [17].

#### C. Enhanced Tools and Applications to Assess

The tools and applications in learning management systems can ensure systematic e-assessment to evaluate students' learning status. Uploading or submitting assignments using these tools is easier and faster than the traditional paper-based submission. Different technical features, such as images, graphics, drawing, audio, video, animation, etc., in learning management systems can help instructors design effective e-assessments. These innovative tools and apps can ease the editing and corresponding writing-intensive assignments. Assignments submitted by students electronically can be easily examined and edited with feedback provided by the instructor. Similarly, students can fix their assignments based on the instructor's feedback [16]. Including real-world problems and simulations can create meaningful assessments [18].

#### D. Accessibility, Control, and Storage of Assessment Data

Storage, access, and control on assignments using digital tools are easier to maintain in e-assessment than in paper-based assessment. The digital records can show the data of students' assignments, such as when they submitted or resubmitted, how long students spent time on their assignments/tests, the missing assignments of individual students for how long and how many times over the semester, etc. The records in the learning management systems also show how long students spend their time in the online class, when was the last time they accessed their class, how many times they accessed it, when they took a test or finished a simulated lab assignment, whether they even try to complete an assignment, etc. [16]. This recorded information is crucial, especially when students claim they have taken their exams/quizzes/tests or submitted their assignments on time. The instructor can verify the claim's authenticity to prove it. The learning management systems provide data about students' class access rates, which can help instructors check students' completion of course outcomes, participation time, message rate and length in the discussion board, etc., to gain insight into students' class participation [19].

### IV. CONSTRAINTS IN E-ASSESSMENT: FAIRNESS CONCERN

The rapid expansion of digital technologies that offer text, image, video, audio, data visualizations, etc., with new tools created opportunities for multiple modalities to demonstrate students' learning achievement [20]. However, while e-assessments provide more opportunities for an effective learning process, it also brings several challenges [21]. There

are many constraints to using e-assessments, that can create the most serious challenge in ensuring fairness. Various contextual factors can constrain the use of innovative digital technologies in assessment. For example, students' difficulties in accessing technology resources, receiving tech support, institutional rules, regulations, and curricula, as well as students' time management, self-discipline, priority, experiences, etc., can risk ensuring fairness in e-assessment [22].

Fairness is a critical issue, mainly when e-assessment outcomes are used for students' admission, placement, and graduation, which have a high impact and accountability on their future careers [23]. Fairness is an essential factor in e-assessment specifically because it impacts students' cognitive learning, perceptions of effective feedback, and evaluation of instructors' effectiveness. E-assessment certifies whether or not students have the knowledge and skills in the relevant areas of expertise. Assessment determines the recognition students receive from their instructors, classmates, and society; therefore, fairness in assessments is critical for ensuring students' positive learning experiences. Consequently, students consider fairness in assessment as the fundamental factor [24]. In this context, it is very important to review following issues.

#### A. Academic Misconduct

Higher educational institutions face an ever-increasing risk of misconduct perpetrated by their students during and even after the assessments. Preventing plagiarism in e-assessment is challenging, which may risk the fairness and reliability of the e-assessment [25]. In particular, summative assessment, which evaluates students' learning outcomes at the end of the learning period, is a high-stakes assessment method because it tremendously impacts the prospect of students' further education and careers. There is a greater possibility of academic misconduct and malpractice by students in summative assessment [26]. The formative e-assessment, which continuously provides students with instant feedback, is a supportive e-assessment method in the learning process [27]. Hence, there is a lesser possibility of academic misconduct in the formative e-assessment method.

#### B. Technology Availability

E-assessment requires computer literacy, which includes knowledge and skill in new devices and application processes [28]. The critical challenge in administering e-assessment is ensuring that all students are familiar with and have access to technology to complete the assessments on time and maintain academic integrity [29]. If those constraints occur, the new technologies used in the e-assessment process must be available and usable for all students [11].

