A Comprehensive Analysis of Online Examination Frameworks and their Applicability to Open and Distance Learning in Namibia: A Scoping Review

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Abstract

Demand for effective assessment methods in Open and Distance Learning (ODL) is rising due to its adaptable, inclusive approach to diverse student populations. Online examination frameworks have become essential tools for ODL. This study involved a scoping review of current online examination frameworks for ODL to establish how they are implemented in higher education institutions and identify the challenges of applying them in Namibia. Data from six electronic databases for the period 2017-2022 was collected using a scoping review methodology. Of the 97 articles identified, only ten satisfied the inclusion criteria. Six relevant online examination frameworks for ODL were identified and recommendations are made to adapt these for Namibian higher education institutions offering ODL.

Key words: online examination, framework, visually impaired, subjective examination, free handwriting, fault-tolerant, unsupervised, natural language processing, Namibia

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Résumé

La demande de méthodes d'évaluation efficaces dans le domaine de l'enseignement ouvert et à distance (EOD) augmente en raison de son approche adaptable et inclusive des diverses populations d'étudiants. Les cadres d'examen en ligne sont devenus des outils essentiels pour l'EOD. Cette étude a consisté en un examen de la portée des cadres d'examen en ligne actuels pour l'EOD afin d'établir comment ils sont mis en œuvre dans les établissements d'enseignement supérieur et d'identifier les défis liés à leur application en Namibie. Six bases de données électroniques pour la période 2017-2022 ont été exploitées à l'aide d'une méthodologie d'examen de la portée. Sur les 97 articles identifiés, seuls dix répondaient aux critères d'inclusion. Six cadres d'examen en ligne pertinents pour la FOAD ont été identifiés et des recommandations sont formulées pour les adapter aux établissements d'enseignement supérieur namibiens proposant une FOAD.

Mots clés : examen en ligne, cadre, malvoyants, examen subjectif, écriture libre, tolérant aux fautes, non supervisé, traitement du langage naturel, Namibie.

Introduction

Open and Distance Learning (ODL) has transformed educational accessibility. This is attributed to its combination of Information and Communication Technology (ICT) that impacts counselling and admissions processes, and overall management of students.

Educational accessibility was facilitated by the growth of online examinations that offer a platform that is both flexible and modifiable. This supports the adoption of on-going technological advancements that enable Higher Education Institutions (HEIs) to cater for global, diverse student cohorts.

Traditional face-to-face paper examinations have given way to online examinations as a result of the expansion of student enrolment and increased use of ICTs (Topuz et al., 2022; Sutherland, 2020). Such examinations offer benefits like automated grading, cost reduction, immediate feedback, and improved student performance (Alruwais,

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2018). Online assessment frameworks also contribute to quality assurance and the gathering of valuable information, especially in varied and complex environments such as Namibia.

However, ODL institutions confront challenges related to modern electronic technologies (Khumalo, 2018; Ngubane-Mokiwa and Letseka, 2015).

While HEIs implemented online examinations during the COVID-19 pandemic, they often lack the scope to assess various question types (Butler-Henderson and Crawford, 2020; Das, 2021). Recent research has focused on technological upgrades and innovative online examination frameworks (Al-Hunaiyyan et al., 2021) and HEIs across the world have developed and implemented such frameworks. However, Fluck (2019) points to a paucity of literature on ODL online examination frameworks. Examination frameworks should be both innovative and user-friendly and capable of adapting to the various socio-economic backgrounds and competencies of students involved in ODL (Moore et al., 2019). Mogey and Fluck (2015) and Dawson (2016) note that online examination frameworks include commercial software and bootable systems installed on students' devices. The high costs associated with purchasing such software and systems may prevent ODL institutions from fully implementing them. Furthermore, given ODL students' diverse backgrounds and abilities in countries such as Namibia, some might be unable or reluctant to adopt these systems.

Ngqondi et al. (2021) proposed an online examination framework for use by South African universities that aims to increase accessibility to students and enhance competitiveness. The framework has yet to be implemented.

Due to poor ICT infrastructure in rural areas such as Kunene, Ohangwena, Omaheke, Otjozondjupa, Oshikoto, Zambezi, and the Kavango regions in Namibia, and societal inequalities such as educational gaps and income inequality, access to the Internet has been a challenge (United Nations, 2018). However, the majority of universities rely on web-based Learning Management Systems (LMS), which require a reliable Internet connection. Data affordability and a lack of devices pose further problems (Reddick, 2020).

