JOURNAL
COMPUTER SCIENCES INSTITUTE

JCSI 34 (2025) 108–112
Received: 19 November 2024
Accepted: 13 January 2025

Design of a Non-Human Proctoring and Authentication System for Mobile Phone-Based Online Examination

Projekt systemu nadzoru i uwierzytelniania bez udziału człowieka dla egzaminów online przeprowadzanych za pomocą telefonów komórkowych

Brendan Ubochi[a]*, Emmanuel Oluleye[b], Charity Odeyemi[b], Chinyere Ubochi[c]

[a] *Department of Electrical and Electronic Engineering, School of Engineering and Engineering Technology, The Federal University of Technology, Akure, Ondo State, Nigeria.*
[b] *Department of Computer Engineering, School of Engineering and Engineering Technology, The Federal University of Technology, Akure, Nigeria.*
[c] *Department of Computer Science, Faculty of Physical Sciences, Imo State University, Owerri, Imo State, Nigeria*

Abstract

Proctored computer-based examinations present challenges that are associated with high operational costs, logistical difficulties, and scalability limitations. While mobile phone applications have emerged as a solution for overcoming the challenges posed with maintaining extensive computer laboratories for assessments, persistent security concerns and fraud in non-proctored examinations remain. In this work, a specialized fraud-resistant mobile phone application is developed for conducting tests and examinations. It leverages on the Flutter framework in order to ensure compatibility with both iOS and Android devices. By disabling screenshots, activating a lockdown mode and using a random user authentication prompt, the developed software can be used to combat cheating and impersonation during an examination. The results indicate that the mobile application can effectively detect and prevent cheating attempts, employing a lockdown mode that automatically submits examination upon detection of irregularities.

Keywords: Mobile Application; Proctoring; Assessment

Streszczenie

Nadzorowane egzaminy komputerowe stwarzają wyzwania związane z wysokimi kosztami operacyjnymi, trudnościami logistycznymi i ograniczeniami skalowalności. W tej pracy opracowano specjalistyczną, odporną na oszustwa aplikację na telefon komórkowy do przeprowadzania testów i egzaminów. Wykorzystuje ona framework Flutter, aby zapewnić zgodność zarówno z urządzeniami iOS, jak i Android. Poprzez wyłączenie zrzutów ekranu, aktywowanie trybu blokady i użycie losowego monitu uwierzytelnienia użytkownika, opracowane oprogramowanie może być używane do zwalczania oszustw i podszywania się podczas egzaminu. Wyniki wskazują, że aplikacja mobilna może skutecznie wykrywać i zapobiegać próbom oszustw, wykorzystując tryb blokady, który automatycznie przesyła egzamin po wykryciu nieprawidłowości.

Słowa kluczowe: Aplikacja mobilna; Nadzór; Ocena

*Corresponding author
Email address: bcubochi@futa.edu.ng (B. Ubochi)

1. Introduction

The increased popularity, processing power and enhanced storage in smart mobile phones have enabled the development of mobile phone software for diverse applications such as in health, education, environment monitoring and agriculture [1-3]. In today's rapidly evolving educational landscape, mobile phone applications have proven to be effective as a learning and evaluation aid as well as a tool for assessments, thus, overcoming the scalability and efficiency challenges of the traditional computer-based assessments [4]. Computer-based assessments offer several advantages over traditional paper-based testing methods that include an improved efficiency and convenience for the administrators and test-takers, a capability to administer examinations remotely and in real time, and increased options for examination design among others. However, it is limited by a high physical infrastructure installation costs, capacity limitations, security and connectivity issues, all of which can be significant factors in resource-scarce environments.

The ubiquity of smartphones and tablets has led to the development of mobile-based applications for assessments, offering flexibility and accessibility to learners. These applications leverage the power of mobile devices to deliver interactive learning experiences and streamline the assessment process [4]. Due to the prevalence of smart phone technology with current estimates at nearly 4.5 billion users in 2024 [5] and the increasing demand for flexible assessment methods, there is a need for the development of a mobile phone application specifically tailored to computer-based tests and examinations. While some of the earlier mobile learning systems have been designed to improve the learning experience of students, others were incapable of providing adequate proctoring and therefore were unsuitable for online examinations.

