

A Proposed Mobile-Based and Secured Attendance Recording System Using Quick Response Codes

Mohammed Abdalla Osman Mukhtar^{1*}, Mohamed H. Sayed², Osman Adam Osman Abdrahman¹, Marwan Ismail Mohammed Idres¹, Majdi Yuosif Hamdalseed Baballa¹

¹ Department of Information Systems/Faculty of Computer Science and Information Tech., Alzaiem Alazhari University/Khartoum Bahri, Khartoum, 1331, SUDAN

² Joaan Bin Jasim, Academy for Defence Studies, Doha, QATAR

*Corresponding Author: mohammedabdalla@aaau.edu.sd

DOI: <https://doi.org/10.30880/jastec.2024.01.02.001>

Article Info

Received: 8 April 2024

Accepted: 24 September 2024

Available online: 12 November 2024

Keywords

Mobile-based and secured system, quick response (QR) codes, attendance recording system, flutter, DART

Abstract

Cell phones are essential to our daily lives in the current technological era. These days, most issues can be quickly and efficiently resolved with smartphones. An array of social media, business, problem-solving, educational, and marketing apps have simplified and eased everyone's life. Conversely, Quick Response (QR) codes have a straightforward appearance but can hold a large amount of data, which can be used in the information security process. However much information they may contain, the user should be able to rapidly and securely access information by scanning the QR code. In most human-controlled companies or academic institutions, gathering attendance information is time-consuming, repetitive, and crucial. Every day, the same process is used to take attendance. However, the attendance records at many universities in Sudan are not automated. It requires a lot of time to accomplish it. This research tries to automate the process of attendance recording using mobile devices and the QR technique. The resulting system will be an automated mobile-based attendance system, which can contribute to securing data to save the rights of either human labour or students and to increase the efficiency of the attendance process. This will help lecturers save time and spend more on academic activities with their students instead of wasting time managing attendance records.

1. Introduction

Getting student attendance from university instructors during each class is time-consuming, especially when classes are large. However, some faculty policies require this task to be performed by the instructor in each lecture. In other words, out of the total hours assigned to a given course, typically twenty hours per semester, up to one hour and a half may be taken to perform this process, which usually takes around ten minutes per lecture. The proposed solution offers a QR code for the students to scan via a specific smartphone application. The code and the student identity taken by the application will confirm the student's attendance. In this way, the system will save not only time but also effort that was supposed to be put in by instructors during each lecture. It will speed up taking attendance using an accurate and secure approach. Hence, it will leave much more time for the lecturer to be given to his students properly.

The popularity of smartphones has increased over the years [1]. This has the potential to transform and accelerate the university attendance process. The manual student involved in the existing manual attendance method takes time. Instructors will allow students to sign the attendance record. After that, he or she will log in to the university's site to note every class's attendance. The professors' valuable time will be wasted on this. Additionally, when paper attendance records are converted to digital ones, human error will be introduced, which is difficult to prevent when students receive their attendance sheets [2].

In higher education institutions, recording students' attendance is laborious and ineffective. The enormous class size makes the process more difficult to oversee. Controlling absenteeism is considerably more difficult. Lecturers must enter attendance sheet information into a web-based system after every class. The entire procedure of processing attendance is taking up lecturers' valuable time.

Notwithstanding all the issues above, universities continue to record students' attendance by having their students sign attendance sheets. Furthermore, many papers are being wasted and printed, and these documents could be lost or damaged by academics. The inability of the current system to perform all the procedures necessary to complete the administrative chores resulted in a delay in the preparation of reports for the college administration.

QR codes will be used in this study to streamline and facilitate the attendance recording procedure. In addition, at the same time, it will secure important data and private information from any risk [3]. What makes QR codes unique? This subject will be addressed in the literature, but to start, let's say that QR codes are two-dimensional matrix barcodes employed to make digital smartphone content easily accessible. [4]. Japanese automatic data capture equipment manufacturer Denso Wave, a TOYOTA subsidiary, developed it. [5] Denso-Wave developed QR codes in 1994 to monitor automotive parts during production.

The rest of the paper explains the related works. The research methodology is described in section 3. The resulting system, security implementation, and functional testing follow this. Section 7 gives the conclusion.

2. Literature and Related Works

The QR code is a matrix code comprising several black and white squares placed in a grid pattern that are technically specified as modules. Its primary purpose in design and development was to create an easily read and comprehended symbol [4]. As an example, it can be referred to in Fig. 1.



Fig. 1 Example of QR code

Every module encrypts information. The maximum character count for traditional codes (bar codes) is 20. In contrast, QR codes can represent 7,089 numeric characters in addition to 4,296 alphanumeric characters, 2,953 binary bytes, 1,817 Kanji characters, or a combination. This makes QR codes significantly more and extensive than bar codes and other 2D codes like PDF417, Data Matrix, and Maxi Code [6]. A detailed comparison of these various 2D code types may be found in Table 1.

Information security must change to accommodate new technology and ways to use it. For security experts, new technologies bring opportunities as well as challenges. New gadgets, like smartphones, or new ways to share information can provide challenges. The utilization of Quick Response (QR) codes is one such quickly developing interface technique [7].

2.1 Related Works

The issue of documenting attendance in academic institutions can be resolved in several ways, including using magnetic cards, facial recognition software, electronic fingerprint systems, and other methods. Table 2 presents a comparative analysis of these methodologies. Among these options, the QR code is regarded as the most effective technology for completing the attendance-taking procedure since it offers a cheap initial

implementation cost and uses resources that all students already possess—thanks to smartphones. Notably, Secure QR Code (SQRC) technology can be used to keep information secured and hidden [8].

