Acta Pedagogia Asiana

Research Article
Volume 5(SI), 2026, 140−150
https://doi.org/10.53623/apga.v5iSI.1124

Optimized QR Code-Based Authentication System for Attendance Management

Rama Abirami K*, Santhana Rohann

Department of Electrical and Computer Engineering, Curtin University Malaysia, Malaysia

*Correspondence: rama.abirami@curtin.edu.my

SUBMITTED: 15 March 2026; REVISED: 7 April 2026; ACCEPTED: 9 April 2026

ABSTRACT: In the modern technological era, various innovations have been developed to simplify and automate tasks that were previously difficult or time-consuming. Institutions such as gymnasiums, universities, and corporate offices have widely adopted automated systems to manage memberships, maintain student records, and monitor employee working hours. As automation became increasingly integrated into everyday operations, attendance monitoring systems in educational institutions also evolved significantly. In the past, attendance was typically recorded manually using paper-based methods. However, recent technological advancements have introduced alternative solutions such as biometric systems, Radio Frequency Identification (RFID), barcodes, and Quick Response (QR) codes to track attendance in large academic institutions. Despite these technological developments, several challenges remained in ensuring that attendance records were accurate, secure, and fair. Some systems involved high implementation costs, while others were vulnerable to misuse, such as students sharing attendance cards or forwarding attendance links to peers. These limitations reduced the reliability of attendance monitoring systems. Therefore, this study proposed an optimized QR code-based authentication system designed to improve the accuracy and reliability of attendance monitoring in academic institutions. The proposed approach aimed to enhance authentication mechanisms, thereby reducing fraudulent attendance practices and improving the efficiency of attendance management.

KEYWORDS: Attendance monitoring; QR code authentication; academic institutions; automated attendance systems; biometric alternatives.

1. Introduction

Attendance has long been recognized as an important component of academic institutions, ranging from elementary education to post-secondary learning environments. Although some universities allow flexible attendance policies, several institutions still require students to meet minimum attendance thresholds to qualify for examinations. The relationship between attendance and academic performance has been widely debated in educational research. Some studies suggested that attendance did not significantly influence academic achievement, whereas other studies reported a strong relationship between class participation and student success. Previous research indicated that students who consistently attended lectures and assessments tended to achieve better academic outcomes, demonstrating a significant

correlation between attendance and performance [1, 2]. These findings highlighted the importance of reliable attendance monitoring and validation systems in modern educational institutions.

Traditionally, attendance was recorded manually using paper-based registers. However, this approach was often time-consuming, prone to human error, and inefficient for large classes. With the rapid development of digital technologies, several automated attendance monitoring systems have been introduced, including QR code-based systems [3], barcode-based monitoring [4], Radio Frequency Identification (RFID) systems [5], and geolocation-based attendance tracking [6]. These technologies aimed to improve the efficiency and accuracy of attendance recording while reducing administrative workload.

Despite these advancements, many existing attendance monitoring systems still faced several challenges. For example, traditional manual methods were susceptible to recording errors and required substantial time for documentation and data management. Similarly, certain digital approaches lacked robust validation mechanisms, allowing students to manipulate attendance records. A commonly used modern approach involved generating a QR code linked to a digital form, such as a Google Form, which students scanned using their mobile devices to mark their attendance. Although this method simplified attendance collection, it introduced vulnerabilities, as students who were not physically present could still mark their attendance by accessing the QR code remotely. In addition, the recorded data were often disorganized, making it difficult for lecturers to manage and analyze attendance records efficiently.

To address these limitations, this study proposed the development of an optimized QR code-based attendance monitoring system designed to improve validation, accuracy, and efficiency in attendance tracking. The system integrated QR code authentication with a structured database environment to enhance data management and ensure reliable attendance recording. The proposed approach aimed to minimize fraudulent attendance entries, streamline data organization, and provide a more efficient mechanism for monitoring student attendance in academic institutions.