Online examinations could be classified into (i) non-proctored examinations where a number of control measures are put in place to thwart examination cheating in the absence of a proctor (ii) remotely proctored examinations which include recorded examinations using electronic devices, and (iii) proctored examinations which are conducted in the presence of a proctor and can be expensive [6-8]. This study falls under the category of non-human proctored online examination. The developed system combines authentication and a real-time supervision by using a facial scan in the case of an IOS device and a password in the case of an android device, disabling screenshots and activating a lockdown mode during the examination. The developed mobile application (MA) is compatible with both Android and IOS devices and includes security features to guarantee the integrity of the assessment.

This paper is organized into five sections. Section 1 introduces the study. Section 2 reviews related literature while section 3 shows the system methodology. Section 4 presents the results and discussion and section 5 concludes the paper.

2. Related Works

Recent studies have shown that based on self-reported experiences, students consider mobile-based assessments to be a more attractive and novel approach compared to computer-based assessments [9]. Also, incorporating mobile phone applications as a teaching/learning aid has been found to improve the learning outcomes [10, 11]. It was identified in [12] that perceived ease of use, perceived usefulness and behavioural intention to use are major predictors of the longer use of mobile-based formative assessment systems. When utilized for examinations, mobile based applications require more stringent functional requirements. Vulnerabilities that may undermine the security of a mobile online examination include inadequate authentication which can lead to impersonation, unattended exam for proctored examination, exchange of mobile devices during the examination, information sharing over the network, and network failure [13]. The SAFE system developed by [14] which has been deployed in large scale competitive examinations, offers a range of options for managing different examination question types, achieving simplicity in setup, fraud-free examinations, robustness, and scalability. However, the developed system is suitable for use only in a proctored classroom environment. A continuous authentication system for android mobile application was developed in [15] by continuously taking random photos of the students during the examination. The developed system uses a biometric authentication method since biometric authentication provides more security against impersonation than knowledge-based and possession-based authentication methods. In [7], a video recording-based proctoring mobile application was developed for post-COVID-19 online examinations and utilized a user experience questionnaire plus to evaluate the user experience when users are recorded during examinations. Although their findings show that the users generally have a positive experience with their developed mobile application, this system can incur additional cost due to the personnel employed to review the recordings and the cost due to the bandwidth requirement. In the developed mobile application for online assessments, anti-cheating features such as anti-screenshot and randomized question sequence were included [16]. However, the application was not designed for remote proctoring and does not disable other actions such as copy and paste.

In the proposed system, a random authentication scheme is used during the examination requiring a password access for android users and a fingerprint for iOS users. Also, the application disables screenshots, implements a lockdown mode when the examination commences and flags application minimization as a cheating attempt. These security features are implemented in addition to the restricted access control that is embedded in firebase to prevent fraud and access to the software by unauthorized users.

3. Methodology

Based on the user requirements, functional specifications, and technical constraints, the conceptual vision for the mobile application is translated into tangible user interface designs, wireframes, and prototypes. User interface designs are created with intuitive and user-friendly interfaces that prioritize ease of navigation, accessibility, and visual appeal. The Agile software Development Life Cycle mode was selected as the most suitable approach for the mobile development. Fig. 1 shows the activity chart which illustrates the sequences of activities a user undergoes when using the application.

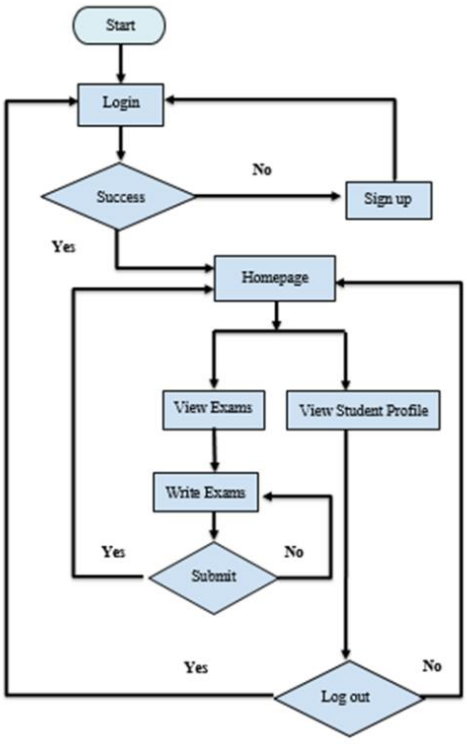

Figure 1: An activity diagram for the mobile application.

Fig. 2 is the use case diagram which shows in detail the application's users and their interactions with the application. It illustrates the access that students and admin have on the application. The student can login, view scheduled exams as well as take an exam or test. On the other hand, the admin has higher access control than the student which includes privileges such as view of results, checking students information, manage database etc.