Higher education institutions across the globe have embraced online digital technologies and platforms to expand the reach of education to a more geographically dispersed audience. This was facilitated by blended teaching approaches, including learning and examination methods (Fahd et al., 2021). Guardia et al. (2020) refer to examination activities conducted using digital devices and over the Internet as e-examinations. Various frameworks are used to implement e-examinations, with a focus on different activities including peer evaluation, quizzes, reviews, graded discussion forums, and simulations. Frameworks are blueprints used to help developers construct digital systems. Students can access questions remotely through an online examination framework. Trivedi et al. (2022) proposed an online examination framework to establish an electronic structure that universities and HEIs can adopt to fulfil specific examination process requirements (Al-Aqbi et al., 2021).

However, despite the widespread adoption of online examination technologies, several studies (see, for example, Kuikka et al. (2014); Fluck (2019) have identified critical gaps. These include concerns regarding security, leading to instances of academic dishonesty and plagiarism. Some frameworks prioritise authentication mechanisms to prevent cheating and impersonation (Fluck et al., 2017), while Alshammari (2020) proposed a variety of alternative online examination frameworks and architecture based on empirical evidence. A further concern is the emphasis on evaluation of knowledge attainment rather than practical application thereof. Historical shortcomings in online examination frameworks, originally designed to accommodate only multiple-choice, short-answer, and objective questions, resulted in this limitation.

Against this background, the study on which this article is based involved a scoping review to analyse existing online examination frameworks and their applicability to ODL environments in Namibia, and make recommendations on the development of the most appropriate online examination framework.

Research Objectives

The review was guided by the following objectives:

1. To gain insight into current relevant online examination frameworks for ODL.

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2. To analyse the appropriateness of existing online examination frameworks for implementation in HEIs in Namibia offering ODL and the challenges encountered.

Methodology

A scoping review was conducted to investigate online examination frameworks following the methodological steps outlined by Arksey and O'Malley (2005). Scoping studies are conducted for several primary reasons, including assessing the current state of research on a specific topic, determining the need for and feasibility of a systematic literature review, synthesising and disseminating research findings, and highlighting significant gaps in the existing literature.

Armstrong et al. (2011), Levac, Colquhoun, and O'Brien (2010), and Rumrill, Fitzgerald, and Merchant (2010) acknowledged the broad and multidisciplinary nature of the online examination literature and deemed that conducting a systematic literature review with comprehensive methodological quality analysis was neither feasible nor appropriate.

The study followed the five sequential stages outlined in Arksey and O'Malley's framework (2005), namely, (1) identifying the research question(s), (2) searching for and retrieving relevant studies, (3) selecting studies that meet the inclusion criteria, (4) extracting pertinent data from the selected studies, and (5) collating, summarising, and reporting the results, with a focus on implications for policy, practice, or further research.

Search Strategy

The initial search encompassed five databases: Institute of Electrical and Electronic Engineers (IEEE), Scopus, SABINET, EBSCO Host Eric, and Google Scholar. We conducted manual searches for relevant journal articles to enhance the search. We retrieved a total of 143 papers published between 2017 and 2022.

The search utilised keywords such as "online examination framework" OR "online examination system," "online assessment frameworks" OR "online assessment systems," and "open distance learning." The

reference lists of all identified articles were also examined to identify additional studies.

Study Selection

The initial step involved consolidating the search results and removing duplicates by importing them into an Excel file. Subsequently, the remaining articles' titles and abstracts were thoroughly screened. We applied specific inclusion and exclusion criteria during this screening phase to determine which studies would be considered for inclusion in the scoping review.

The inclusion criteria were: (1) articles published from 2017 onwards, and (2) clear relevance to online examination frameworks. Studies excluded from the review fell into the following categories: (1) non-English literature, (2) articles subject to systematic literature reviews, (3) publications published before 2017, (4) publications discussing eLearning and ODL without a focus on online examination frameworks, and (5) publications discussing utilisation and satisfaction with specific eLearning systems.

The second stage of the review process involved evaluating the full texts of selected articles to determine their eligibility for inclusion.

Charting the Data

Following the afore-mentioned stage, the data was extracted and the following information was included: author(s), year and location of the study, reason for the study, target population or audience, methodology/software/technologies used, framework type, use of the framework, and challenges. This information is depicted in Table 1.

