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An Electronic Examinations Framework with Electronic Free Handwriting

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ABSTRACT

Institutions of higher learning in developing countries are gradually embracing electronic examinations as a result of Covid-19 standard operating procedures that emphasize social distancing. However acquiring secure and acceptable electronic examinations has been a challenge as most of the available electronic examination systems are constrained by limited question types, highly reliant on keyboard typing, and lack of an electronic answer booklet. The electronic examinations framework with free handwriting presented in this paper seeks to address all the aforementioned challenges in-order to improve the usage and security of electronic examinations. To achieve the aforementioned goal, design science methodology was. Results obtained indicated that for usage and security to be eased, various parameters should be put in place i.e. user-friendly interfaces, authentication mechanisms, electronic examination setting, marking and attempt with electronic free-handwriting, electronic results, and a repository for student and lecturer data. The research output/artifact will be beneficial to Students, Lecturers and Institutional administrators.

INTRODUCTION

An electronic examination is the conduct of students' assessments and evaluations in academic institutions with the use of electronic devices like desktop computers, laptops, and mobile devices like tablets and palmtops. An electronic examination is a component of electronic learning, it's a module that was designed to conduct an assessment of students electronically. Previous studies show that electronic examinations were invented to reduce the challenges of paper-based examinations which include the high cost of conducting the examination, lack of examination flexibility, and cheating in examinations among others (Ndunagu, 2013).

Electronic examinations were meant to replace paper-based examinations and also solve their challenges; however, these examinations are currently limited by the scope of the question types that can be examined electronically (Butler-Henderson & Crawford, 2020; Das, 2021). Examination question types include multiple-choice, objectives, short answers, diagrammatic, mathematical, and essay questions. Currently, the electronic examination frameworks support all other question types apart from essay, mathematical and diagrammatic question types, this is due to the marking technics currently available with the current technology that supports string match technic for electronic marking.

Essay questions are examination questions that require an answer in lengthy paragraphs or composition and are designed purposely to test the students' deep understanding of a given phenomenon (Hillier & Fluck, 2013). In the Ugandan education setting, essay questions require students to write various pages of answers in a storyline format. Such question types are ignored in examination systems since it is hard to have them marked electronically. More so, mathematic questions also are never examined well since the student is unable to provide a working formula.

Previous research shows that there have been some attempts to design and develop frameworks for electronic examinations (Ngqondi, Maoneke, & Mauwa, 2021). A study by (Zubairu, Oyefolahan, Etuk, & Babakano, 2018) on an electronic

examination system for subjective questions proposed a framework that improved electronic marking by incorporating a semantic dictionary into the electronic examination system. However, the framework only catered to subjective questions that were mainly short answer based and didn't cater for descriptive question.

A related study by (Qureshi & Rizwan, 2015) was carried out to evaluate descriptive answers in electronic examinations, the proposed framework supports automatic setting and marking of examinations with the help of the string match algorithm for marking descriptive answers. The framework is based on a multi-tier application architecture. However, this framework doesn't cater to essay descriptive questions.

An online examination system was recently provided by (Abdallah, 2020), the system provides lecturers' with the capability to set and mark secure electronic exams. The system was based on a client-server architecture where lecturers provide an examination to the system and the system reconstructs the exam format and distributes it among the students registered for the exam. However, this system has a limited question type scope since it only caters to short answers and objective questions. Yagci & Unal (2014) provided an adaptive online examination framework that automatically generates questions randomly from the electronic question bank however an evaluation was not done to affirm the feasibility of this framework.

According to the previous studies and reviews of the field of electronic examination technologies (Kuikka, Kitola, & Laakso, 2014), (Fluck, 2019), some research gaps need to be addressed. First, most electronic examination systems were developed focusing on examining the learner's knowledge acquisition rather than the application of the knowledge acquired. This is because most of the previously designed systems commonly cater to objective, short answer, and multiple-choice questions

Secondly, others were developed with a major focus on security such as authentication limiting their completeness when deployed in a real examination environment (Fluck, Adebayo, & Abdulhamid, 2017). Some of the available electronic examination systems lack empirical development based on earlier attempts proposing a wide variety of different architectures of electronic examination systems (Alshammari, 2020). More so, the most current electronic examination systems do not support a learner from a developing country like Uganda where learners have attended an educational culture that emphasizes pen and paper with handwriting being key thus electronic examinations become challenging (Shalatska, Zotova-Sadylo, Makarenko, & Dzevytska, 2020). Hence, based on the pre-mentioned issues, the study focused on an electronic examination framework with free handwriting.

METHODS

Design science methodology was used in the design of the electronic examination framework (Dresch, Lacerda, & Antunes, 2015); the process involved 5 phases i.e. (1) Problem awareness involved the analysis and clearing understanding of the problem. This was done by the use of a literature survey where some related frameworks and algorithms involved in the electronic examination process were analyzed; (2) Suggestion to the solution which involved looking at all possible solutions and vetting/choosing the most appropriate solution to the problem. Different ideas were got from literature and different variables for examination setting, exam attempt, exam marking, and computation of marks were combined to come up with an improved easy-to-use electronic examinations framework; (3) Design of the artifact which involved designing the framework. The electronic examinations framework with free handwriting is a diagrammatic framework that was designed based on the seven-layer architecture. The framework contains the interface module which enables users to access the different components of the framework at their respective levels and a communication module that helps in linking all the layers together. Lucidchart software application (Moreira & Ferreira, 2016) was used in modeling the framework. 4. Evaluation of the framework that involved analysis of the different layers of the framework to confirm whether they can address the problem in question. 5. Conclusion phase that involved proposing recommendations for future works and improvements on the designed framework.