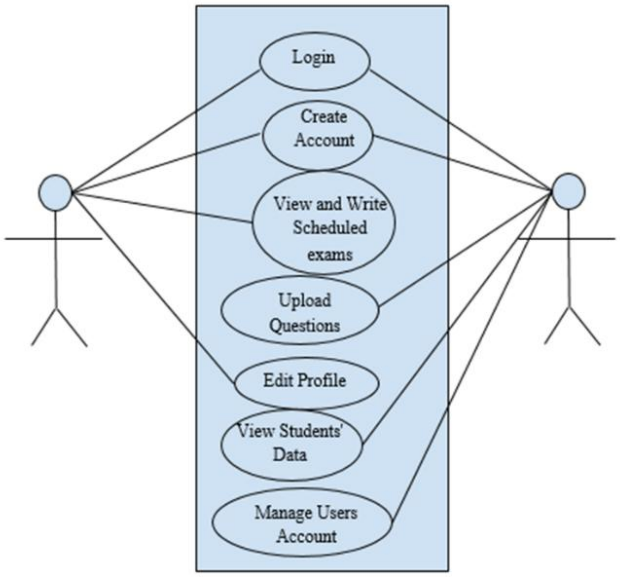

Figure 2: A use case diagram showing the student (left) and admin (right) access privileges.

The mobile application was built using Flutter (dart programming language); the backend was built using firebase services while Getx was implemented to serve as a state manager in the mobile application. The development tools encompassed a wide array of software applications, platforms and utilities throughout the software development lifecycle. These tools assist in coding, testing, debugging, and optimizing the application. Figs. 3 and 4 show the home screen and examination screen user interfaces of the developed mobile application.

A variety of testing techniques, including unit testing, integration testing, regression testing, and user acceptance testing were employed to identify and address software defects, functional inconsistencies, and usability issues. Automated testing frameworks and tools were utilized to streamline the testing process and improve test coverage. Test results and feedback were meticulously documented and tracked using issue tracking systems, such as Jira or Trello.

Figure 3: An image displaying the home screen user interface displaying the user's progress.

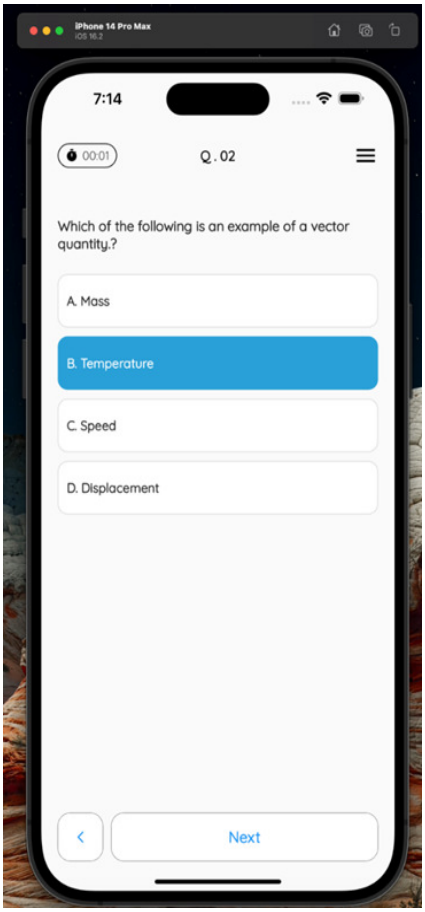

Figure 4: An image showing the exam screen user interface as well as a timer for the exam.

4. Results and Discussion

The mobile application installation package size and the installed application size on both Android and iOS are large. The file size of the mobile CBT application, after downloading the .aab file from vscode to an Android device, is reported to be 51.46 megabytes (MB), while for the IOS ipa file for app is 60.4 megabytes (MB). This is shown in Table 1. The application size could be reduced by a further optimization of the code, removing redundancies and unused functions.

