Decryption of Attendance Monitoring of Senior High School Students at ACTEC Using Zebra Crossing Algorithm

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Abstract

This study focused on developing an attendance monitoring system for senior high school students at Asian Caregiving and Technology Education Centers, Inc. (ACTEC) using the Zebra Crossing (ZXing) algorithm to enhance efficiency and data security. The application functioned as an online platform where teachers could monitor attendance through QR codes, addressing the manual method's inefficiencies, which are time-consuming and prone to record-keeping errors. By implementing a two-layered security feature, including a verification code and location-based access, the system enhanced data protection, reducing the risk of attendance manipulation by unauthorized individuals or students attempting to falsely log attendance remotely. The results indicated that the new system improved attendance reliability and integrity by allowing only authorized, on-site students to log attendance, with immediate implications for improved record accuracy, administrative efficiency, and secure data handling. Moreover, these measures safeguarded against potential security breaches and unauthorized access, which are critical as educational institutions increasingly adopt digital systems. Thus, this study suggests that integrating multi-layered security with QR code technology could serve as a model for similar attendance monitoring systems, ultimately contributing to a more trustworthy, cost-effective, and streamlined educational management process.

Keywords*:* attendance monitoring, decryption, encryption, QR Code, ZXing algorithm

1. Introduction

In monitoring school attendance, the existing system relies on calling student names and using paper sheets, which is time-consuming and prone to errors affecting attendance accuracy and grade calculations. Without robust security,

students can fake attendance by listing absent classmates, or even by scanning QR codes remotely, which undermines the integrity of the attendance record. QR codes are often vulnerable because any scanner can decrypt them without additional safeguards, making the system susceptible to unauthorized access and data breaches. The manual process is labor-intensive for administrators and incurs paper costs. Digitizing attendance tracking not only aims to streamline the workflow but also reduces the need for paper, supporting sustainability efforts and reducing operational expenses. Attendance monitoring using QR code technology has been a great help to schools and other organizations, such that it can save time from recording many people at campus (Galgo, 2020). Maleriado and Carreon (2019) believe that the system is extremely acceptable owing to its reliability, efficiency, accuracy, and use. Researchers are also very concerned about its security and confidentiality. In Rivera and Lagarteja's (2020) study, it is said that the design program, in which the student has a barcode indicated on the IDs, improved student attendance. Hence, student attendance is efficient because it lowers the dropout rate and increases performance ratings. In addition, it also implements an SMS notification for the parents to inform them about the child.

This study aimed to develop and evaluate a QR code-based attendance monitoring system for senior high school students at ACTEC using the Zebra Crossing (ZXing) algorithm. The system addressed inefficiencies in traditional manual attendance processes and enhanced data security by implementing dual-layered protection mechanisms: verification codes and geolocation.

2. Methodology

This research sought to develop an application that would assist the teachers and administrators of ACET, as well as other teachers and administrators in schools. This study is about the integration of two-layered securities in the application using the zebra crossing algorithm. The method of developing the application was based on two views: user view, which was the mobile application used by students, teachers, and administrators, and firebase, which can only be viewed by administrators in web. Also, two accounts should be created: student and instructor. The first phase was the encryption procedure, which entailed encoding topic details using the subject code as the verification code, a location pin for where the QR code should decode during attendance

recording, and other subject details. Subject code and location pin were the two layers of security that keep the encoded data, which is now known as encrypted data, secure (other term: generated). The second phase was the decryption procedure, which was assigned to students and entails decrypting (or scanning) the encrypted QR code.

The researchers employed the ZXing technique to encrypt and decrypt QR codes. Moreover, any chart was utilized to analyze the student's present, absent, and late attendance. The following were the methodology's specifics:

Using the android studio java programming language, researchers created a mobile application that incorporated the ZXing algorithm, which was used to encrypt and decrypt the QR code. The reverse geocoder class in android studio employed the approach of turning a coordinate's (latitude, longitude) value into a (incomplete) address.