Table 1 Comparison between different 3D types of codes

	 QR code	 PDF417	 Data Matrix
Density	High density	High density	High density
Character Set	Full ASCII	Full ASCII	Full ASCII
Maximum Capacity	<ol style="list-style-type: none"> Numeric: 7089 Alphanumeric characters: 4296 Bytes: 2953 	<ol style="list-style-type: none"> Numeric: 2710 Alphanumeric characters: 1850 Bytes: 1108 	<ol style="list-style-type: none"> Numeric: 3116 Alphanumeric characters: 2335 Bytes: 1556
Error Detection & Correction	QR codes use the Reed-Solomon algorithm, which enables the code to be read even if up to 30% of it is damaged [9]	PDF417 barcodes use the Reed-Solomon algorithm, which enables the code to be read even if up to 50% of it is damaged [10]	Data Matrix code ECC 200 symbolizes use the Reed-Solomon algorithm for error detection and correction; ECC 000-140 uses convolutional error correction[11]
Usage Scenarios	<ol style="list-style-type: none"> online or app payments augmented reality mobile operating systems website login loyalty programs virtual stores marketing and advertising campaigns 	<ol style="list-style-type: none"> boarding passes driver licenses identification cards postal packages 	<ol style="list-style-type: none"> direct parts marking electronics product packaging posters pill bottles

In comparing identity verification techniques presented in Table 2, the methods include traditional/manual, Bluetooth, facial recognition, biometric systems, QR codes, and card readers. Each technique differs in cost, ease of implementation, scalability, and effectiveness in securing attendance systems.

- **Traditional/Manual Methods** involve simple attendance records, but they are time-consuming, prone to human error, and offer low data integrity
- **Bluetooth-based Systems** automatically register attendance within a coverage area but are prone to medium errors and require students to have smartphones with Bluetooth enabled
- **Facial Recognition Systems** offer higher accuracy but require prior facial scans and expensive equipment, making them costly to implement.
- **Biometric Systems**, such as fingerprint scanners, are highly accurate and secure but have high infrastructure costs.
- **QR Code Systems** provide a balanced solution with medium infrastructure costs, high data integrity, and scalability. This method requires students to scan a QR code displayed in the classroom, reducing time and preventing attendance manipulation.
- **Card Readers** are like QR code systems but need physical student ID cards. The infrastructure costs and ease of faking attendance are moderate.

Overall, QR codes and Bluetooth-based systems offer the best balance between cost, ease of use, and scalability for educational institutions.

Table 2 Comparison between different identity verification techniques

Features	Traditional or Manual	Bluetooth	Facial Recognition	Biometric	QR Code	Card Reader
Description	Nothing (just a record of students) [12]	Automatically register attendance when within the Bluetooth coverage area [13][14]	Requires prior Scanning of every face [15]	Requires prior Scanning of every fingerprint [16]	Required students to scan QR code that displayed in the class [17]	Required students to scan their student ID on card readers [18]
Infrastructure Cost	Low	Medium	High	High	Medium	Medium
Required equipment	Need Physical File or MS Excel Sheet	Smartphone with Bluetooth turned on	Installed Cameras	Installed Fingerprint scanner	Smartphone	Student ID, card reader
Easy to fake attendance	Very Tedious	Medium	Quite Easy	Quite Easy	Medium	Medium
Scalability	Very Difficult	-	Very Difficult	Very Difficult	Grows with you	-
Usage (based on number of persons)	One person at a time	-	One person at a time	One person at a time	Multiple people at a time	-
Data Integrity	Low	-	High	High	High	-
Process Time	4-5 seconds per student	-	2-3 seconds per student	2-3 seconds per student	Same time for 'n' number of students	-

In the modern world, it can be difficult to secure and conceal private information. A person may suffer a significant loss from the forgery of confidential information due to a lack of security and confidentiality. Personal and confidential information must be securely shared, concealed from the intended recipient, and able to be authenticated by the recipient. More and more people are sharing data using QR codes for various purposes. The high data capacity of the QR code makes it significant in information communication. However, encryption is rarely used and the majority of QR code systems in use today use unsafe data formats [19].

Because two-dimensional barcodes have a significant increase in information capacity, they are widely used in many different fields. Thus, the QR-code-based user authentication system is made possible. Thus, the widespread adoption of smart devices has encouraged the spread of authentication systems using QR codes [20].

3. Research Methodology

3.1 General Description

Students can use their smartphones to scan a QR code provided by the suggested solution. The identity from the smartphone will be used to verify attendance. In addition to saving time and effort, this will reduce needless paper use during recording attendance. The suggested method uses multi-factor authentication to detect fraudulent attendance registrations.

Three modules comprise the solution: a web module, a backend service module, and a mobile module. The backend service module has already generated the QR code displayed by the web module. To stop cheating, the QR code will show for ten seconds. This can prevent students from scanning the QR code while they are not in class. Students can verify their attendance by scanning a QR code with the mobile module. After that, the backend service module receives the validation request. The backend service module will update the attendance records database once the attendance is confirmed.

Compared to the traditional method, the attendance recording process should take less than five minutes. The processes used to build the suggested approach are described in Fig. 2, along with how the three modules can work together to finish the academic attendance tracking process.