The proposed system aimed to achieve several key objectives related to improving attendance monitoring performance. The study sought to develop a robust QR code-based attendance monitoring system integrated with a MySQL database to ensure accurate and reliable attendance tracking. The system was designed with a user-friendly interface to facilitate interaction for both lecturers and students, enabling lecturers to manage attendance records and generate reports efficiently while allowing students to scan their unique QR codes to register attendance quickly. The system also incorporated real-time QR code validation by cross-referencing scanned data with the MySQL database to maintain data integrity and minimize inconsistencies. In addition, the system architecture was designed to support scalability, performance optimization, and enhanced security to protect sensitive student information in large academic environments. A prototype mobile application was developed to improve usability and accessibility, enabling students to generate and display QR codes that could be scanned during attendance registration. The system further provided advanced filtering and reporting capabilities that allowed lecturers to analyze attendance patterns and generate customized reports. Finally, comprehensive testing and validation were conducted to evaluate the system's reliability, accuracy, and effectiveness in practical academic settings.

2. Literature Review

2.1. Manual attendance monitoring system.

Manual attendance monitoring was one of the earliest methods used to record student attendance before the widespread adoption of digital technologies. In educational institutions and workplaces, attendance was traditionally documented using paper-based methods without the assistance of automated systems. These methods were developed primarily because student attendance during teaching and learning activities was often associated with academic engagement and success. Attendance served as an important indicator of student participation in academic programs and was frequently used to evaluate learning commitment, academic progress, and student retention. Several manual techniques were commonly implemented for attendance tracking. These included handwritten attendance registers, paper time sheets, punch clocks, card swipe systems, and honor-based attendance declarations [7]. Although these methods were simple to implement, they often required considerable administrative effort and were prone to human errors, such as incorrect recording, loss of records, and time inefficiencies when managing large classes.

2.2. Barcode attendance monitoring system.

Barcode-based attendance monitoring emerged as an improvement over manual attendance recording. Barcode technology had already been widely implemented in various sectors, including retail and inventory management, and was later adopted by educational institutions for identification and attendance tracking. In many universities, student identification cards were printed with unique barcodes that allowed the cards to be scanned for authentication and access to institutional resources. Barcode attendance systems were designed to simplify attendance monitoring by allowing lecturers to scan student identification cards using barcode scanners or barcode readers installed in classrooms. This approach enabled faster data processing and allowed attendance information to be recorded automatically in a digital system. Furthermore, the system could generate real-time attendance reports, which improved administrative efficiency and data management [8]. Despite these advantages, barcode systems required the barcode and the scanner to be properly aligned, which sometimes slowed the scanning process and reduced operational efficiency in large classes.

2.3. RFID attendance monitoring system.

Radio Frequency Identification (RFID) technology represented another advancement in attendance monitoring systems. RFID systems operated using radio waves to transmit data between RFID tags and readers. In this system, an RFID tag containing a microchip and antenna transmitted signals when activated by a reader device. These signals were then converted into digital data for processing and storage. RFID technology had already been widely used in applications such as electronic toll collection systems, where RFID cards were scanned automatically to process payments. In attendance monitoring systems, RFID-enabled identification cards allowed students to record their attendance by simply bringing the card near an RFID reader. Compared with barcode systems, RFID technology offered greater convenience because it did not require precise alignment between the card and the scanner [9]. However, one of the major limitations of RFID-based attendance systems was the high

implementation cost. RFID readers were often significantly more expensive than barcode scanners, which limited their widespread adoption in educational institutions.

2.4. Biometric attendance monitoring system (fingerprint).

Biometric attendance systems based on fingerprint recognition were developed to improve the reliability and security of attendance monitoring. These systems used biometric sensors to capture and verify an individual's fingerprint before recording attendance. In educational environments, students placed their fingers on a fingerprint scanner connected to a handheld device or computer system. The captured fingerprint data were then compared with stored templates in a database to confirm the student's identity. Fingerprint-based attendance monitoring automated the attendance process and eliminated the need for lecturers to manually call student names during lectures. The system typically communicated with a host computer through a USB interface, and a graphical user interface (GUI) allowed lecturers to manage attendance records and monitor system performance [10]. Although this technology improved accuracy and prevented proxy attendance, it also had certain limitations. The cost of biometric devices could be relatively high, and the system could experience delays when many users attempted to scan their fingerprints simultaneously.