#### C. Authentication and Authorship in e-Assessment

One of the main challenges in e-Assessment is to ensure the authentication of students and authorship of their class works. Authentication refers to the person who assesses the student, and authorship refers to the work performed as original. Checking the students' identity and authorship of their submitted classwork is a significant challenge [30].

Authentication verifies a user's identity to access a system [31]. Students' authentication in e-assessment is a serious challenge [21] because it may enable students to cheat. Therefore, recognizing students' identity and authorship of their class assignments submitted online is a serious concern from a cybersecurity perspective [27]. The threat to data security in database server systems is a significant concern in e-assessment. Consequently, an appropriate authorization technique is critical to ensure that only legal users can access the data [32].

### V. STRATEGIES TO ADDRESS CHALLENGES

To ensure fairness in academic assessment critical strategies need to be taken. There are several technical and non-technical strategies that can play critical role in this regard. The following strategies must be adopted as probable solutions to address the challenges.

#### A. Ensure e-Authentication and Authorship

Appropriate measures to identify the source of misconduct are essential to upholding the academic honesty and integrity of the assessment system [26]. To prohibit academic misconduct, it is essential to ensure reliable ways to confirm students' identities by developing systems for students' authentication and authorship verification of their class works [33]. To address academic misconduct in e-assessment, students' authentication and authorship of their classwork can be checked using digital identities. With successful authentication of students, e-assessment systems can be perceived as secure. Therefore, e-authentication and authorship verification need to be integrated into e-assessment at the course design stage. Existing literature recommends using security tools to identify students and detect any misconduct in e-assessment [30]. It is possible to implement authentication and authorship in e-assessment in higher education [18].

#### 1. E-authentication and Authorship Verification Mechanisms

Verifying authentication and identity of authorship in an e-learning platform is critical to ensure security in an e-assessment. However, providing authentication and authorship is a significant challenge in e-assessment [34]. Various mechanisms can be used to secure e-authentication [31]. Student ID, logging information, challenging questions based on student profiles, course activities, content interaction, etc., can be used to identify and authenticate students [35]. Also, digital signatures to authenticate and timestamps to determine when the computer records an event can be helpful in this regard [36].

The e-authentication mechanisms can be knowledge-based, possession-based, biometric character-based, content-based, etc. The knowledge-based authentication is a standard authentication method that uses a password, which is inexpensive but effective. However, more than knowledge-based authentication is required to ensure e-authentication because of the impersonation risk - where students can share their login credentials with others for better grades. In possession-based authentication, students possessing identity

objects are counted as authentic. However, identity objects can be stolen or given to a third party [21]. The username and password identification are often used to control access to the system, but there needs to be a better approach to authentication. Therefore, some systems also deploy biometric technologies. E-authentication can be ensured by arranging third-party-provided e-proctoring, such as ProctorU, RemoteProctor, SmarterProctoring, etc., in high-stakes examinations [33]. However, proctoring software using cameras should be avoided because it may increase stress on students, making exams and quizzes unnecessarily complex [29].

Different types of instruments are used for e-authentication and authorship, such as biometric instruments for e-authentication and textual analysis instruments for verifying e-authorship. However, some textual analysis instruments, such as writing style (Forensic) analysis, can also be used for e-authentication verification [30].

#### *a. Biometric Authentication*

E-authentication can be based on students' physiological and behavioral characteristics. Physiological characteristics include facial images, fingerprints, voice recognition, hand geometry, palm prints, iris, etc. Behavioral characteristics include students' posture, signature, mouse movement, keystroke analysis, etc. [36]. Physiological biometric methods such as fingerprint, face reorganizations, iris matching, etc., are considered the most scientific authentication [37].

There are Biometric authentication instruments for face recognition and voice recognition, authorship verification instruments for forensic analysis and plagiarism detection, security instruments for face anti-spoofing, voice anti-spoofing, and certificate-authorization [38]. TeSLA (Trust-based e-assessment System for Learning), a model for a trust-based e-authentication system, is a suite of instruments for e-authentication; the core functionality of students' authentication is provided by biometric and forensic instruments [30]. TeSLA system's features include biometric instruments such as facial recognition, voice recognition, and keystroke dynamics, as well as textual analysis instruments such as plagiarism detection and forensic analysis [39].