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Table 1: Key Characteristics of Included Articles

Author (s)	Year and location of study	Reason for the framework	Target population/ Audience	Methodology/ Software/ technologies used	Framework Type	Use of the framework	Challenges
Dharmasena and Jaya-kody	2022 Sri Lanka	Build a voice-based online examination framework for visually impaired students.	Visually Impaired students.	Linear Predictive coding (LPC). Mel Frequency Cepstral Coefficients (MFCC). Hidden Markov Models (HMM). Dynamic Time Warping (DTW).	Students with visual impairments can utilise this voice-based online examination framework.	It is used to read the examination questions that are displayed on the screen to the student and obtain students' responses via voice command.	None mentioned.
Eko and Essien	2022 Nigeria	Create a resilient examination framework capable of withstanding technical faults like power outages, network disruptions, and component failures while maintaining security.	Tertiary Institutions in Developing Countries.	Incremental software development model in conjunction with prototyping technique method.	Secure, fault-tolerant online examination framework.	The online examination framework restores lost time during power outages, network failures, or computer component failures. Students can resume taking the online examination upon login without loss of information.	The current framework only applies to MCQ.
Ayoub, Muham-mad, Khan, M. A., and Khan, L. M.	2022 Malaysia	Propose the design of a new online exam-ination framework.	Schools, Colleges, and Universities.	CodeIgniter and MySQL Server Technologies - HTML, CSS, PHP, JavaScript, and Bootstrap.	Online examina-tion framework for HEIs.	The web-based online examination platform should be used by educa-tional institutions to improve online testing.	None mentioned.
Najaah and Ahamed	2021 Sri Lanka	Design a voice-based online examination framework to help visually impaired students take the examinations online.	Visually Impaired students.	Voice interface Schools Government Universities.	Voice-based on-line examination framework for the visually impaired.	To allow visually im-paired students to attempt to take an online examination without any human support.	A suitable bench-mark dataset could not be identified to evaluate students' answers, which makes evaluating and experimenting with the system a difficult task. Voice corpus is based on US English. As a result, words pronounced may be recognised different-ly by the system. There is a need for noise filtering.

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Author	Year / Country	Objective / Description	Target	Tools / Technology	Framework	Purpose	Challenges / Limitations
Sapre, Shinde, Shetta, and Badgujar	2021 India	The primary objective of the smart AI-ML-based online framework is to mitigate instances of malpractice during online examinations. This innovative framework aims to address the shortcomings of current systems and pave the way for the development of a new and improved examination platform.	University students and lecturers.	Dlib / OpenCV library.	Artificial Intelligence-Machine Learning Based Smart Online Examination Framework.	Authenticate students during an examination session. Detect malpractice activities.	Only suitable for objective questions. Analysis of students' front view is difficult.
Kulkarni and Al-fatmi	2021 Malaysia	Conduct online examinations using pre-installed software or a website on the intranet.	Universities, institutes.	CompareHashAndPassword GoCV Dlib	Online framework using Smart Contract for credential checking.	Conduct secure online examinations.	None mentioned.
Mohite, Patil, Borhude, and Pawar	2021 India	Ensure accessible and reliable online examinations using deep learning models for the proctoring system. Ease of use and simplicity.	Schools and Colleges.	HTML3, CSS5, BOOTSTRAP5, Django, and Python.	Proctored online examination framework.	Monitor students during the online examination session.	None mentioned.
Pandey, Kumar, Rajendran, and Bindhumadhava	2020 India	Conduct virtual scrutiny using the web-based examination.	Universities, Schools, and Colleges.	Secure streaming protocol RTMPS and WebRTC. Stream from students' devices during the examination writing process. Streaming server checking for malpractice/impersonations. OpenCV library.	An online examination framework aimed at eliminating ambiguities and ensuring fair conduct of online examinations. Makes use of a mobile-based platform to conduct exams.	Used to take online examinations from a mobile phone app. Used to facilitate supervised and unsupervised remote monitoring.	Virtual scrutiny of students is a challenge. Android phones are unable to operate both rear and front cameras at the same time.
Nandini and Uma Maheswari	2020 India	Suggested an automated descriptive answer evaluation system for online examinations.	Universities and Schools.	Django SQLite version 3 HTML version 5 CSS version 3 Bootstrap and JavaScript.	Online examination framework for grading descriptive answers. Descriptive online examination framework.	Evaluate descriptive types of answers.	Challenges are linked to the evaluation scheme, including resource-intensive processes, significant time requirements, and substantial human effort.
Das, Sharma, Rautaray, and Pandey	2019 India	Propose an automated online examination framework that allows examinees to submit descriptive answers for evaluation.	Schools and Universities.	None.	Online examination framework using Natural Language Processing to grade descriptive questions.	Grading students' responses using AI.	None mentioned.