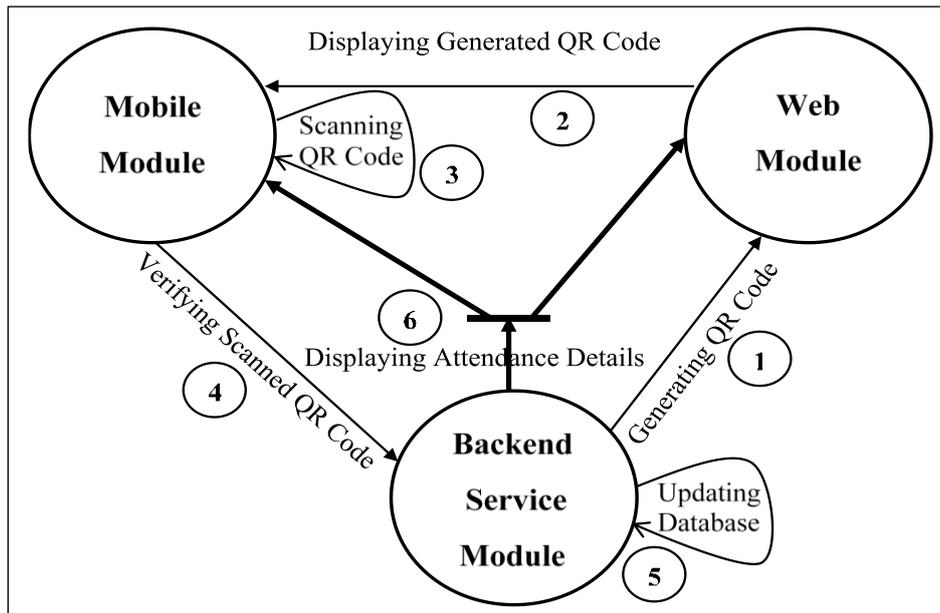


Fig. 2 Interaction of the system's modules

3.2 Development Tools

This section discusses tools and integrated development environment (IDE) services, programming languages, frameworks, and databases.

3.2.1 Tools and IDEs

3.2.1.1 Flutter

Flutter is essentially an SDK for designing smartphone applications focusing on user interfaces (UIs). It is programmed for the back end using the Dart programming language. Making Flutter a useful tool for rapidly and effectively developing applications was one of the main priorities during development. It is also thought to be a perfect option for businesses or developers that wish to quickly and cheaply reach people on the Android and ISO platforms [21][22].

3.2.1.2 Android Studio

Built on top of JetBrains' IntelliJ IDEA software and intended exclusively for Android development, Android Studio is Google's Android operating system's official integrated development environment (IDE). In 2020, it has been offered as a subscription-based service or for downloading for Linux, macOS, and Windows operating systems. It serves as the primary IDE for developing native Android applications in place of the Eclipse Android Development Tools (E-ADT) [23][24].

3.2.2 Services

3.2.2.1 Firebase

Google has offered Firebase as a suite of backend cloud computing services and platforms for developing applications. It supports various apps, including JavaScript, Node.js, Android, iOS, PHP, C++, Unity, and Java. It also hosts databases, services, authentication, and integration. Firebase is a platform for online and mobile development. It provides a range of services appropriate for web and mobile development [25][26][27].

3.2.3 Programming Languages

3.2.3.1 Back End

I. HyperText Processor (PHP)

PHP is a scripting server programming language that may create dynamic, interactive websites. PHP is a popular, cost-free, and adequate substitute for competitors like Microsoft's ASP [28].

II. DART

Dart is a programming language for web, Android, and iOS apps. Google developed it and targets web and mobile application developers. One of the Dart language's objectives is to work on all sophisticated web browsers, mobile devices, and even web servers. The ability to develop an application and publish it on Android and iPhone devices without having to rewrite it in another language is what sets this language apart [29][30].

III. Unified Modeling Language (UML)

UML is a standardized modelling language composed of an integrated collection of diagrams that helps system and software engineers define, visualize, build, and record the artefacts of software systems, business modelling, and other non-software systems. The UML is a collection of cutting-edge engineering methods effectively representing complex and large systems. UML is essential to both the software development process and the production of object-oriented software. Graphical notations mainly express software project design in the UML. With UML, project teams can discuss, look into potential designs, and assess the architectural design of the software [31][32].

3.2.3.2 Front End

I. HyperText Markup Language (HTML)

Hypertext Markup Language is the standard document markup language for web browser display. In addition, it can conveniently be written and manipulated in a text editor [33].

II. Cascading Style Sheets (CSS)

CSS is a style sheet language used to specify how a document produced in an HTML should appear in browsers. As an essential element of the World Wide Web, CSS is used in conjunction with HTML and JavaScript [34].

III. Java Script

JavaScript is a programming language that complies with the ECMAScript specification (JS). JavaScript is multi-paradigm, high-level, and frequently compiled just in time. It has many features, just like first-class functions, prototype-based object orientation, dynamic typing, and curly bracket syntax [35].

3.2.4 Databases

3.2.4.1 Firebase Database

Data recorded as JSON (JavaScript Object Notation)¹ is kept in a real-time database called Firebase, a cloud-hosted database. It gives clients direct access to a secure back-end database so they may create sophisticated collaborative apps. End users get a responsive experience because the data is stored locally on the device while offline and real-time events continue. The real-time background database will immediately synchronize with the local data updates made while the client was offline and merge any conflicts when the device connects back to the Internet [25][26][27].

3.2.5 Platforms

The system consists of two platforms: a web platform and a mobile platform. The web platform is used by/for lecturers, while the mobile platform is used and accessed by the students.