The study employed a quantitative research design that involved collecting data through questionnaires and interviews to evaluate the usability, security, and user experience of the attendance monitoring system based on the ZXing algorithm. A purposive sampling method was chosen to target individuals who would interact directly with the attendance monitoring system. By including both end-users (students) and administrators (teachers and employees), the study captured a range of perspectives on the system's functionality and usability. Ethical considerations were carefully addressed to protect participants' rights and privacy: all participants were briefed on the study's purpose, their role, and the voluntary nature of their participation. Consent was obtained before data collection. Given the sensitivity of attendance data and user identity, the study ensured that all data were anonymized. Identifying information was excluded from the dataset to protect the participants' identities and was securely stored following the guidelines of the Data Privacy Act (Republic Act No. 10173., 2012). To ensure that the questionnaires provided reliable and accurate data, several validity mechanisms were employed. The questionnaires were developed based on the study's objectives and were reviewed by two experts in the field to ensure alignment with the research goals. The questions were designed to measure user perceptions, security effectiveness, and the usability of the attendance system. To maintain consistency in responses, a five-point Likert scale was used to measure respondents' level of agreement with each statement, allowing for standardized responses across participants and minimizing response bias.

2.1 Data Encryption

Figure 1 shows that the plain data is generated using the Zxing algorithm with a hash function. This generates a QR code, a machine-readable code made up of a grid of black and white squares. The generated data is encrypted by the sender's (admin) unique keys to the specific class.

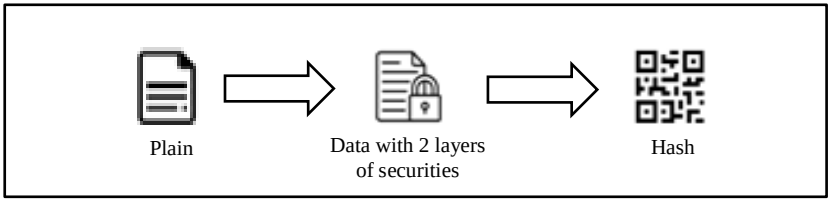


Figure 1. The encrypting phase of plain data with two layered securities to QR Code

2.2 Data Decryption

Figure 2 shows that if the first security breaks, it will proceed to identification and verification of location.

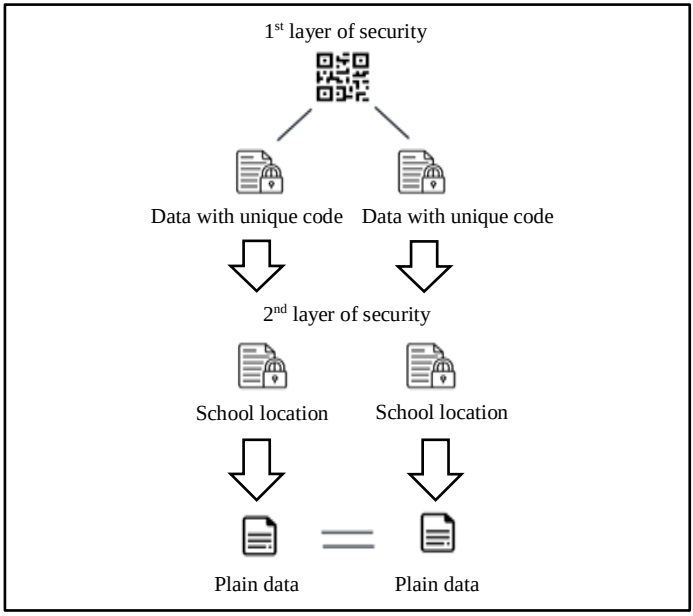


Figure 2. The decrypting phase of plain data with two layered securities in terms of unique code and location verification to QR code

If the receiver is not in the scope of the location of the school, then the receiver is absent. Therefore, if two variables do not match each other, then the receiver

will not get attendance. If the plain data of the sender and receiver match, the receiver will get attendance

2.3 Flowchart

The system flowchart in Figure 3 illustrates the start of the process and user authentication for student and admin log-ins.