Table 2: Key Characteristics of Articles Identified from the Reference Lists

Author (s)	Year and location of study	Rationale for the framework	Target population/ Audience	Methodology/Software/ technologies used	Framework Type	Use of the framework	Challenges
Zubairu, Mohammed, Etuk, Babakano, and Anda	2021 Nigeria	Develop a model to integrate WordNet into the online examination framework for improved evaluation purposes.	Universities and Schools.	WordNet database. Design science methodology was used to design the electronic online examination framework.	Framework for subjective questions.	To allow automatic processing and evaluation of students' responses.	None mentioned.
Natumanya and Nabaasa	2022 Uganda	Address the challenges experienced during pen-and-paper examinations.	Universities Students.	Design science methodology was used in the design of the electronic examination framework.	Electronic examination framework with free handwriting.	To use mobile devices such as cell phones and tablets with electronic free handwriting features.	None mentioned.

Findings

The research identified six online examination frameworks that aim to accommodate students with varying abilities from diverse geographical locations and socio-economic backgrounds, with a focus on assessing knowledge application. This section presents the findings and introduces these six frameworks, outlining details regarding their implementation or intended implementation. We also highlight any weaknesses or limitations identified.

Table 3 below presents the six online examination frameworks identified and the dates developed, as well as improved versions of the original frameworks, and the names of the developers.

Table 3: Identified online examination frameworks

Online Examination Framework	Date developed	Developer/s
1. Electronic examination Framework with free handwriting	2022	Natumanya and Nabaasa
2. Fault-tolerant web-based examination framework	2022	Eko, Eteng, and Essien
3. Framework for unsupervised online examinations	2020	Pandey, Kumar, Rajendran, and Bindhumadhava
4. Online examination framework for visually impaired students	2020	Dharmasena and Jayakody
5. Online examination framework for visually impaired students	2019	Mukul, Reshma, Srinivas, and Leelavathy
6. Natural Language Processing Automation Online Examination Framework	2019	Das, Sharma, Rautaray, and Pandey
7. Subjective online examination framework	2015	Qureshi and Rizwan
8. Online examination framework for visually impaired students	2004	Raghuraman

Online Examination Framework for Visually Impaired Students

Globally, many individuals are living with some form of vision impairment and the number of visually impaired (VI) people enrolling for courses in HEIs is increasing (NCES, 2016). Consequently, there is a need for assistive technologies to aid these students. Existing online

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examination frameworks were found not to cater for VI students in ODL (Azeta et al., 2017). Research reveals that ODL institutions need to set acceptable standards to enable them to accommodate students who are VI (Liakou and Manousou, 2015). This would render education opportunities more accessible and reduce social exclusion.

In 2004, an online examination platform was developed for VI students (Islam et al., 2019). It was mainly designed to use a keyboard, which provided guidance and feedback by voice. This framework was developed as a stand-alone application that used text-to-speech and speech-to-text technology, which made it a voice-enabled online examination framework. In recent years, an updated version of the online examination framework has been proposed, aimed at addressing the challenges students often encountered with the earlier version. Rabiner and Juang (1993), cited in Koffi (2020), noted that techniques associated with Automatic Speech Recognition (ASR) were initially applied towards the end of 2015. This led to remarkable achievements in speech synthesis for creating artificial human speech. The framework could range from multiple-choice to essay questions for different subjects. The application is linked to the database used to store the online examination questions. Therefore, a framework was developed to read the questions and their different options to VI students to enable them to make an informed decision and press the option number. Once the option is selected, the framework saves the response and the next question is read to the student until all the questions are answered. A report is generated at the end of the examination.

Several weaknesses were identified in the framework, including time delays as a result of speech-to-text, which results in the student's answers being received late by the framework; poor accuracy of the data recorded by the framework; the need to manually monitor the entire online examination process; the need for the student to be accompanied by someone for assistance in opening the online examination; and the fact that the framework is only available in English.

To address the weaknesses identified by HEIs and students, Mukul et al. (2019) proposed an online examination framework deemed to produce better results than previous versions. It was not a stand-alone application

and relied on an Internet connection to function properly. The proposed framework also uses text-to-speech and speech-to-text technology.

Mukul et al. (2019) were of the view that this online examination framework offered several advantages compared to the existing framework. Visually impaired students can easily access and work through the framework and there is no need for an invigilator. The proposed framework allows students to access the online examination without assistance from start to finish, as the system provides all the required guidance. It enables students to review all answers provided to questions and make corrections before final submission. During the online examination, the student receives a message alerting him/her to the time remaining. The student uses fewer keys on the keyboard, which helps to reduce the possibility of errors. This reduces noise problems and the synthesis of voice problems.