4. Resulted System

In this section, the system results will be explained only by some interface generated after running the system modules (Web, Mobile, or Backend Service) in the corresponding platform, whether it is a web platform or a mobile platform.

4.1 Web Module

Fig. 3 represents the main screen for the system managers, where the user chooses to log in as a *Teacher* or an *Admin*; by pressing the Teacher button, the Teacher login screen will open, while if the Admin option has been chosen, Fig. 4 will be displayed.

¹ JSON is a lightweight format for storing and transporting data. JSON is often used when data is sent from a server to a web page. JSON is "self-describing" and easy to understand.

The admin can manage the system by adding the details for the new teacher, adding new courses for a specific semester, assigning a group of students to a particular course, or deleting any details from the system like teacher, student, course, or semester. The critical task for the Teacher on his screen is to generate the QR code for the current lecture by specifying the subject code, as you can see in Fig. 5.

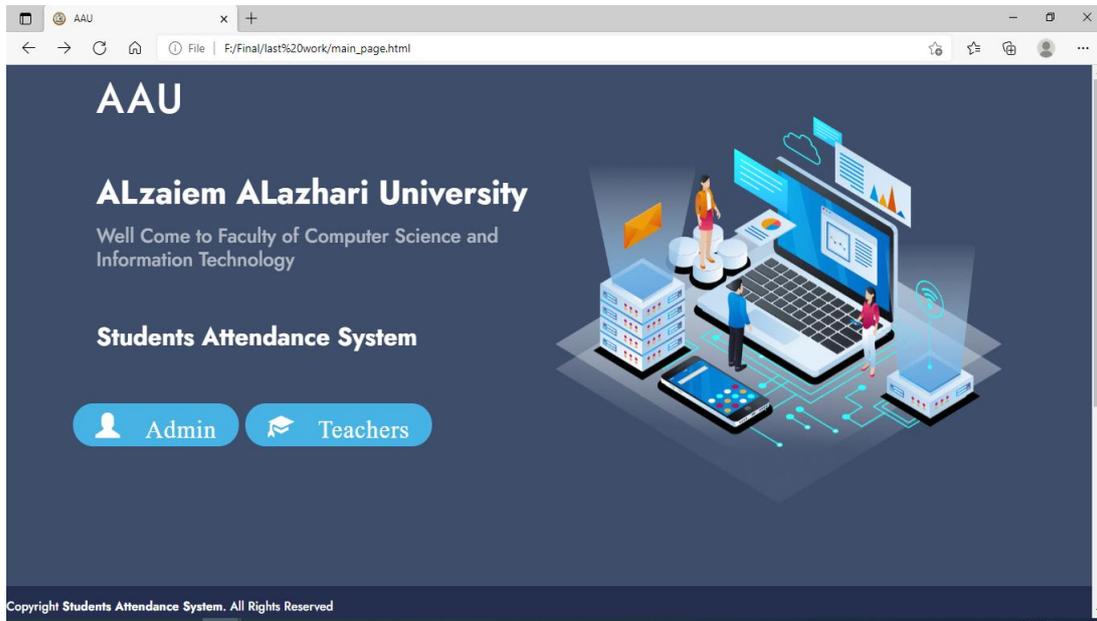


Fig. 3 The main screen for the generated system

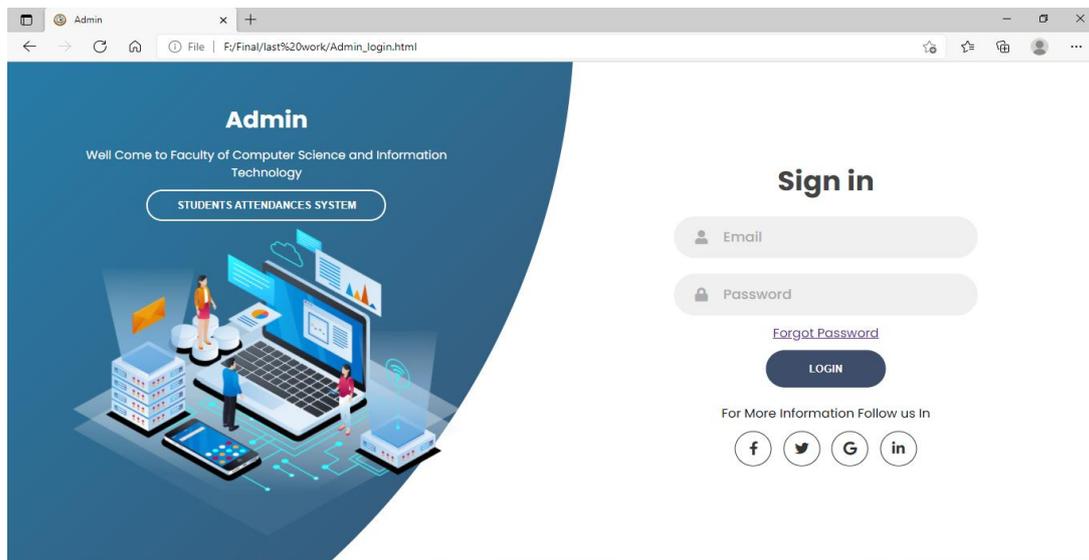


Fig. 4 The screen for entering the admin authority

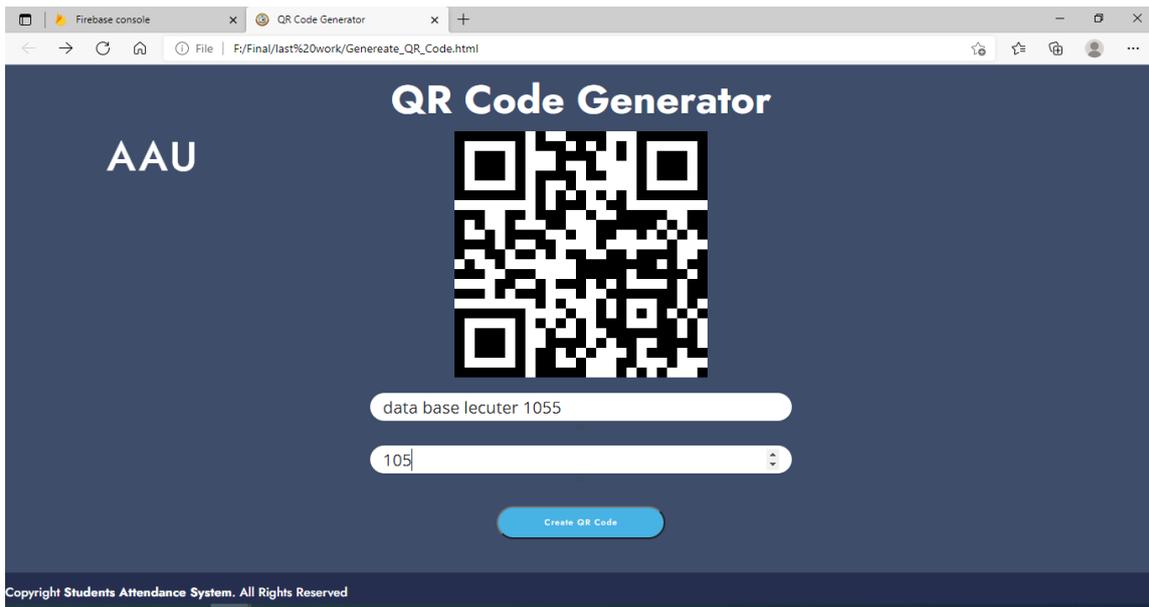


Fig. 5 Generating QR code for specific lecture before displaying to the targeted students

4.2 Mobile Module

As mentioned before, this part is dedicated to the lecture’s attendees (students). Hence, all related screens should be displayed on the student’s devices (Mobiles, Notebooks ... etc.). Fig. 6 (a) is the main screen that enables students to record their attendance, while Fig. 6 (b) displays the main screen for a specific student.

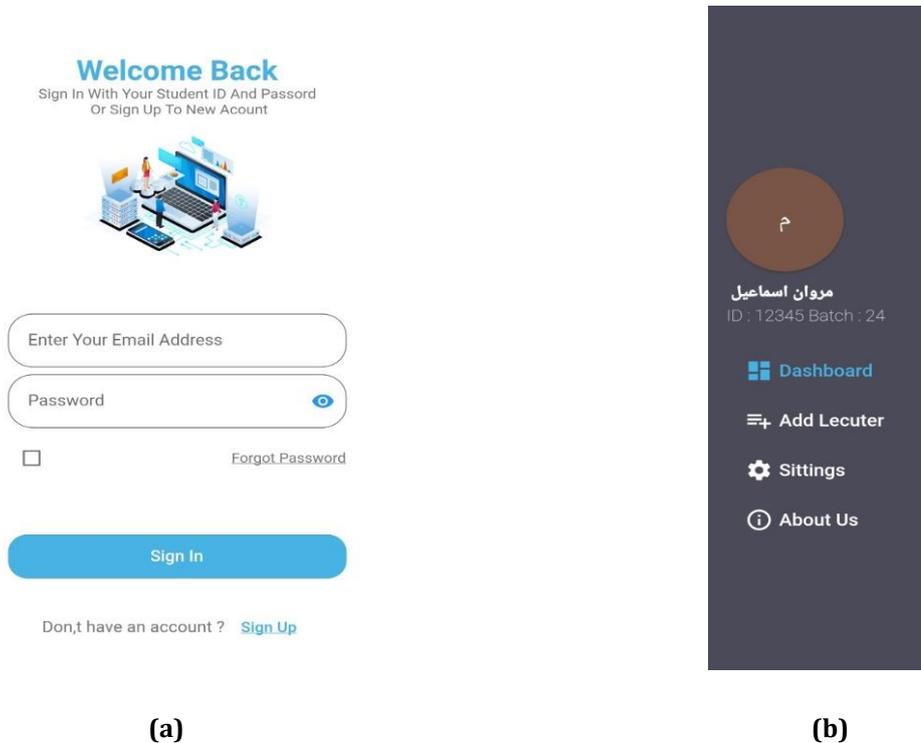


Fig. 6 (a) Main screen for all students; (b) Main screen for specific student

4.3 Backend Module

In this section, some screens will display querying or calculating data results. As shown in Fig. 7, much information is displayed to a named student. This information includes the teacher's name, course name, the date and time that the attendance was taken, and several lectures attended by that student for a specific teacher.