2.5. Biometric attendance monitoring system (facial recognition).

Facial recognition technology represented another biometric approach used for attendance monitoring. In this system, cameras captured images of students' faces, which were then analyzed using computer vision algorithms to verify their identities. Algorithms such as the Local Binary Pattern Histogram (LBPH) and Haar cascade classifiers were commonly used for facial detection and recognition processes. Studies reported that such systems achieved approximately 94.5% accuracy in facial recognition and 98.5% accuracy in face detection when compared with barcode and other biometric-based attendance systems [11]. Facial recognition attendance systems allowed real-time attendance tracking without requiring physical interaction between the user and the device. This improved convenience and efficiency, especially in large classroom environments. However, the deployment of facial recognition systems often required specialized cameras, computational resources, and complex software infrastructure. As a result, the implementation cost could be significantly higher, particularly when the system needed to be installed across multiple classrooms.

2.6. QR code attendance monitoring system.

Quick Response (QR) code-based attendance monitoring systems have recently gained popularity as a cost-effective and efficient alternative to traditional attendance methods. QR codes are two-dimensional barcodes that can store a larger amount of information and can be scanned quickly using smartphone cameras. In educational institutions, QR codes can be generated for attendance sessions and scanned by students to record their presence. Masalha and Hirzallah [12] proposed a QR code-based attendance system designed to address inefficiencies associated with manual attendance recording in university lectures. The system leveraged the widespread use of smartphones among university students to simplify attendance collection. By scanning QR codes during lectures, students were able to register their attendance electronically, which significantly reduced the time required for attendance

recording and minimized classroom disruptions. Studies suggested that such systems could reduce lecture time spent on attendance tracking by up to 90%.

Additionally, QR code systems offered advantages such as faster data processing, higher storage capacity, and ease of implementation compared with traditional barcode systems. To enhance security, some systems integrated additional verification mechanisms such as facial recognition or GPS-based location verification to ensure that attendance was recorded only when students were physically present in the classroom. These improvements highlighted the potential of QR code-based attendance systems to enhance accuracy, efficiency, and reliability in academic attendance monitoring.

3. Methodology

The methodology section details the sequential approach followed in developing the QR code-based attendance system. The procedure encompassed planning, design, development, integration, and testing stages to ensure the system's effectiveness and accuracy. Python was chosen as the primary programming language due to its simplicity, versatility, and extensive libraries such as Tkinter, PyzBar, and Pandas, which facilitated graphical interface development, QR code decoding, and data processing. The project began with visual representation of the system through diagrams, followed by iterative software development and testing to refine functionalities.

3.1. Scope and objectives.

The project initially aimed to track attendance using barcodes on student identification cards. However, it was later revised to employ QR codes scanned by a desktop camera, which offered higher efficiency and security. The objectives included developing a reliable QR code scanning mechanism, implementing a validation procedure to ensure accurate recording of student attendance, and creating a system capable of filtering and organizing attendance records. Additionally, the project aimed to design a model for statistical analysis of attendance data to provide meaningful insights into student participation patterns. The methodology emphasized accuracy, real-time validation, and user accessibility while maintaining system robustness and security throughout the data processing workflow.

3.2. Timeline and key milestones.

The project was divided into multiple phases, each with specific deadlines to ensure timely progress. The initial phase focused on requirements collection and analysis to understand the needs of lecturers and students. Subsequent stages involved system design, including architecture development and diagram creation, followed by the core software development. This included QR code scanning, database integration, and user interface creation. The final phases incorporated unit and integration testing, followed by deployment and user training to ensure seamless adoption of the system. By adhering to a structured timeline, the project team could systematically address technical challenges and maintain development efficiency.

3.3. Tools and resources.

Python was selected as the primary development language due to its flexibility and availability of essential packages such as PyInstaller for executable creation, Tkinter for GUI development, OpenCV and PyzBar for QR code scanning, and MySQL for database management. The hardware requirements included PCs equipped with cameras to facilitate QR code scanning. The project team consisted of software developers, database administrators, UI/UX designers, and project managers. This combination of tools, technologies, and skilled personnel enabled the development of a fully functional and reliable attendance management system.