Table 1: Application package sizes for different operating systems

Operating System	App size (installer) (MB)	Size on disk (MB)
Android	51.46	61.72
IOS	60.40	N/A

The start-up time, obtained from the firebase performance application dashboard, on both Android and IOS devices took about 11.14 seconds to load up to the splash screen. One of the major contributors to start-up time is the initialization of the Flutter engine. This process involves loading the Dart runtime, Flutter framework, and essential components, influencing the time taken for the application to become fully operational. Asset loading, another factor influencing start-up time, plays a significant role in applications that involve the retrieval and rendering of assets such as images and fonts. The time taken to load and display these assets contributes to the overall perception of the app's responsiveness during start-up. The recorded application response time at the time of testing was 1.42 seconds. This is variable and depends on the network connectivity of the user. According to google firebase firestore documentations, a free quota account has limits to the requests, document write and read access along with their usages [17]. There are rate limits placed on the total amount of functions an app using firebase can consume.

The capacity of a mobile application is pivotal, and it depicts its ability to handle diverse usage scenarios ranging from individual user interactions to concurrent engagements with multiple users. According to google firebase integrating an application with their backend services accounts can either be created as anonymous or registered [18]. The number of anonymous users account has a limit of 100 million while that of registered users is unlimited. For the mobile CBT application, each account is created as a registered user which gives the app an unlimited capacity in terms of users' registration. The integration of Firebase allowed for real-time updates, providing users with dynamic content and ensuring data consistency between the app and the backend.

Beside the embedded access restrictions in Firebase to secure the data and application from malicious users, the implemented security features include screenshot prevention, lockdown mode, submit mode and random authentication requests. Using the Flutter framework, the developed application disables screenshot during the examination thereby curtailing unauthorized distribution of the content of the examination and uphold the confidentiality of the assessment. The lockdown mode feature ensures that the app is entirely on lockdown mode as soon as the exam begins. In order to prevent cheating, a submit mode is triggered whenever the user minimizes the app, the application flags this as cheating and automatically submits the user's work on return to the app. In order to prevent impersonation, the CBT mobile application has facial recognition integrated for IOS users and passwords for Android users. To begin the exam, a facial scan is required in the case of an IOS device while that of an Android requires a password. A continuous authentication is performed at random intervals during the course of the exam in order to prevent impersonation.

A user feedback was achieved by means of an online survey that used a 5-point Likert scale to respond to five questions provided in Table 2. The survey was conducted without a prior training on the use of the mobile application and users were allowed to download and give their assessments. 17 students participated in the survey and the evaluation results are given in Fig. 5. The results indicate that about 50% of the students would prefer using the developed mobile application for examinations to computer based examinations (Q1) with only about 30% disagreeing. This result is consistent with the findings in [9, 10] which suggests an enhanced user experience with mobile phone application based assessments. While nearly 60% of the students agree that using the application could potentially improve the evaluation process (Q3) which agrees with the results in [13] following a similar survey, only 40% of the students think that the security features are adequate for examination (Q5). The developed mobile-based examination application generally received positive opinions and suggest that the use of the application would be favourably received if widely deployed for examinations.

Table 2: User Survey

Question No.	Question text
1	I would prefer using the MA for conducting an examination over a computer-based examination.
2	Using the MA would be helpful in conducting exams.
3	Using the MA would greatly improve the evaluation process
4	The MA's user interface is friendly and easy to use.
5	The MA's security features are active and sufficient for an examination.

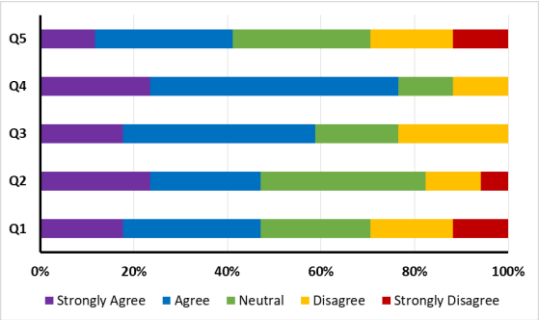

Figure 5: Students' evaluation of the developed application.

5. Conclusions

This study has presented the development of a non-human remote proctoring and authentication system for mobile-phone-based online examination. The software integrates Flutter, Firebase, and GetX which improves its responsiveness and real-time capabilities. The measured response time is 1.42 seconds, which can be influenced by network connectivity. The application is designed to be scalable and its security features include facial recognition, password authentication, and restricted application access, enabling a secure assessment environment. The evaluation of the developed application was carried out by means of a survey and the results indicate that it is easy to use even without a prior training and provides a secure tool for remote mobile phone-based examinations. Future work will focus on iterative improvements based on user feedback and emerging technologies to further enhance its functionality and user experience.