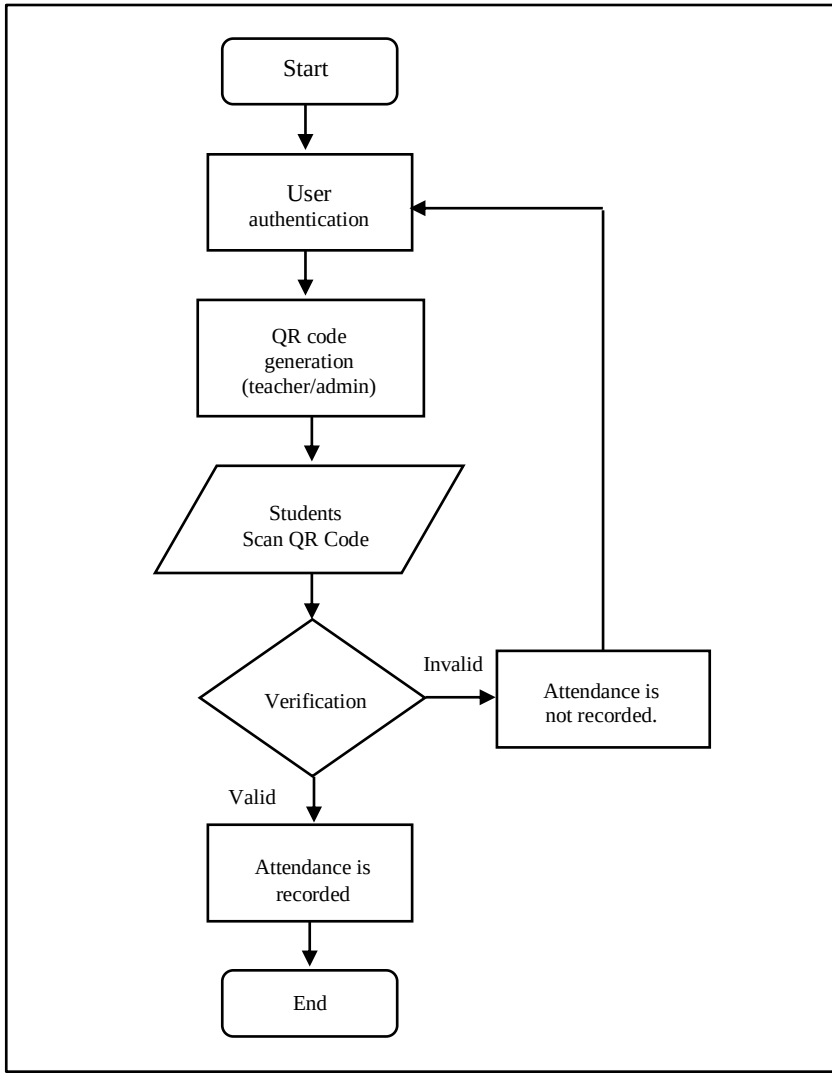


Figure 3. System flowchart

The teacher/admin generates a QR code with specific details, and then the students scan the QR code. For the verification process, the system verifies the subject code and location. If both are correct, attendance is recorded, if either is incorrect, attendance is not recorded. If the verification succeeds, the system displays attendance status.

2.4 Functional Requirements

Table 1 shows the admin functional requirements for the ZXing and application.

Table 1. Admin functional requirements

Admin		
No.	ZXing algorithm	Description
1	Generate QR Code that applies first security: subject code	The first security is the subject code that the specific class has only access to. Admin will provide each subject code for sections.
2	Encrypt a QR Code that applies second security: location identification of school	The second security is the school location to match the student location.
3	Modifiable data to contain in QR code	Input subject details including subject code, subject name, professor name, subject day and time, semester, and terms and conditions of the app.
4	Adding	Add students under the profile of the teachers and its subject held.