3.4. System design.

The system design stage began with requirement analysis, identifying both functional and non-functional needs. Functional requirements included the ability to scan QR codes, validate student information, collect and filter attendance data, and generate statistical reports. Non-functional requirements focused on usability, reliability, security, performance, and scalability. The system architecture comprised several critical components. The QR code scanner utilized OpenCV with a desktop camera to capture and decode QR codes. The database manager oversaw interactions with the MySQL database to store and manage attendance and student records. The record management module maintained CSV-formatted attendance files for ease of access and analysis, while the statistics calculator generated reports and visual insights from the attendance data. The architecture ensured smooth operation from scanning QR codes to generating comprehensive reports.

3.5. Development process.

The development process involved implementing the technology stack, module development, and user interface design. MySQL managed database operations, OpenCV and PyzBar handled QR code processing, and Tkinter facilitated the creation of an intuitive GUI. Module development included the QR code scanner, database manager, record management system, and statistics calculator. Each module was designed to perform its specific function while maintaining compatibility with the overall system. The user interface was designed for simplicity and ease of navigation, allowing lecturers to monitor attendance, filter records, and generate reports, while enabling students to scan QR codes quickly and securely.

3.6. Integration, testing, and challenges.

Integration involved combining all modules into a unified system, ensuring seamless communication and data flow between components. Testing was conducted in multiple phases, including unit testing of individual modules, integration testing to verify interactions between components, system testing for overall performance, and user testing to gather feedback on usability and functionality. Several challenges arose during development, including QR code decoding errors caused by variations in QR code quality and environmental factors affecting camera performance. Database connectivity issues also occurred, particularly in maintaining stable connections and executing queries efficiently. These issues were resolved through advanced error-handling methods, query optimization, and connection pooling strategies, which ensured reliable QR code scanning and consistent database operations. Through rigorous

testing and iterative problem-solving, the system achieved a dependable and efficient solution for attendance management.

4. Results and Discussion

4.1. Results.

The project successfully achieved its objectives by developing a reliable, efficient, and user-friendly QR code-based attendance monitoring system. The system employed QR code technology combined with a robust software architecture to modernize conventional attendance tracking methods, which had traditionally relied on manual [7], barcode [4, 8], and RFID [5] methods. By using QR codes, the system enabled accurate, real-time recording of attendance while reducing human error and administrative effort [3, 6]. The development methodology, which encompassed careful planning, systematic implementation, iterative testing, and continuous user feedback, ensured the system's reliability and performance. The application featured an intuitive interface with three main tabs, as illustrated in Figures 1–4. Figure 1 shows the start menu of the application, which allowed users to navigate easily between the QR Code Scanner, Records Filter, and Statistics tabs. This interface design ensured accessibility and simplicity, improving user adoption among both students and instructors.

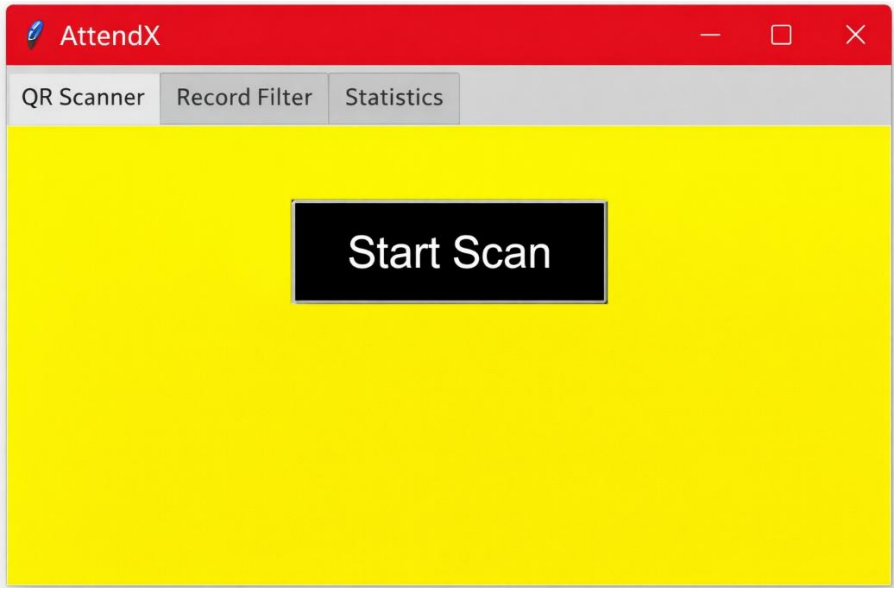

Figure 1: Start menu of the QR code attendance application showing navigation tabs.