References

[1] M. Kamal, T. A. Bablu, Mobile applications empowering smallholder farmers: an analysis of the impact on agricultural development, International Journal of Social Analytics 8(6) (2023) 36-52, https://norislab.com/index.php/ijsa/article/view/24

[2] J. L. Chong, K. W. Chew, A. P. Peter, H. Y. Ting, P. L. Show, Internet of things (IoT)-based environmental monitoring and control system for home-based mushroom cultivation, Biosensors 13(1) (2023) 98, https://doi.org/10.3390/bios13010098

[3] A. D. Samala, M. Amanda, Immersive Learning Experience Design (ILXD): Augmented Reality Mobile Application for Placing and Interacting with 3D Learning Objects in Engineering Education, International Journal of Interactive Mobile Technologies 17(5) (2023) 22-35, https://doi.org/10.3991/ijim.v17i05.37067

[4] K. Butler-Henderson, J. Crawford, A systematic review of online examinations: A pedagogical innovation for scalable authentication and integrity, Computers and Education 159 (2020) 104024, https://doi.org/10.1016/j.compedu.2020.104024

[5] J. Degenhard, Number of smartphone users worldwide 2014-2029, [Infographic], Statista (2024). [19.11.2024]. https://www.statista.com/forecasts/1143723/smartphone-users-in-the-world

[6] G. R. Cluskey, C. R. Ehlen, M. H. Raiborn, Thwarting Online Exam Cheating Without Proctor Supervision, Journal of Academic and Business Ethics 4 (2011) 1-7, https:// www.aabri.com/manuscripts/11775.pdf

[7] B. Setiaji, M. Hayaty, A. Setyanto, H. B. Santoso, Assessing User Experience of a Secure Mobile Exam Application Using UEQ+, International Conference on Information and Communication Technology (2020) 246-251, https://doi.org/10.1109/ICOIACT50329.2020.9332091

[8] F. Noorbehbahani, A. Mohammadi, M. Aminazadeh, A Systematic Review of Research on Cheating in Online Exams from 2010 to 2021, Education and Information Technologies 27 (2022) 8413-8460, https://doi.org/10.1007/s10639-022-10927-7

[9] S. A. Nikou, A. A. Economides, A Comparative study between a computer-based and a mobile-based assessment: usability and user experience, Interactive Technology and Smart Education 16 (4) (2019) 381-391, https://doi.org/10.1108/ITSE-01-2019-0003

[10] S. Becker, P. Klein, A Gößling, J. Kuhn, Using mobile devices to enhance inquiry-based learning processes, Learning and Instruction 69 (2020) 101350, https://doi.org/10.1016/j.learninstruc.2020.101350

[11] M. Huang, Empowering oral proficiency in a large-scale class: video-recorded oral presentations and mobile-assisted peer assessment in a Chinese Middle School, Computer Assisted Language Learning (2024) 1-21, https://doi.org/10.1080/09588221.2024.2382851

[12] J. Bacca-Acosta,C. Avila-Garzon, Student engagement with mobile based assessment systems: A survival analysis, 37 (1) (2021) 158-171, https://doi.org/10.1111/jcal.12475

[13] M. Kaiiali, A. Ozkaya, H. Altun, H. Haddad, M. Alier, Designing a Secure Exam Management System (SEMS) for M-Learning Environments, IEEE Transactions on Learning Technologies 9 (3) (2016) 258-271, https://doi.org/10.1111/jcal.12475

[14] K. Chebrolu, B. Rama, V. C. Dommeti, A. V. Boddu, K. Zacharia, A. Babu, P. Chandan, SAFE: Smart Authenticated Fast Exams for Student Evaluation in Classrooms, Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education, (2017) 117-122, https://doi.org/10.1145/3017680.3017754

[15] S. Aisyah, Y. Bandung, L. B. Subekti, Development of Continuous Authentication System on Android-Based Online Exam Application, In 2018 International Conference on Information Technology Systems and Innovation (ICITSI), Bandung, Indonesia, (2018) 171-176, https://doi.org/10.1109/ICITSI.2018.8695954

[16] W. N. N. W. Osman, N. H. Ab Rahman, EdQuizy: Development of a Quiz Mobile Application with Anti-Cheating Features, Applied Information Technology and Computer Science 4 (1) (2023) 168-184, https://doi.org/10.30880/aitcs.2023.04.01.011

[17] Google, https://firebase.google.com/docs/firestore/quotas, [19.11.2024].

[18] M. Firebase Authentication Limits, https://firebase.google.com/docs/auth/limits, [19.11.2024].