Table 2 shows the six teacher functional requirements for the application.

Table 2. Teacher functional requirements

Teacher		
No	Application	Description
1	Create date	If the day of class has come, the teacher should create a date to allow students to scan the QR Code.
2	List of sections	It views the section and its subject.
3	Subject report	The pie graph is visualized according to the number of three attendance statuses. Filtering date, and a total of students scanned are seen here.
4	List of students	It views the students that have already scanned the QR code.
5	Student report	Each student on the list gets a report that will visualize the percentage of the attendance statuses. Every scan of the QR code is counted in total.
6	View data	The list of students who scans the QR code. Also, it will be known if students are not scanned the QR yet by getting an absent status. The teacher approves that te student is absent by clicking the button.

Tables 3 and 4 show the students' three functional and eight non-functional requirements for ZXing algorithm, respectively.

Table 3. Student functional requirements

	Student	
No.	ZXing algorithm	Description
1	Allow the camera in the device to scan the QR code.	If first time installing the app, allow the camera of the device to scan.
2	Input a subject code upon the window panel called verification code.	Different subject code is only accessible to the sections. It serves as the password of each section to get verification.
3	The scanner identifies the location of a student.	The location of the student is matched with the location of the school. If the two locations do not match, the student will not be allowed to record their attendance.

Table 4. Non-functional requirements for ZXing algorithm

No.	Non-functional requirements of zebra crossing algorithm	Non-functional requirements category
1	An application can run on all Android devices except iOs devices.	Operational
2	The application should be available 24 h a day, 365 days a year.	Performance, availability
3	The application must support multiple users per day.	Performance
4	A subject code security that QR code contains.	Security
5	Location security to verify if the student's location matches the school location	Security
6	Data privacy will be held by Google Firebase as the database of the application and the admin is the only one to access it.	Security, reliability, and data integrity
7	The data should automatically be updated as every student scans the QR Code.	Performance
8	Application of two-layered securities in QR Code.	Data integrity

2.5 Sample Size

Table 5 shows the total of 42 respondents were purposely selected as responses to the survey from senior high school in ACET. The sample size for the study was determined through the respondents' experience, relevance to the study, and technical background.

Table 5. Types of respondents

Respondents	Population	Sample size
Teacher	14	6
Employee	10	6
Student	80	30
Total	104	42

2.6 Statistical Treatment

The following statistical tools were used in the interpretation of the results according to sub-problems. The study employed descriptive (frequency, weighted mean, ranking, and percentage).

Table 6 shows the descriptive interpretation of evaluation in Likert Scale. The Likert scale was interpreted as "5" strongly agree, "4" as agree, "3" minimally agree, "2" as disagree, and "1" as strongly disagree.

Table 6. Likert's Scale to evaluate the result and its descriptive interpretation

Scale	Range	Verbal interpretation
5	4.50-5.00	Strongly agree (SA)
4	3.50-4.49	Agree (A)
3	2.50-3.49	Undecided (U)
2	1.50-2.49	Disagree (D)
1	1.00-1.49	Strongly disagree (SDA)

3. Results and Discussion

3.1 Distribution of Respondents According to Type

Table 7 shows the distribution of respondents as to their type.

Table 7. Distribution of respondents as to their type

Type of respondents	Frequency	Percentage
Employee	6	14.3
Student	30	71.4
Teacher	6	14.3

It was revealed that there were 6 (14.3%) employee respondents, 30 (71.4%) student respondents, and 6 (14.3%) teacher respondents. This implied that the majority of the respondents were students.