RESULTS AND DISCUSSION

The proposed electronic examinations framework with free handwriting consists of different components combined to provide a user-friendly and secure electronic examination platform as shown in Fig. 1 below. The framework has seven layers, and each layer has a specific task to perform. The enhanced electronic examinations framework with free handwriting is characterized by the communication functions within the examination process from the time the exam is set to results dissemination. This framework partitions the electronic examination process into seven layers and various modules under each layer. The layers are Repository management, Result, Exam marking, Exam attempt, Exam setting, Authentication, and Interface layer. Each of the layers serves a unique purpose and runs unique functionality which all aim at meeting the common goal of the electronic examination system.

Figure 1: Proposed Electronic Examination Framework with Free Handwriting

<table>
<tr><td>Interface Layer</td><td colspan="3">Students</td><td colspan="2">Lecturers</td><td colspan="2">Administrator</td></tr>
<tr><td>Authentication layer</td><td colspan="3">User Registration</td><td colspan="2">Availability and access</td><td colspan="2">Interfacing</td></tr>
<tr><td>Exam setting layer</td><td>Generate Electronic questions</td><td>Compose Electronic Paper</td><td>Paper Student Allocation</td><td>Timer Setting</td><td>Exam Upload</td><td rowspan="4">Buffering and Communication</td></tr>
<tr><td>Exam attempt layer</td><td rowspan="2">Exam Access</td><td colspan="2">Proctoration</td><td rowspan="3">Electronic Handwriting Invocation</td><td>Exam Session Monitor</td></tr>
<tr><td colspan="2">Timer activation</td><td>Script Marking</td></tr>
<tr><td>Exam marking layer</td><td>Script access</td><td colspan="2" rowspan="2">Script Identification Tracker Invocation</td><td>Marks Allocation and Computation</td></tr>
<tr><td>Timer activation</td></tr>
<tr><td>Result layer</td><td colspan="2">User categorization</td><td colspan="2">Results session Monitor</td><td>Results access and display</td><td colspan="2">Link</td></tr>
<tr><td>Repository management layer</td><td>Student & lecturer Information</td><td>Question Bank</td><td>Answer scripts</td><td colspan="4">Students' results</td></tr>
</table>

Layer 1: Interface Layer

This is the very first layer of the electronic examination framework; its role is to display the different categories of users that the framework handles.

Layer 2: Authentication layer

This layer is managed and monitored by the administrator. It mainly focuses on user registration where students and lecturers provide the necessary data to be granted access to the framework. This layer also ensures that all the other framework layers are always available and accessible to the right authorized users and also creates a communication link between users and their designated layers.

Layer 3: Exam setting layer

The Lecturer accesses this layer through the interface layer where they are required to register and enter their credentials to ensure that they are the right persons to access this layer. Once access is granted, they can generate electronic questions of various categories i.e. essay, multiple-choice, true/false, objectives, diagrammatic and mathematical. Each question is allocated marks and each course can have multiple questions preset. The lecturer then can generate an examination script by selecting questions from the pool of preset questions and this examination paper may be divided into sections depending on the lecturer's wish. The examination paper is allocated a particular course and the date and time for the exam are set. When all the requirements for the exam are

fulfilled, then the lecturer may go ahead and upload the exam which is then available for the students under the exam attempt layer.

Layer 4: Exam attempt layer

The student through the interface gets access to the exam attempt layer where he/she can access the electronic answer booklet and the question paper. The examination proctor, timer, and free handwriting modules are activated to enable the smooth running of the examination. The examination monitoring sessions is also invoked to keep track of the exam details.

Layer 5: Exam marking layer

This layer receives data information of answer scripts that were submitted by the exam attempt layer, upon reception of an answering script, the students' identification tracker, timer, and electronic free handwriting modules are invoked enabling the lecturer to start the marking process. During the marking process, marks allocation is done by the lecturer and this layer runs the marks computation functional to find the total score on each answer script.

Layer 6: Results layer

After the marking of the examination is done, this layer receives the marks attached to each answer script and sends it to the proper storage space. This layer categorizes the different types of users and gives different access privileges depending on the user type.

Layer 7: Repository Management layer

This is the last layer in the framework and its purpose is to provide storage for student and lecturers' data, examination questions and papers set, electronic answered booklets, and results or reports on students' marks. The framework database is hosted at this layer and supports various queries and requests made by the students and lecturers.

CONCLUSION

The proposed framework provides a platform for developers to design systems that cater to learners' and lecturers' needs and also improve the universities examination process through improved computation of marks, storage of students' marks and answer scripts, and security. The framework proposes the use of mobile devices like tablets and the electronic free handwriting feature to access and attempt the examination. An electronic proctor is in place to cater to security issues like cheating and a double authentication mechanism is in place to avoid cases of impersonation. The framework is entirely secure and user-friendly as the examinee gets to maintain the same examination environment as that provided by pen-on-paper examination through the use of an electronic answer booklet that is similar to the usual university answer booklet.

This paper presents an electronic examination framework with free handwriting, it's a work in progress that proposes the design and development of algorithms and an electronic examination artifact based on the above framework. There is a need to design algorithms to support the framework of the electronic examination with free handwriting. These algorithms will also enable the testing and validation of the framework to ensure that it's fully functional. Future researchers may also focus on a few other improvements to the framework like catering for the disabled system users like those with an inability to write and read, incorporating an artificial intelligent marking component.

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