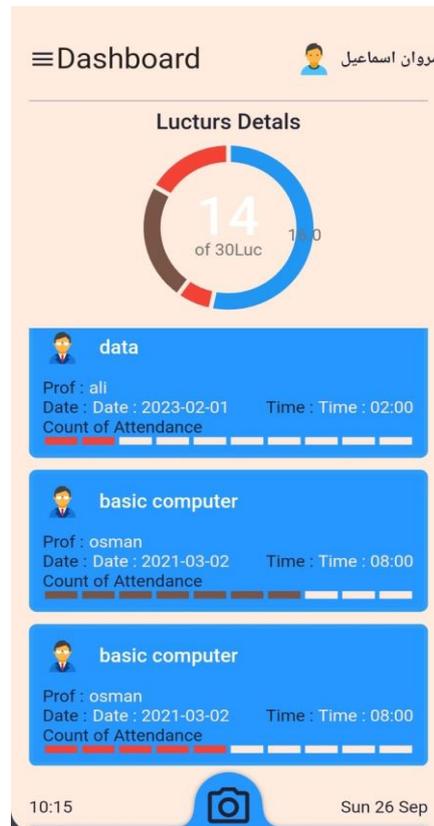


Fig. 7 Displaying of many details for specific student

5. Security Implementation

The researchers applied security to the proposed attendance recording system by incorporating several key features to safeguard user data and system integrity. First, encryption methods were employed to protect the data contained within the QR codes, ensuring that sensitive information, such as student identities, could not be decoded or tampered with during transmission. This step was crucial, as QR codes can store significant amounts of information that, if compromised, could lead to unauthorized access. Additionally, the system utilized time-limited QR codes that would refresh automatically after a short duration, preventing users from reusing or sharing codes outside of the classroom setting. This effectively mitigated the risk of fraudulent attendance.

Furthermore, multi-factor authentication was integrated to verify both the QR code scan and the student's identity, enhancing the system's security by adding another layer of verification. Secure communication protocols between the mobile application, server, and database ensured that data was transmitted and stored securely, adhering to privacy regulations. These security measures were applied to protect the integrity of attendance records and prevent unauthorized access, ensuring the system remained robust and reliable for academic use.

6. Testing of System Functionality

To evaluate the effectiveness and functionality of the proposed mobile-based attendance recording system using Quick Response (QR) codes, a systematic testing process was conducted. The testing was aimed at ensuring the system's reliability, security, and usability across multiple dimensions. The key phases of the testing process included:

6.1 Unit Testing

Each system module was tested individually, such as QR code generation, scanning, and attendance recording. Unit tests were written to ensure that each function performed as expected. This involved generating QR codes based on unique identifiers (e.g., student ID) and verifying that the QR codes could be scanned accurately and consistently on different mobile devices. The correctness of the data stored in the backend database was also verified to ensure proper attendance tracking.

6.2 Integration Testing

After successfully validating the individual components, integration testing was conducted to assess how different modules interacted with one another. This stage tested the entire flow of attendance recording, from generating a QR code on the mobile device to scanning it via the system's interface and recording attendance in the database. Special attention was given to ensuring the accuracy of data transmission between the mobile app and the server.

6.3 Functional Testing

Functional testing was conducted to confirm that the system met its core requirements. This included:

- Verifying students could quickly scan their QR codes and record their attendance.
- Ensuring the system accurately differentiates between legitimate and illegitimate QR codes, with immediate error notifications for invalid scans.
- Testing generating and updating QR codes for different users and classes in real-time.

6.4 Security Testing

Since security was a primary concern in this system, comprehensive security testing was performed. This included:

- Testing the encryption of QR code data to ensure that sensitive information could not be easily decoded.
- Simulating potential attack scenarios, such as unauthorized access or QR code duplication, to validate the system's defence mechanisms.
- Ensuring the system adhered to data privacy standards by securing personal and attendance data during storage and transmission.

6.5 User Acceptance Testing

Finally, user acceptance testing was conducted with a small group of students and faculty to validate the user experience and ensure that the system was easy to use. Feedback from users was collected and analyzed to identify any usability issues or potential improvements in the system's design. This phase helped ensure that the system was user-friendly, efficient, and intuitive.

7. Conclusion

Attendance recording with a QR code is the cheapest, most secure, and most adaptable option among the other solutions. It does not require infrastructure changes to adapt. With the popularity of smartphones and internet accessibility, it can be widely used in universities. With the automatically refreshed QR code, cheating on attendance has become even more difficult. In addition, it eliminates a lot of lecturers' effort in managing students' attendance records in a safe and secure environment.

The tedious method of taking attendance will be eliminated by digitizing the procedure amongst all colleges. The university has low-cost, automated, and effective alternatives. As a result, teachers and students will find the management system that has been designed and put into place with QR codes to be much more comfortable and user-friendly, improving their ability to save time and energy.

The overall time structure of the lectures and the ability to be recognized as digital technology adopters are two benefits that QR codes will provide to the users. The project will eventually encompass a tremendous amount of work to integrate it into a learning management system and create a comprehensive experience for the university.

References

- [1] X. Carbonell, A. Chamarro, U. Oberst, B. Rodrigo, and M. Prades, "Problematic Use of the Internet and Smartphones in University Students: 2006 – 2017," *International journal of environmental research and public health*, vol. 15, no. 3, p. 475, 2018, doi: 10.3390/ijerph15030475.
- [2] A. Nuhi, A. Memeti, F. Imeri, and B. Cico, "Smart Attendance System using QR Code," in *9th Mediterranean*