3.2 Assessment

Table 8 establishes the assessment of respondents when grouped to the questions about decryption of attendance monitoring using ZXing algorithm. It was shown that the respondents agreed that the QR code's authenticity ensured data privacy (WM = 4.43), security could prevent students from cheating the attendance (WM = 4.36), the data visualization for updating the student's status was analyzable (WM= 4.31), and the function of QR codes could be improved with the assistance of the ZXing algorithm (WM = 4.31). Furthermore, the respondents agreed that the reliability of SMS notifications can make it easy to receive their warning that they reached the limitation (WM = 4.29), the user interface enabled pleasing and satisfying interaction for the user (WM = 4.29), and the application was able to provide functions that meet the stated and implied needs (WM = 4.29).

Moreover, the respondents agreed that they recognize the integrity of the application (WM = 4.24), agreed on the efficiency of two-layered security (WM = 4.19), and agreed that. It maintained the privacy of data encrypted in QR codes (WM = 4.19).

The study's results indicated that the QR-based attendance system using the ZXing algorithm improved the efficiency and accuracy of attendance monitoring. This finding is consistent with research by Yazid *et al.* (2019), who found that QR-based systems enable faster data processing and reduce human errors inherent in traditional attendance methods. QR code technology also streamlines the attendance process, allowing teachers and administrators to quickly confirm student presence without manual roll calls, which was described as one of the key advantages of QR code technology in educational institutions (Jathar *et al*., 2019). The system implemented at ACTEC aligns with these advantages by providing an automated and accurate record of student attendance, thereby reinforcing its value in educational contexts where accuracy and time efficiency are essential for effective classroom management. The study revealed high levels of satisfaction among students and teachers due to the simplicity and ease of use of the QR code system. This aligns with the findings by Stupina *et al.* (2021), who note that intuitive and user-friendly interfaces are essential for the successful adoption of educational technology. When technology in education is perceived as simple and effective, users are more likely to engage with it, as usability minimizes frustration and improves overall experience (Mishra *et al*., 2021).

Table 8. Assessment of respondents when grouped according to the questions about the decryption of attendance monitoring using ZXing algorithm

Indicators	Employee		Student		Teacher		Total	
	WM	VI	WM	VI	WM	VI	WM	VI
1. Do you recognize the integrity of the application?	4.00	A	4.27	A	4.33	A	4.24	A
2. The security that was implemented can prevent students from cheating the attendance.	3.83	A	4.47	A	4.33	A	4.36	A
3. The efficiency of two-layered security.	4.17	A	4.20	A	4.17	A	4.19	A
4. The reliability of SMS notifications can make it easy to receive the warning that they reach the limitation.	4.00	A	4.30	A	4.50	A	4.29	A
5. The QR code's authenticity ensured data privacy.	4.17	A	4.47	A	4.5	A	4.43	A
6. The data visualization for updating the student's status is analyzable.	4.00	A	4.37	A	4.33	A	4.31	A
7. It maintains the privacy of data encrypted in QR codes.	3.83	A	4.23	A	4.33	A	4.19	A
8. To be able to improve the function of QR codes with the assistance of the ZXing algorithm.	3.83	A	4.37	A	4.50	A	4.31	A
9. User interface enables pleasing and satisfying interaction for the user.	4.00	A	4.37	A	4.17	A	4.29	A
10. An application can provide functions that meet the stated and implied needs.	3.83	A	4.33	A	4.50	A	4.29	A

WM means weighted mean, while VI means verbal interpretation.

Beyond ACTEC's context, this study's findings suggest that QR-based attendance systems with multi-layered security can be valuable for other educational institutions, especially as they adopt digital tools to support hybrid or remote learning environments. Rama *et al.* (2022) emphasize that the use of QR code technology is adaptable, allowing it to serve diverse attendance needs across in-person, remote, and hybrid learning models.

3.3 System Implementation

Table 9 outlines a system implementation designed to streamline teacher account management and student attendance tracking. The system uses QR codes, OTP verification, and location-based services. Students' names and details are all fictional.