Figure 2 illustrates the QR Code Scanner tab, where the system automatically activated the laptop's front-facing camera. Students presented their unique QR codes to the camera, which scanned and validated attendance in real time, storing the data directly in the MySQL database. This method eliminated errors commonly encountered in manual attendance tracking [1,2] and improved efficiency compared to traditional barcode [4,8] and RFID [5] methods.

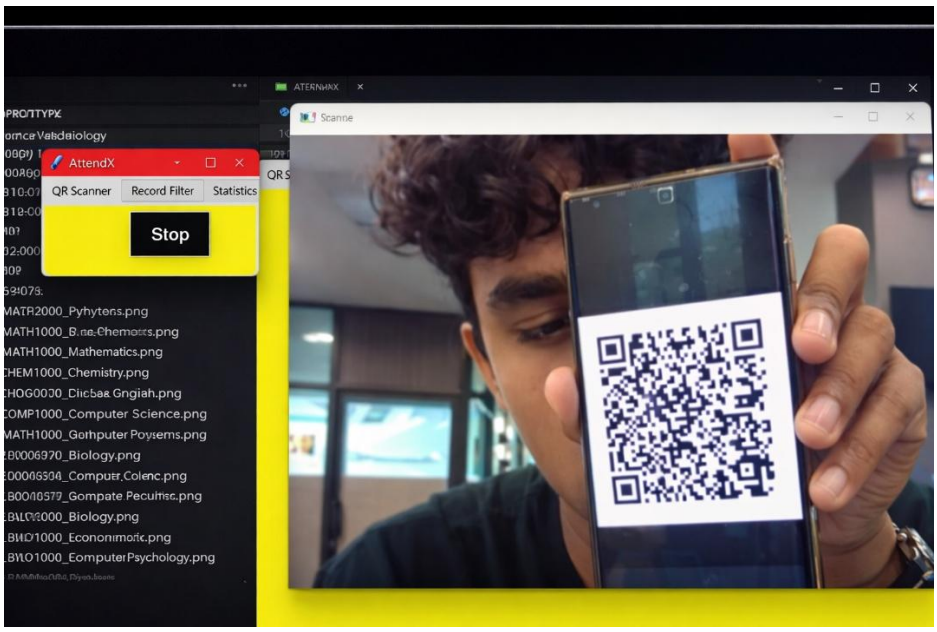

Figure 2. QR Code Scanner tab with live camera view and automatic validation functionality.

Figure 3 presents the Records Filter tab, which allowed users to retrieve specific attendance records based on multiple criteria, such as Student ID or Course Code. Users selected the filtering criteria from a drop-down menu and input the corresponding value to access the relevant attendance data. This function enabled lecturers to monitor attendance trends for individual students or groups efficiently, supporting personalized interventions where necessary.