- Conference on Embedded Computing (MECO)*, 2020, pp. 1–4. doi: 10.1109/MECO49872.2020.9134225.
- [3] A. Sankara Narayanan, "QR Codes and Security Solutions," *International Journal of Computer Science and Telecommunications*, vol. 3, no. 7, pp. 1–14, 2012, [Online]. Available: <https://blog.nasm.org/sports-performance/the-value-of-vo2-health-measure-or-performance-marker%0Ahttp://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.467.9840&rep=rep1&type=pdf%0Ahttps://www.jcalc.net/motor-torque-calculator>
- [4] Z. Deineko, N. Kraievska, and V. Lyashenko, "QR Code as an Element of Educational Activity," *International Journal of Academic Information Systems Research*, vol. 6, no. 4, pp. 26–31, 2022, [Online]. Available: <https://openarchive.nure.ua/server/api/core/bitstreams/5586f25b-10c6-43e2-9181-406d315bd5ab/content>
- [5] M. AHMED and A. ALAM, "QR Codes Awareness from a Developing Country Perspective," *International Review of Management and Business Research*, vol. 6, no. 4, pp. 1366–1371, 2017, [Online]. Available: https://www.researchgate.net/profile/Aftab-Alam-21/publication/321904679_QR_Codes_Awareness_from_a_Developing_Country_Perspective/links/5a38aeb0458515919e7251d8/QR-Codes-Awareness-from-a-Developing-Country-Perspective.pdf
- [6] S. Yakub and K. A. F, "Student Identity Card Based On Advanced Quick Response Code Technology. Computing, Information Systems," *Development Informatics & Allied Research Journal*, vol. 7, no. 4, pp. 149–158, 2016, [Online]. Available: www.cisdijournal.net
- [7] N. Thompson and K. Lee, "Journal of Digital Forensics , Security and Law," *Information Security Challenge of QR Codes*, vol. 8, no. 2, p. 2, 2013, doi: 10.15394/jdfsl.2013.1143.
- [8] M. S. Ahamed and H. Asiful Mustafa, "A Secure QR Code System for Sharing Personal Confidential Information," in *5th International Conference on Computer, Communication, Chemical, Materials and Electronic Engineering, IC4ME2 2019*, 2019, pp. 1–4. doi: 10.1109/IC4ME247184.2019.9036521.
- [9] R. Hendry, M. N. A. Rahman, and A. H. Seyal, "Smart Attendance System Applying QR Code," in *12th International Conference on Latest Trends in Engineering and Technology (ICLTET'2017)*, Kuala Lumpur, MALAYSIA, 2017, pp. 1–5. doi: 10.15242/iie.e0517002.
- [10] J. Gao;, V. Kulkarni;, H. Ranavat;, L. Chang;, and H. Mei;, "A 2D Barcode-Based Mobile Payment System," in *Third International Conference on Multimedia and Ubiquitous Engineering*, China, 2009, pp. 320–329. doi: 10.1109/MUE.2009.62.
- [11] M. R. Ghunawat;, "Data Encoding and Decoding Using Data Matrix," *Open Access International Journal of Science & Engineering (OAIJSE)*, vol. 1, no. 1, pp. 1–6, 2016, [Online]. Available: https://www.researchgate.net/publication/320187484_DATA_ENCODING_AND_DECODING_USING_DATA_MATRIX
- [12] Z. H. Arif, N. Salih Ali, N. A. Zakaria, and M. N. Al-Mhiqani, "Attendance Management System for Educational Sector: Critical Review," *International Journal of Computer Science and Mobile Computing*, vol. 7, no. 8, pp. 60–66, 2018, [Online]. Available: https://d1wqtxts1xzle7.cloudfront.net/57185204/V718201814-libre.pdf?1534252523=&response-content-disposition=inline%3B+filename%3DAttendance_Management_System_for_Educati.pdf&Expires=1691566092&Signature=QplBH12LwS1gUhQLQhjZslfPqjwwr4x7Cj2SPzBXllQG84qldf
- [13] A. Puckdeevongs, N. K. . Tripathi, A. Witayangkurn, and P. Saengudomlert, "Classroom Attendance Systems Based on Bluetooth Low Energy Indoor Positioning Technology for Smart Campus," *MDPI - Information*, vol. 11, no. 6, p. 329, 2020, doi: 10.3390/info11060329.
- [14] B. Zorić, M. Dudjak, D. Bajer, and G. Martinović, "Design and development of a smart attendance management system with Bluetooth low energy beacons," in *2019 Zooming Innovation in Consumer Technologies Conference (ZINC). IEEE*, 2019, pp. 86–91. doi: 10.1109/ZINC.2019.8769433.
- [15] Pamith Madusanka Kumara, Mehrdad Tahmasebi, and Devika Sethu, "Automatic Attendance Recording System Using Facial Recognition," *Malaysian Journal of Science and Advanced Technology*, vol. 1, no. 2, pp. 68–71, 2021, doi: 10.56532/mjsat.v1i2.12.
- [16] Maurizfa; and T. Adiono;, "Smart Attendance Recording Device Based on Fingerprint Identification," *International Journal of Computer Science Engineering (IJCSE)*, vol. 10, no. 1, pp. 1–4, 2021, doi: 10.1109/ISESD53023.2021.9501823.
- [17] K. Alagasan;, M. H. Alkawaz;, A. I. Hajamydeen;, and M. N. Mohammed;, "A Review Paper on Advanced Attendance and Monitoring Systems," in *IEEE 12th Control and System Graduate Research Colloquium (ICSGRC)*, Shah Alam, Malaysia, 2021, pp. 195–200. doi: 10.1109/ICSGRC53186.2021.9515249.
- [18] I. G. Sujana Eka Putra, A. Lee, I. M. Tirta Mahayana, and I. G. Agung Wicaksono Dharmayasa, "Design and Development Of Lecturer Attendance System Using Radio Frequency Identification (RFID)," *International Journal of Computer Science Engineering*, vol. 10, no. 1, pp. 15–27, 2021, doi: 10.21817/ijcsenet/2021/v10i1/211001010.
- [19] M. S. Ahamed and H. Asiful Mustafa, "A Secure QR Code System for Sharing Personal Confidential Information," *5th International Conference on Computer, Communication, Chemical, Materials and Electronic*