Table 9. Teachers account system implementation

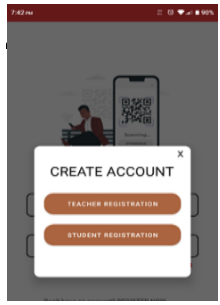
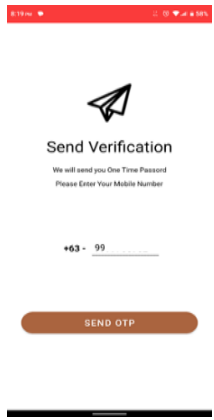
Teachers' manual		
User manual	Name	Description
	Landing page	The general home where you can register and login and retrieve your password.
	Teacher registration	Click the teacher registration to register as a teacher as to create an attendance.
	Verification code	Input your active mobile number. Do not include the 0 at first. Click 'Send OTP' to send the OTP code in your SMS.

Table 9 continued.

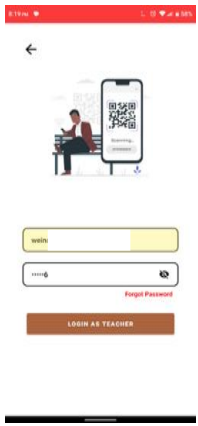
	OTP code	The sent OTP code will be entered in the blank gray blocks. Click 'Verify Code' to create your account successfully.
	Log in as a teacher	Before this, on a landing page, click the Teacher login to enter your email and password. Then click 'Login as Teacher'.
	Homepage	This is the homepage of the teacher account which will be seen the current date and time. View section and today's classes.

Table 9 continued.

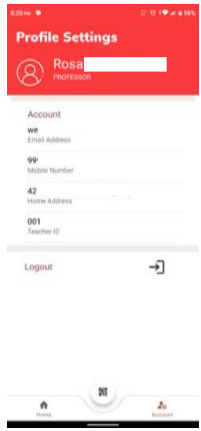
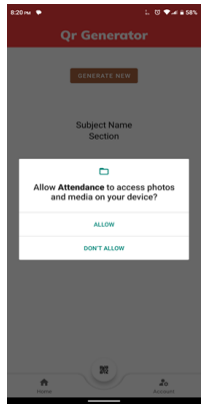
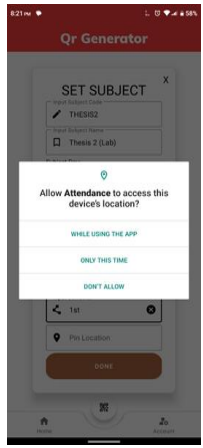
	Profile settings	This is where you can see account details of the teacher and logout button.
	QR code generator	Click the QR Code icon in the middle to encrypt the QR Code. First, if you are a new user, allow the app to access your files. After that, click 'Generate New' to view the set subject details.
	Location pin	The applications will automatically be asking permission to allow your location. If you click your pin location in the set subject, the location automatically detects. That is the QR code where located.

Table 9 continued.

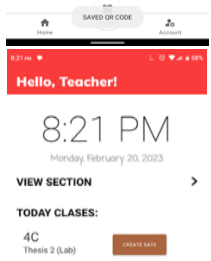
	Set Subject	After you enter all details of the subject and allow the location of your device, click 'Done' to encrypt the QR Code.
	Save QR Code	You can now save the QR code to your files and send it to the class.
	Create date	You can only tap this if your class is about to start and to enable the student to scan the QR code.

Table 9 continued.

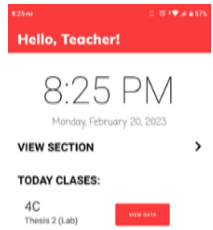
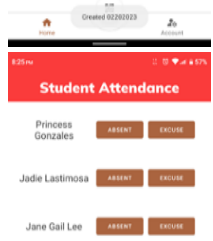
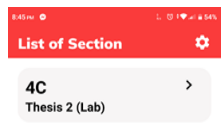
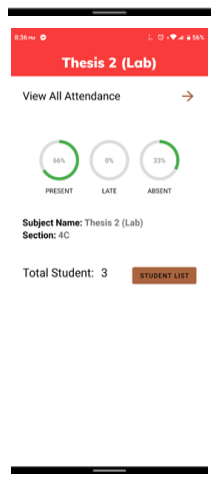
	View data	After tapping 'Create Date,' you can now view the data of students who have already scanned and those who have not.
	Student attendance	This is the data of those students who have already scanned and those who have not.
	View section	Click the 'View Section' on the homepage and you will see the list of all sections with the subject you are in.
	Student list	Click 'Student List' to view all the registered/enrolled students in a specific section.