The proposed framework architecture is embedded within Python software for programming languages (Ghimire, 2020). The Python package is built into the framework to allow the student to log in using speech-to-text and text-to-speech technology. The student uses a microphone built into the framework to provide a username and password.

In 2021, a voice-based online examination framework was proposed and introduced by Dharmasena and Jayakody (2022).

Table 4 below sets out the architecture that shows the order in which the online examination is taken by VI students following a number of steps.

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Table 4: The Architecture of the Visually Impaired Online Examination

Step Number	Description
1	The initial step involves guiding the VI student to a computer equipped with headphones to receive examination instructions. He/she must input his/her login details, typically received via email after manual registration by the administrator, to access the examination framework and commence the assessment.
2	The university educator uploads the examination question papers and answer scripts before the online examination begins. A random question selection process within the database then conveys the questions to the student through a blend of text-to-speech and speech-to-text technology. In turn, the student utilises speech-to-text and text-to-speech technology to answer the online examination questions.
3	The student is able to skip questions using the "skip" voice command, with the framework saving all answers, and marking the skipped ones accordingly. To save the answers, the student issues a "submit" voice command.
4	The fourth step involves using specific voice commands: • The "next" command prompts the system to read the next question. • The "repeat" command allows the framework to repeat the question. • The "edit" command permits the framework to repeat preferred question items for editing and navigate back to skipped questions. • Lastly, the "finish" command signals the framework to conclude the examination.
5	The final step signals the end of the online examination.

When the allocated time expires, the framework automatically ends the examination. While it automatically marks multiple-choice questions (MCQs), the process takes more time for structured questions as the framework must tokenise the student's responses and compare them to the standard answers. Finally, the "log-out" key allows users to exit the framework after receiving their final score (Dharmasena and Jayakody, 2022).

Subjective Online Examination Framework

Quereshi and Rizwan (2015) developed an online examination framework where university educators submit examination questions to an online question bank. Moderators review and make recommendations for improvements or edits, and the questions and answers are stored in a data store. The framework generates examination papers based on student modules. For subjective questions, the framework uses knowledge and data mining techniques to match keywords and grades answers, with approval by educators and the Head of the Department before students access their grades.

Vimal and Kumbhana (2016) and Sychev and Prokudin (2020) highlighted that online examination frameworks require syntax and semantic evaluation to support subjective questions like sentence and descriptive answers. Zubairu et al. (2018) proposed an enhancement to Quereshi and Rizwan's framework by integrating WordNet, a semantic dictionary, to improve system performance. This is limited to the English language. The framework with semantic inclusion outperforms the previous one, using AI for automatic marking based on keyword extraction.

In comparing the existing framework with the proposed one, Zubairu et al. (2018) found that the former is easy to implement than the latter. The existing framework relies on syntax-based matching, whereas the proposed one incorporates semantic-based matching. Furthermore, the existing framework lacks a semantic dictionary and artificial intelligence (AI), both of which the proposed framework includes.

Online Examination Framework with Free Handwriting

Natumanya and Nabaasa (2022) identify various types of examination questions such as essays, multiple-choice, short answers, objective, mathematical, and diagrammatic questions. They observe that, in general, existing online examination frameworks support most question types but fall short when it comes to essays, diagrams, and mathematical questions due to limited marking technology, primarily relying on string match techniques.

To address this gap, Natumanya and Nabaasa (2022) developed a diagrammatic framework with free handwriting, structured around a seven-layer architecture. This architecture comprises two modules: the interface module, enabling student access to various components, and the communication module, responsible for linking all framework layers. Table 5 below outlines the proposed online examination framework with free handwriting, which is an ongoing project.

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Table 5: The different layers of the Electronic Examination Framework with Electronic Free Handwriting

Layer	Name of layer	Description
Layer 1	Interface layer	This layer displays the different categories of the users handled by the framework.
Layer 2	Authentication layer	The administrator oversees and supervises this layer, requiring registration data for both students and university educators to grant access to the framework. This layer ensures that authorised users can access other framework layers.
Layer 3	Examination setting layer	At this layer, university educators must first register on the interface layer and then authenticate themselves by entering their login credentials. Once logged in, they can create a wide range of questions, including multiple-choice, essays, objective, true/false, diagrammatic, and mathematical. Each course can have multiple question sets with specified marks for each item. Educators can select questions from this pool to generate an examination script, which can be organised into sections. Each examination paper is associated with a specific course, date, and time. Once the prerequisites are met, the university can upload the examination paper, making it accessible to students through the examination attempt layer.
Layer 4	Examination attempt layer	In this layer, students gain access to the electronic answer book, which includes the question paper for a specific course. The proctoring, timekeeping, and free handwriting modules are activated to facilitate the examination process. Monitoring is initiated to track the progress of the examination session.
Layer 5	Examination marking layer	Answer scripts are submitted to the examination attempt layer, and once the timer ends the examination session, the marking process begins. University educators mark the scripts, and scores are calculated for each question item.
Layer 6	Results layer	The results layer receives marks from the examination marking layer and attaches them to each student's examination script. Subsequently, the scripts are stored in their respective storage spaces.
Layer 7	Repository manager layer	The final layer serves as data storage for university educators and students, housing their answer booklets, reports, and marks. It hosts the framework database and supports queries and requests by university educators and students.