#### *b. Biometric Instruments*

Different biometric instruments can help ensure students' authentication. Those instruments include Facial recognition, Face presentation attack detection, Voice recognition, Voice presentation attack detection, and Keystroke dynamics. Facial recognition compares students' faces and facial expressions using images and at least 10-second videos. The Face presentation attack detection detects presentation attacks to the face recognition instrument using a natural person with a minimum distance of 50 pixels between the center of eyes in front of the camera. Voice recognition compares voice structures of speech samples with a minimum resolution of 16 kHz. The Voice presentation attack detection detects attacks in the voice presentation of a student's uncompressed recorded audio file with a minimum resolution of 16 kHz. The Keystroke

dynamics compares the rhythm and speed of typing of at least 30 samples extracted from 125 consecutive pressed keys with the learner model [30].

#### *c. Textual Analysis*

Different textual analysis instruments can help ensure students' authentication. Those instruments include anti-plagiarism or plagiarism detection that uses text matching to detect similarities between documents and forensic analysis by verifying written document authorship [36]. Plagiarism detection detects similarities of word-for-word copies between a given set of text documents using text matching. Plagiarism detection software such as Turnitin, iThenticate, etc., can be used. Although these are licensed-based with a fee, free software is on the market. Forensic analysis compares students' writing styles with new documents submitted over time [30].

Biometric authentication methods can be relatively secure because they are based on biometric data, a student's behavioral and physiological characteristics that are difficult to steal or share with others. Consequently, a multimodal biometric authentication approach should be adopted to address the impersonation risks. However, biometrics traits should not be used as primary authentication methods because of privacy issues [21]. Biometric authentication requirements raise concerns about data security and privacy issues in dealing with students' sensitive data [40]. A study shows that students feel less comfortable sharing their biometric data with a third-party private vendor than their academic institution [33]. Also, while biometric tools can be more effective, they can be technically complex and expensive [36]. Therefore, e-authentication should combine various mechanisms to ensure more effective, robust, and trustworthy authentication and authorship [30] [31].

#### *B. Design and Development of E-assessment*

Different innovative technologies have been used to address fairness issues in e-assessment. However, these high-tech solutions are not applicable in all assessment situations. Therefore, some techniques may be used in designing e-assessment, such as setting up time limits in tests, presenting test questions randomly or in a different order, creating a test pool and presenting random questions to each student, online proctor-based exams, and using Respondus in LMS to obstruct students opening any other website when taking exam online [25]. Also, e-assessment systems can generate test questions randomly for each student individually to prevent students from copying from each other [5].

Using test bank questions with easily searchable answers on websites should be avoided. Instead, asking students questions that require substantiated answers using scientific reasoning to demonstrate their understanding should be part of the e-exam [29]. Therefore, selecting appropriate assessment techniques such as performance tasks, e-portfolios, peer and self-assessments, etc., is another option for better e-assessment. These assessment techniques activate higher-level skills, which trigger student's thinking, criticizing, evaluating, and creating ideas. These tasks can hinder the possibility of students' responses without intellectual effort.

Additionally, detailed rubrics with rating scales can be used, especially for assessing writing assignments. Using open-book quizzes with unlimited time settings is another alternative to preparing students for extensive exams such as midterm or final exams, which will be set as time-limited. These open-book quiz tests that allow students to use books, notebooks, and other learning materials may decrease cheating by preparing students for midterm or final exams [16].

### C. Technology Accessibility

Students' inability to use learning technology because of limited access to devices with high-speed internet can negatively impact their performance in e-assessment. Therefore, it must be ensured that students have access to all the software and hardware infrastructure with high-speed internet connection. Limitations of the tools, devices, and technology, such as learning management systems or administrative decisions, may negatively affect the application of effective e-assessment. These might hinder the instructors' preferences for using technology for assessments in their classes [16]. Also, students' familiarity with technology is essential to make e-assessment compatible with their learning process [1]. Therefore, academic institutions must ensure that all students have proper support for computer literacy and access to technology to participate in e-assessment.