Table 9 continued.

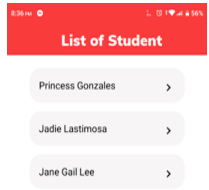
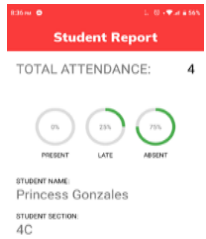
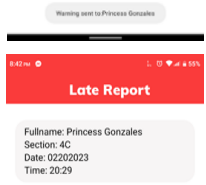
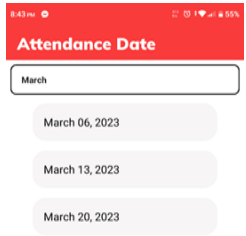
	List of students	Here, you can see the list of students per section.
	Student report	Tap one of the pie graphs to view the details of the student including the scan time.
	Attendance report	List of the student details including the scan time and date.
	Attendance date	First, go to the homepage and click the arrow of 'View all attendance'. Search specific month day, and year to filter all matched data. Click some date.

Table 9 continued.

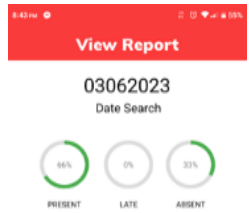
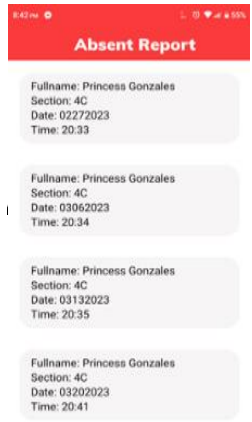
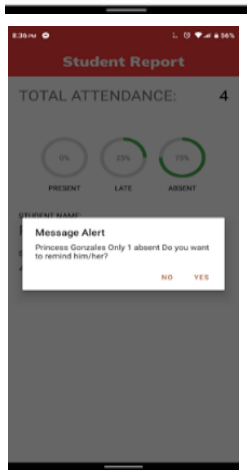
	View report	Once you click the date, three pie graphs will be shown: Present, Late, and Absent. All data that will be gathered will be equal to 100%.
	Absent report	You can see that the same person has 4 absences. She has one present and 3 absences for that semester.
	Warning SMS notification	Equivalent to 3 absences will be reminded by the teacher. Just click ‘Yes’ if you want to remind that student via SMS. Note: The teacher must have a load balance in her registered number to send a warning SMS.

Table 9 continued.