Natumanya and Nabaasa (2022) proposed the use of mobile devices like laptops and electronic tablets with free handwriting features for online examinations. To address security concerns like impersonation and cheating, they implemented an electronic proctor system. The proposed framework prioritises user-friendliness, replicating the experience of traditional pen-and-paper examinations through an electronic examination answer booklet designed to resemble its physical counterpart.

Fault-tolerant Online Examination Framework

Eko et al. (2022) developed a robust online examination framework for use in developing countries. It is fault-tolerant and allows concurrent online examinations across different subjects. The framework includes random assignment of MCQs from a question pool and boasts a user-friendly interface.

A standout feature is its fault tolerance, enabling examination recovery from power outages, network failures, or device issues without restarting. In case of power failure, selected responses are saved, and the timer resumes. Network failure pauses question transmission but resumes upon network restoration. Component failure allows students to switch devices with the administrator's approval.

In essence, this framework ensures uninterrupted exams despite disruptions, making it ideal for developing countries.

Framework for Unsupervised Online Examinations

Researchers like Pandey et al. (2020) introduced the "e-Parakh Unsupervised Online Examination Framework" to address concerns about invigilation during online examinations. To combat cheating and impersonation, the framework allows remote invigilation through real-time audio-visual broadcasting via mobile phones. Face recognition and secure streaming protocols are used to verify student identities and maintain examination integrity.

The process begins with student registration, following which the examination paper is loaded on their device screen. Face detection using OpenCV ensures the student's identity and a countdown timer is displayed. Students must submit their answers within the allocated time. The framework stops streaming upon submission, with recorded video available for review if needed.

Android phone hardware limitations hinder simultaneous front and rear camera use. Sapre et al. (2021) developed the AI-ML-based Smart

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Online Examination Framework, an upgrade to e-Parakh, with similar features. Examiners can create question papers in CSV/DOC format and import them into the framework. OpenCV and Dlib are employed, and certain online features are disabled to prevent cheating.

Natural Language Processing Automation Online Examination Framework

Nandini et al. (2020) proposed a Natural Language Processing framework to grade subjective online examination answers. It reduces the workload for teachers and eliminates bias and human errors in grading. Answers are stored as strings, and marks are awarded based on correctness and quality by matching them with predefined keywords. Common "Stop-Words" like "the," "a," "on," "is," and "all" are excluded from the matching process, and marks are automatically calculated by the framework. The automated grading process ensures accuracy and consistency in evaluating student responses.

Discussion

The study's primary objective was to identify and explore existing online examination frameworks. This section discusses these frameworks and their relevance to ODL institutions.

VI Online Examination Framework

Each year, ODL institutions in Namibia admit VI students who appreciate the flexibility of distance education (Firat and Bildiren, 2022). They benefit from technology-driven accessibility and supportive devices like portable magnifiers, braille material, and accessible online examination frameworks (Altinay et al., 2018; Erickson and Larwin, 2016; Uusiku et al., 2021). Despite challenges such as equipment reliability, limited material, and a shortage of educators, VI students excel in online studies and perform better compared to other modes of study (Pokhrel and Chhetri, 2021). To overcome these challenges, ODL institutions can provide assistive technologies and establish special education units (Alatheeb, 2017). Specialised technologies like text-to-speech and speech-to-text enhance accessibility.

Platforms like Moodle are used by ODL institutions for online courses and assessments, although these platforms are text-based and graphical,

posing accessibility barriers (Karipi, 2020; Armano et al., 2018). While the study identified existing online examination frameworks suitable for VI students, their applicability in Namibian ODL institutions depends on factors such as device availability, strong Internet connectivity, and incorporation of speech-to-text and text-to-speech recognition technologies into Moodle platforms (Corr, 2021). Adapting existing frameworks or designing new ones requires sufficient funding for planning, design, and piloting before full implementation (Firat and Bildiren, 2022). Despite the advantage of technology-driven accessibility, VI students may still experience challenges which include limited material, unreliable equipment, and a shortage of trained facilitators, which have the potential to impact equitable learning. In this regard, the Moodle platform fails to meet the needs of VI students while adequate funding remains a crucial element of actual adaptation and support.