- Engineering, IC4ME2 2019*, no. July 2019, 2019, doi: 10.1109/IC4ME247184.2019.9036521.
- [20] S. Sung, J. Lee, J. Kim, J. Mun, and D. Won, "Security Analysis of Mobile Authentication Using QR-Codes," in *Computer Science & Information Technology-Computer Science Conference*, 2015, pp. 151–160. doi: 10.5121/csit.2015.51612.
- [21] R. Payne, *Beginning App Development with Flutter Create Cross-Platform Mobile Apps*. Dallas, USA: Apress Berkeley, CA, 2019. doi: 10.1007/978-1-4842-5181-2.
- [22] M. Olsson, "A Comparison of Performance and Looks Between Flutter and Native Applications: When to prefer Flutter over native in mobile application development," Blekinge Institute of Technology, 2020. [Online]. Available: <http://urn.kb.se/resolve?urn=urn:nbn:se:bth-19712>
- [23] H. Ted, *Android Studio IDE Quick Reference: A Pocket Guide to Android Studio Development*. Apress Berkeley, CA, 2019.
- [24] H. Ted, "Android Studio IDE. In: Learn Android Studio 4," in *Android Studio IDE Quick Reference: A Pocket Guide to Android Studio Development*, Apress Berkeley, CA, 2020.
- [25] R. A. Murti;, A. F. A. Putri;, B. A. Putra;, S. Salsabilla;, A. Akrabullah;, and Sujito;, "Android-Based Dam Management and Monitoring System: Wireless Communication using Google Firebase," in *7th International Conference on Electrical, Electronics and Information Engineering (ICEEIE)*, Malang, Indonesia, 2021, pp. 351–354. doi: 10.1109/ICEEIE52663.2021.9616787.
- [26] U. Bharti;, D. Bajaj;, Tulika;, P. Budhiraja;, M. Juyal;, and S. Baral, "Android Based e-Voting Mobile App Using Google Firebase as BaaS," in *Sustainable Communication Networks and Application; Part of the Lecture Notes on Data Engineering and Communications Technologies book series (LNDECT, volume 39)*, 2020.
- [27] T. Ahmed;, A. T. BinNuruddin;, A. BinLatif;, S. S. Arnob;, and R. Rahman;, "A Real-Time Controlled Closed Loop IoT Based Home Surveillance System for Android using Firebase," in *IEEE 6th International Conference on Control, Automation and Robotics (ICCAR)*, Singapore, 2020, pp. 601–606. doi: 10.1109/ICCAR49639.2020.9108016.
- [28] M. I. N. Saroni and B. Mulyanti, "Hypertext Preprocessor Framework in the Development of Web Applications," *IOP Conference Series: Materials Science and Engineering*, vol. 830, no. 2, pp. 8–12, 2020, doi: 10.1088/1757-899X/830/2/022096.
- [29] B. A. P. Candra and R. Ahmad, "Design and Development of Automotive Workshop Application Based on Android and IOS Using Dart Programming Language," *Journal of Physics: Conference Series*, vol. 1539, no. 1, p. 012016, 2020, doi: 10.1088/1742-6596/1539/1/012016.
- [30] A. M. Hassan, "JAVA and DART programming languages: Conceptual comparison," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 17, no. 2, pp. 845–849, 2019, doi: 10.11591/ijeecs.v17.i2.pp845-849.
- [31] R. . Oberhauser, "VR-UML: The Unified Modeling Language in Virtual Reality – An Immersive Modeling Experience," In: *Shishkov, B. (eds) Business Modeling and Software Design. BMSD 2021. Lecture Notes in Business Information Processing*, vol. 422, no. Springer, Cham, 2021, doi: https://doi.org/10.1007/978-3-030-79976-2_3.
- [32] G. Rumbaugh, J. Jacobson, I., & Booch, *The Unified Modeling Language Reference Manual*. 2021. [Online]. Available: [http://debracollege.dspaces.org/bitstream/123456789/404/1/UML Reference Manual by James Rumbaugh.pdf](http://debracollege.dspaces.org/bitstream/123456789/404/1/UML%20Reference%20Manual%20by%20James%20Rumbaugh.pdf)
- [33] D. K. Ahmad, A. Ahmad, M. F. Ahmad, M. N. Ahmad, and A. S. Ahmad, "An Experiment of Animation Development in Hypertext Preprocessor (PHP) and Hypertext Markup Language (HTML)," *International Journal of Scientific Research in Computer Science and Engineering*, vol. 8, no. 2, pp. 45–51, 2020, [Online]. Available: <https://www.researchgate.net/publication/341165905>
- [34] S. Casteleyn, I. Garrig'os, and J.-N. Maz'on, "Ten Years of Rich Internet Applications: A Systematic Mapping Study, and Beyond," *ACM Transactions on the Web (TWEB)*, vol. 8, no. 3, pp. 18:1–18:46, 2014, doi: 10.1145/2626369.
- [35] M. F. Sohan and A. Basalamah, "A Systematic Literature Review and Quality Analysis of Javascript Malware Detection," *IEEE Access*, vol. 8. Institute of Electrical and Electronics Engineers Inc., pp. 190539–190552, 2020. doi: 10.1109/ACCESS.2020.3031690.