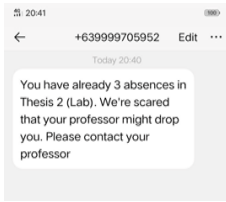
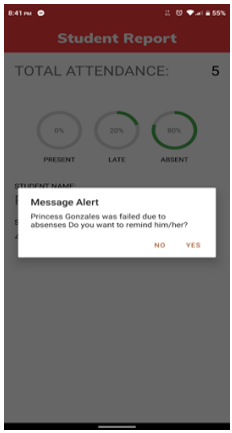
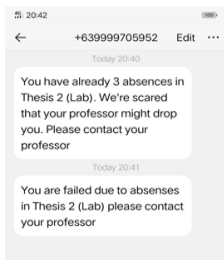
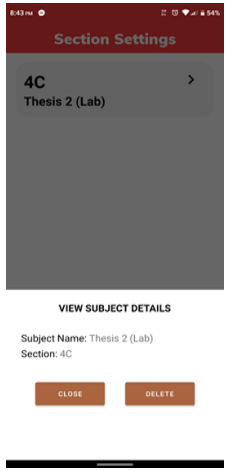
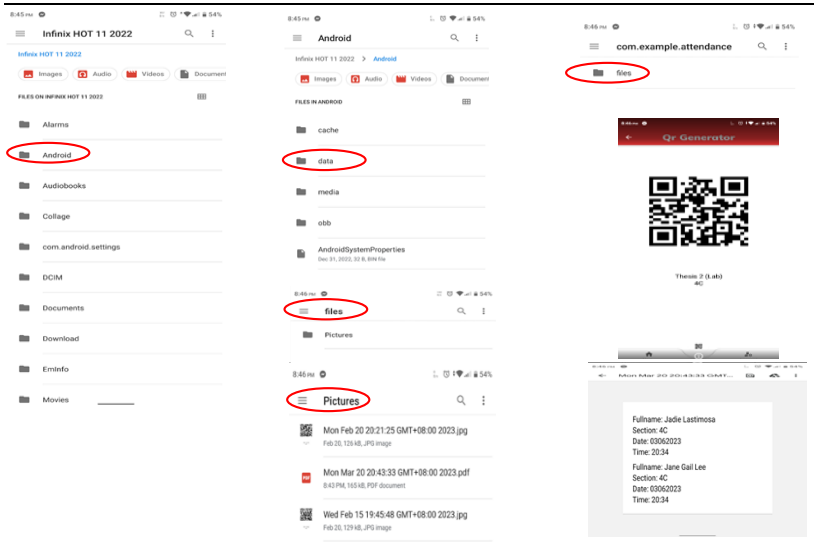
	Student received warning notification	This is the device of the student and the phone number is from the teacher.
	Failed SMS notification	The equivalent of 4 absences will be dropped by the teacher from the list. Click 'Yes' to remind the student that they will fail the subject via SMS. Note: The teacher must have a load balance in her registered number to send a warning SMS.
	Student received failed notification	The second message is the warning sent by the teacher for failing the subject.
	Section settings	Go to the 'View section' and you can see there the setting icon to delete the subject if necessary.

Table 10 shows the location of all the saved files of the system.

Table 10. Saved file location

Go to your File Manager > Internal Storage > Android > data > com.example.attendance > files > Pictures.



4. Conclusion and Recommendation

The study's results demonstrated that the QR code-based attendance monitoring system using the ZXing algorithm significantly improved attendance tracking efficiency and accuracy at ACTEC. By automating attendance with QR codes, aligning with recent literature that highlights the benefits of digital attendance systems.

The implementation of dual-layered security, comprising verification codes and geolocation, proved highly effective in ensuring the integrity and reliability of the QR code-based attendance monitoring system. By requiring both a subject-specific verification code and location matching, the system ensured that only students physically present at the school could log their attendance. This dual-layered security not only enhanced data accuracy but also minimized the potential for attendance manipulation. The findings

validate the dual-layered security framework as a robust solution for maintaining data integrity in digital attendance systems, offering a scalable and secure model for educational institutions.

User feedback indicated high satisfaction with the system's ease of use, reliability, and SMS notifications for absences, which teachers found helpful for managing student attendance proactively. Overall, the study supports the potential of QR-based attendance systems to enhance efficiency, accuracy, and security in educational settings, particularly in adapting to digital and hybrid learning models. Future research could expand on these findings by examining the system's scalability and long-term impact on data accuracy and institutional productivity.

Future studies should evaluate the system's performance with metrics such as verification efficiency, response times, error rates, and attendance accuracy. This could involve testing the system over a prolonged period and with a larger user base to measure reliability and identify any challenges in real-world applications. Conducting more detailed usability studies would provide insights into how students, teachers, and administrators interact with the system. Including metrics such as ease of use, user satisfaction, and system adoption rates could help refine the interface and features for better user engagement.

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