Subjective Online Examination Framework

Several concerns can be raised with regard to the applicability of a subjective online examination framework for ODL students in Namibia. Subjective examinations allow for diverse student responses, calling for frameworks to analyse synonyms and keywords using syntax and WordNet (Zubairu, 2018). However, variations in answer length and language proficiency present challenges. Visually impaired students might struggle due to English being a second language for many Namibian learners (Frans, 2016). While automating subjective marking reduces educator workload, it may not be fair in the Namibian context, potentially penalising students for language limitations.

One proposed solution is an AI-centered Answer Verifier (AV) to mimic human grading (Mathew et al., 2017). However, implementing such frameworks can be costly, and some argue that manual grading provides better sensitivity, allowing educators to track student performance (Ramesh et al., 2022). Automated grading may lack parameters like content relevance, idea development, and domain knowledge (Jagadabma, 2020). The balance between human grading and automation depends on various factors.

The framework's text-to-speech and speech-to-text conversion features offer advantages to VI students (Eklavvya, 2023). However, heavy

reliance on syntax matching and the cost associated with language expert input into marking schemes are drawbacks. Labour-intensive tasks, especially in ODL institutions that rely on part-time educators, may hinder implementation.

The subjective online examination framework may raise concerns for Namibian ODL students. These include issues associated with fairness, particularly for VI students with language barriers. Moreover, auto-grading frameworks may lack sensitivity, particularly to content relevance. The subjective online framework may also be costly for Namibian institutions to implement. The manual grading framework may be more affordable, but it involves high labour intensity.

Online Examination Framework with Free Handwriting

This framework offers the option for students to write online examinations using a pen and electronic board, particularly benefiting those unfamiliar with keyboard and computer screen use (Abdel-Rahman and Mohammed, 2017). It caters to learners who are still in the early stages of computer literacy.

To ensure that students have the necessary equipment, institutions can either require them to purchase e-tablets or include the cost in student fees, providing tablets as part of annual study material. However, it is important to note that this system does not accommodate VI students or those with limb disabilities.

The framework also incorporates an electronic proctor system to address security concerns like impersonation and cheating. Its user-friendly design mimics pen-and-paper examinations through an electronic answer booklet, offering a familiar experience to students.

The online examination framework with free handwriting provides hands-on solutions for online examinations. It would benefit students with poor computer literacy and has the potential to enhance security. However, it lacks inclusivity as it fails to accommodate VI and students living with disabilities. Acquisition of e-tablets may impose financial burdens on students from disadvantaged and low-income backgrounds.

Fault-tolerant Online Examination Framework

The fault-tolerant online examination framework is likely to be suitable for ODL institutions. Sakowicz et al. (2012) developed a fault-tolerant online examination engine for primary and secondary schools in Portland, with a focus on ensuring uninterrupted examination sessions, even in the face of unreliable network conditions. This architecture allows students to resume online examinations without losing previous data, addressing issues like Internet connection loss during the examination. Such interruptions could occur due to server problems on the institution's end or issues on the student's side, such as power outages.

However, ODL students, particularly in semi-urban, rural, and remote areas, often face challenges accessing technology, including the Internet (Iilonga et al., 2020). These regions may lack electricity and reliable Internet connectivity, impeding the integration of ODL with technology (Kanwar et al., 2020). While some HEIs provide Internet access to students, it's often reported to be slow, prompting students to seek alternative means of access (Iilonga et al., 2020).

Issues such as uninterrupted examination sessions and network interruptions are effectively addressed by the fault-tolerant online examination framework. However, technological and connectivity issues remain a significant barrier for students in remote rural and semi-urban areas that limit this framework's applicability to ODL institutions.

Natural Language Processing (NLP) Automation Online Examination Framework

The NLP automation online examination framework is comparable to the subjective online examination framework. It enables educators to design online essay-type questions and uses auto-grading. The auto-grading framework is designed to identify keywords and key phrases in students' responses and equipped with predefined answers and corresponding feedback. The use of NLP plays a central role in this context.

Mah et al. (2022) emphasise that NLP is a logical approach that involves using computers to understand how humans apply, comprehend, and use language. Sailunaz et al. (2018) describe NLP as the interaction

between humans through speech and text. One of the advantages of this framework is that ODL institutions can assess students using questions that require structured answers to evaluate their knowledge application. Furthermore, Chowdhary (2020) notes that various NLP software products are available, some of which are freely accessible, while others are commercially available.