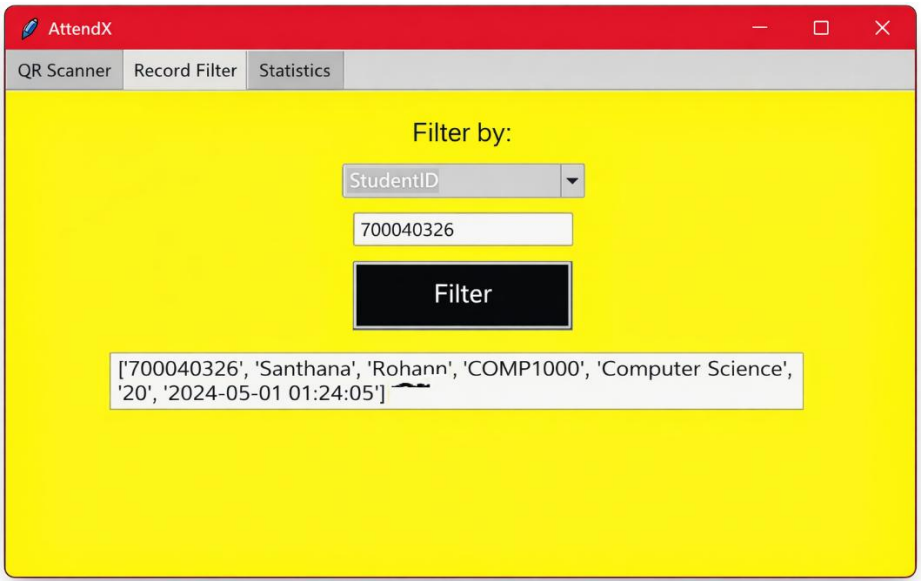

Figure 3. Records Filter tab demonstrating filtering by Student ID.

Figure 4 depicts the Statistics tab, which generated comprehensive analytical reports, including total attendees, most attended units, most attended courses, and the student ID with the highest attendance. These metrics provided instructors with insights into classroom engagement, participation trends, and potential areas for improving teaching and learning strategies. The system's statistical functionality demonstrated its added value over conventional attendance monitoring approaches, enabling evidence-based decision-making [12].

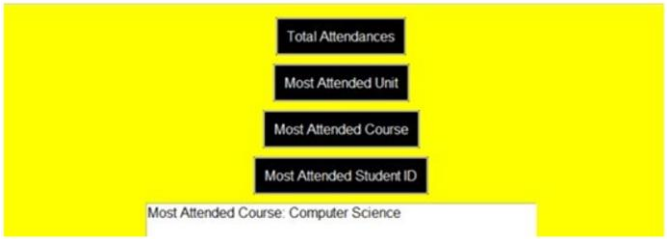

Figure 4. Statistics tab showing total attendees, most attended unit, most attended course, and student with highest attendance.

4.2. Discussion

The developed attendance management system represented a significant advancement in automating and enhancing attendance tracking within educational institutions. By integrating QR code scanning, database validation, and a modular, user-friendly interface, the system provided a reliable and scalable solution suitable for diverse classroom settings. The results indicated that the system not only improved administrative efficiency but also mitigated errors commonly associated with manual attendance [7] and traditional automated systems such as barcodes [8] and RFID [5].

The user-centric design facilitated easy adoption and interaction. The QR Code Scanner ensured real-time validation of attendance, while the Records Filter and Statistics tabs provided a streamlined approach to data retrieval and analysis. For example, the Statistics tab offered lecturers detailed insights into student participation patterns, enabling them to identify trends, address absenteeism, and tailor interventions effectively. These functionalities also supported broader institutional objectives, such as improving student engagement and monitoring academic progress [1, 2].

By leveraging QR codes, the system achieved a balance between cost-effectiveness and accuracy. Unlike fingerprint [10, 11] or facial recognition-based systems [9], which may incur high implementation costs, the QR code approach offered a practical and affordable solution without compromising security or reliability. Additionally, location-based verification, as described by Masalha and Hirzallah [12], could further enhance data integrity by ensuring that students are present in the classroom when scanning their QR codes.

Overall, the system demonstrated how modern technology could transform conventional administrative processes in educational institutions. The combination of QR code-based validation, database integration, and interactive statistical reporting provided a robust platform for attendance monitoring, improving operational efficiency and supporting data-driven decision-making. Figures 1–4 illustrate the system's interface and core functionalities, highlighting the practicality and usability of the application in real-world academic settings.