### D. Instructor Training

Innovative technology can facilitate and accelerate the advantages of e-assessment techniques. However, instructors must be trained to develop valid and reliable assessments for students' learning achievement evaluation. For designing and developing valid and reliable assessments, instructors must have experience considering appropriate digital tools and apps and how to use those. Instructors' inexperience, technical problems, or lack of expert tech personnel to support them can negatively affect the design and development of reliable and valid e-assessments [16]. Existing literature recommends that instructors train on e-assessment, including e-authentication, authorship verification, etc. [30]. Therefore, educational institutions must employ all resources to help instructors design and develop effective e-assessment [8].

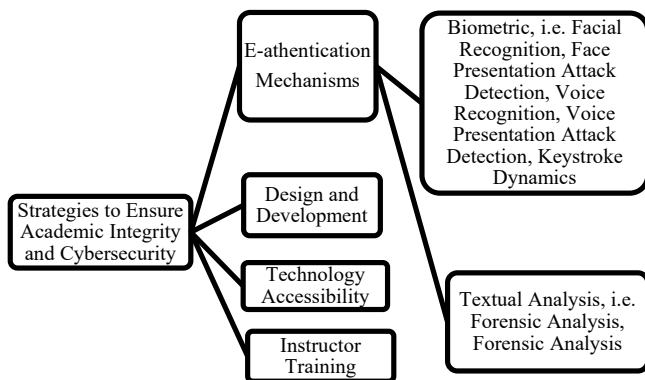


Fig. 1 Strategies to safeguard academic integrity and cybersecurity in e-assessment

## VI. CONCLUSION

Assessment is a significant part of the learning process without which students' learning objectives cannot be completed. For academic institutions and students, e-assessment has advantages over traditional paper-based assessments. These include efficient administration, student preference, immediate score reporting, etc. [41]. Secure e-assessments in virtual learning environments provide opportunities for immediate feedback, which improves students' learning by giving information about their learning progress [37].

At the institutional level, e-assessment is closely related to institutional culture, management, quality assurance, staff development, and planning. At the faculty and student level, it affects the course design, training, workload, and work practices [42]. Therefore, the correlation between learning goals, instructional strategy, and assessment must be carefully considered in e-assessment. Hence, the implementation of e-assessment needs to consider technical obstacles and how to overcome such issues, especially in highly technical academic programs, such as cybersecurity and engineering [18].

There are some significant challenges in e-assessment [42]. There is concern over malpractice in e-assessment, such as plagiarism and cheating. In this context, e-authentication systems are emerging to detect malpractices in e-assessment [36]. E-assessment uses unique identification features using biometric characteristics, such as facial recognition, fingerprint, hand gestures, retinal patterns, voice recognition, etc., which is the automatic identification of students based on their physiological or behavioral characteristics. All these biometric indicators have their advantages and disadvantages regarding accuracy, user acceptance, and applicability [41].

The biometric method is inherently more reliable and has a higher identification capability than the knowledge-based methods used in e-authentications because students' physiological or behavioral characteristics are unique [41]. However, biometrics for e-authentication can be more effective and trustworthy when combined with different methods [36], such as design and development of e-assessment, technology accessibility, and instructor training. Therefore, to implement e-assessments, higher education institutions must support adequate conditions required for e-assessments and train instructors to design and develop e-assessments using tools. Higher education institutions also need to train students to use e-assessment systems. So, students can be well acquainted with the online assessment system when appearing in the e-exams. In addition, the e-assessments must be embedded in the higher education institutions' strategic planning [8]. Therefore, developing and sharing best practices based on combined e-authentication and authorship verification instruments is essential for institutions to evaluate their students' advancement in learning [30].

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