The NLP automation online examination framework enables easy questions and automatic grading using keyword identification. It increases comprehension of human language, improving assessment of subjectively written responses. However, cost remains a consideration for ODL institutions.

Conclusion

This article presented a scoping review of existing online examination frameworks applicable to ODL institutions in Namibia. The findings will assist ODL HEIs that seek to implement full-scale online examinations. The article provides guidelines on different frameworks that HEIs can adopt. It shows that ODL institutions have confronted challenges in sustaining traditional pen-and-paper examinations including the cost of printing, venue hire, and transporting examination papers to different venues. Furthermore, such examinations are time consuming and there is a risk that examination question papers could be leaked. Online examinations could alleviate many, if not all, the above-mentioned challenges. The existing online examination frameworks presented in this article could be adapted for use by ODL institutions in Namibia by analysing and discussing their applicability and potential to promote inclusivity in education. The online examination framework for VI students is useful since it may enable them to gain admission to different HEIs and obtain their desired qualifications through online examination opportunities. The latest framework for VI students was designed to allow them to write online examinations without third-party assistance as it uses speech-to-text and text-to-speech technology without requiring a keyboard. Navigation is simplified by the use of a specific voice command. In addition, students can review their responses by prompting the framework to repeat them to them and in turn, make the required amendments. This framework will enable more VI students to

be admitted to HEIs and not be limited to seeking admission to special schools that offer limited study options.

The subjective online examination framework was designed to allow students to answer essay questions. It incorporates syntax and WordNet software applications that automatically grade subjective examinations online. The student's responses can also be accessed for human grading. Visually impaired students can use this framework by building in speech-to-text and text-to-speech technology. It has the same characteristics as the NLP automation online examination framework.

The online free handwriting framework was also found to be applicable to online examinations within the ODL fraternity. It is still a work in progress and proposes maintaining an online examination environment similar to the traditional pen-and-paper examination. The framework should be tested by institutions opting to adopt it before full implementation.

The fault-tolerant framework is an innovative framework that will assist ODL institutions in implementing online examinations without the need to track students that need to retake an examination due to network or power outages.

The framework for unsupervised online examinations is also applicable because it considers the use of mobile-based applications for online examinations. Students in Namibia opt to study via distance learning due to its affordability and flexibility. They can study and generate income by being employed or engaging in income-generation activities.

Recommendations

Theoretical and practical recommendations are offered based on the literature review. One of its strengths is the different online examination frameworks identified and reviewed that will assist policymakers in selecting an appropriate framework. The review also points to areas for future research.

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Implications

Development of the Most Appropriate Online Examination Framework for Namibian ODL Institutions

This article adds to the body of knowledge in this field, thus enabling institutions to develop or adopt online examination frameworks that cater for students' different needs or develop an all-inclusive framework. It is recommended that ODL institutions develop an online examination framework that caters to all students' needs to avoid exclusion due to demographics, geographic location, income level and different abilities.

Development of an Online Examination System Architecture Based on the Framework

An online examination system should be designed from the framework. The architecture for the framework should be designed to include multiple features and functionalities to enable university educators to design online examination questions and in the same vein, to enable students to write the test. The online examination framework should include functional requirements (Weng, 2016). Institutions might need to adjust, modify, or extend their Moodle platforms to enable them to include the software needed to implement online examinations suitable for both able-bodied students and those with different forms of impairment. Azeta et al. (2022) introduced a Support Vector Machine (SVM) aimed at improving the assessment and examination quality of open-source systems such as Moodle used in ODL.

Configuring the Moodle Software

Moodle software is used by ODL institutions to conduct teaching, learning and online assessments. It will need to be configured to establish a reliable computing infrastructure. Because Moodle is open source, modifications might be problematic and costly in the long run. This could result in sub-optimal use of Moodle software due to the possible knowledge gap of the institutional Moodle technicians or the restrictions of the open-source licence. There is a need for ODL institutions to continue using an already existing system.

Customising Online Examination Questions to Test the Application of Knowledge

To implement any of these online examination frameworks in Namibia, ODL institutions should contextualise them by designing quality online examinations that aim to assess students' application of knowledge.

Availability of Resources

There is a need for ODL institutions to consider the resources at their disposal and those of their students. Institutions should not strain their resources by developing over-ambitious online examination frameworks. The framework should be user-friendly and cost-effective for all stakeholders.

Limitations of the Study

A comprehensive, collaborative search was undertaken with an experienced librarian and it was established that online examination frameworks were difficult to search. It is possible that not all relevant studies were identified because not all electronic databases were searched.

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