5. Conclussion

The adoption of the attendance management system marked a significant achievement in enhancing administrative efficiency in educational institutions. By integrating QR code scanning, database validation, and an intuitive GUI, the system overcame the limitations of traditional attendance methods. The primary goal was to optimize the attendance recording process, ensuring accuracy, reliability, and ease of use. QR codes significantly reduced the time required for attendance and minimized human errors, enabling immediate and precise data

collection, which benefited both students and lecturers. Database validation played a crucial role in maintaining record integrity by verifying scanned data against a centralized MySQL database. This ensured that only legitimate entries were recorded, preventing fraudulent entries and guaranteeing data reliability. The system's ability to handle large volumes of data and perform real-time verification demonstrated its robustness and dependability. Future work for the QR code attendance monitoring system includes creating a mobile app for easier access and notifications, integrating with learning management systems for seamless data sharing, implementing advanced analytics to gain deeper insights into attendance patterns, and exploring additional functionalities to enhance security. These improvements are intended to increase the effectiveness of the system and offer greater benefits to both lecturers and students.

Author Contributions

All authors contributed equally to the conception, design, implementation, analysis, and manuscript preparation of this study. All authors have read and approved the final manuscript.

Competing Interests

The authors declare that they have no competing interests.

Data Availability

The data supporting the findings of this study, including sample attendance records and system-generated statistics, are available from the corresponding author upon reasonable request.

Reference

[1] Adair, K.; Swinton, O.H. (2012). Lab Attendance and Academic Performance. *ISRN Education*, *2012*, 1–5. https://doi.org/10.5402/2012/364176.

[2] Lukkarinen, A.; Koivukangas, P.; Seppala, T. (2016). Relationship between Class Attendance and Student Performance. *Procedia - Social and Behavioral Sciences*, *228*, 341–347. https://doi.org/10.1016/j.sbspro.2016.07.051.

[3] Wei, X.; Manori, A.; Devnath, N.; Pasi, N.; Kumar, V. (2017). QR Code Based Smart Attendance System. *International Journal of Smart Business and Technology*, *5*, 1–10. https://doi.org/10.21742/ijsbt.2017.5.1.01.

[4] Saheed, Y.K.; Hambali, M.A.; Adedeji, A.A.; Adeniji, I.A. (2016). Attendance Management System Using Barcode Identification on Students' Identity Cards. *The Pacific Journal of Science and Technology*, *17*, 2.

[5] Kuriakose, R.B.; Vermaak, H.J. (2015). Developing a Java Based RFID Application to Automate Student Attendance Monitoring. 2015 Pattern Recognition Association of South Africa and Robotics and Mechatronics International Conference (PRASA-RobMech). https://doi.org/10.1109/robomech.2015.7359497.

[6] Amirulloh, I.; Iskandar, I.D.; Apriyani, Y.; Warnilah, A.I.; Purnia, D.S.; Surahman, M. (2020). Teacher Attendance Monitoring System Teaching with QR-Code and Geo Location Using Android Platform. *Journal of Physics: Conference Series*, *1641*, 012030. https://doi.org/10.1088/1742-6596/1641/1/012030.

[7] The Old Ways vs New Ways of Taking Attendance. HRM-Labs. (accessed on 06 Jan 2020) Available online: https://hrmlabs.com/old-and-new-ways-of-taking-attendance/.

[8] Nguyen, V.D.; Khoa, H.V.; Kieu, T.N.; Huh, E.-N. (2022). Internet of Things-Based Intelligent Attendance System: Framework, Practice Implementation, and Application. *Electronics*, *11*, 3151. https://doi.org/10.3390/electronics11193151.

[9] Rohini, V.; Sobhana, M.; Chowdary, C.S. (2022). Attendance Monitoring System Design Based on Face Segmentation and Recognition. *Recent Patents on Engineering*, *16*. https://doi.org/10.2174/1872212116666220401154639.

[10] Rukhiran, M.; Wong-In, S.; Netinant, P. (2023). User Acceptance Factors Related to Biometric Recognition Technologies of Examination Attendance in Higher Education: TAM Model. *Sustainability*, *15*, 3092. https://doi.org/10.3390/su15043092.

[11] Mohamed, B.K.P.; Raghu, C.V. (2012). Fingerprint Attendance System for Classroom Needs. 2012 Annual IEEE India Conference (INDICON). https://doi.org/10.1109/indcon.2012.6420657.

[12] Masalha, F.; Hirzallah, N. (2014). A Students Attendance System Using QR Code. *International Journal of Advanced Computer Science and Applications*, *5*, 3. https://doi.org/10.14569/ijacsa.2014.050310.