DEVELOPMENT of a QR-Based Attendance Tracking System with Geofencing and Parent NOTIFICATIONS

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ABSTRACT

This study successfully developed and evaluated an integrated Geo-Attendance Tracker in Suzhou, China, employing an iterative Agile methodology to address the inefficiencies of traditional manual monitoring through a centralized platform combining QR codes, GPS-based geofencing, and automated parent notifications. Grounded in the Technology Acceptance Model (TAM) and the Input-Process-Output (IPO) framework, the research demonstrated exceptional systemic acceptability among students, parents, and teachers, yielding an exceptional overall mean score and confirming that high reliability in precise geolocation verification and real-time communication significantly reduced student tardiness and absenteeism. By strictly adhering to ethical standards and data privacy protocols, the platform effectively mitigated proxy attendance and enhanced institutional transparency, providing a scalable model for modernizing school management and fostering robust school-home partnerships through its multi-layered, secure architecture. Moving forward, the study's Strategic Implementation Plan ensures long-term sustainability while recommending that future iterations explore the integration of artificial intelligence and biometrics to maintain technological relevance and proactive student monitoring.

KEYWORDS: *Education, information technology integration, QR-based attendance system, geofencing, China.*

INTRODUCTION

Effective attendance monitoring is vital for student accountability, administrative efficiency, and parental engagement. However, traditional manual methods remain prone to inefficiencies, data errors, and limited transparency, often lacking the automated verification and real-time communication essential for modern learning environments (Kumar et al., 2020; Lewis & Sauro, 2023). Specifically, the absence of geolocation validation and automated parent

notifications increases administrative burdens and undermines school-home accountability.

While various digital alternatives exist globally, they remain fragmented. For example, systems in the UK and US historically lacked integrated geofencing, while QR-based implementations in India and Southeast Asia—such as Indonesia, Malaysia, and Thailand—faced user resistance and a lack of real-time parental engagement features. Similarly, in China, despite rapid technological integration, attendance practices vary; while high-resource schools leverage advanced biometrics, many institutions still struggle to maintain transparent, real-time communication with parents. Suzhou was selected as the research locale because its advanced technological infrastructure and diverse educational landscape make it an ideal urban hub to evaluate how a system integrating QR codes and GPS-based geofencing adapts to institutional needs.

Recent literature highlights that QR-based systems enhance accuracy and operational ease (Adithya, 2024; Sopan et al., 2024). When paired with geofencing, these systems ensure location accountability by restricting logs to designated geographic coordinates (Babatunde et al., 2022; Viswanath et al., 2023). Furthermore, integrating real-time notifications via email or SMS strengthens school-home collaboration and improves student compliance (Alpasan et al., 2021; Lewis & Sauro, 2023). Despite these advancements, a critical gap has remained: existing studies have often treated these technologies in isolation, lacking a centralized, scalable platform that combines QR codes, geofencing, and real-time parent engagement. The current study addressed this gap by developing and evaluating an integrated attendance tracking system designed to enhance transparency, reduce administrative burdens, and foster robust school-home partnerships

Statement of the Problem

1. How can a QR-based attendance tracking system with geofencing and parent notifications be developed to improve student monitoring?
2. What is the acceptance level of the Geo-Attendance Tracker?
3. What strategies can be implemented for the adoption of the Geo-Attendance Tracker in educational and organizational settings

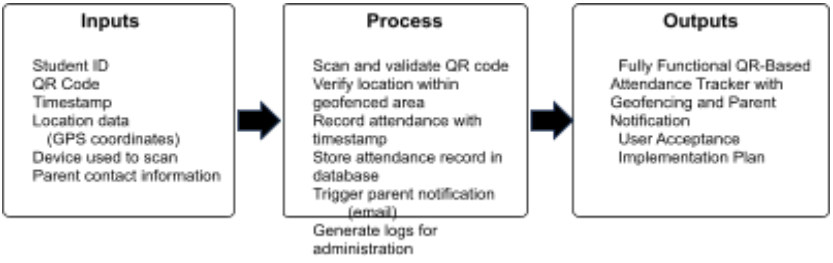
Theoretical Lens

This study utilized Davis's (1989) Technology Acceptance Model (TAM) to evaluate user acceptance of the developed system. TAM assessed four

core constructs—perceived usefulness, perceived ease of use, attitude toward use, and behavioral intention—to predict and determine actual system adoption (Venkatesh et al., 2003). By synthesizing the system's integrated features within this model, the research extended prior work, evaluating how effectively the user-friendly design met stakeholder expectations, supported attendance monitoring, and enhanced communication.

Figure 1

The Input-Process-Output (IPO) Model of the QR-Based Attendance Tracking System

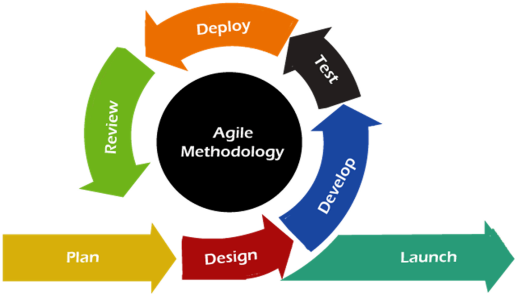


METHODOLOGY

Research Design. This study employed a quantitative descriptive research design to examine the features, functionality, and user perceptions of the system without manipulating variables. The development utilized the Agile Software Development Life Cycle (SDLC), which followed seven iterative phases: Plan, Design, Develop, Test, Deploy, Review, and Launch. As illustrated in Figure 2, this iterative approach facilitated continuous user feedback, ensuring the system evolved to meet specific real-world institutional needs.

Figure 2

The Agile Software Development Life Cycle (SDLC) of the Geo-Attendance Tracking System.



System Architecture. As illustrated in Figure 3, the Geo-Attendance Tracker was developed utilizing a modular, layered architecture to ensure scalability, reliability, and security, aligning with established software engineering principles for educational platforms (Sommerville, 2016). The frontend layer served as the primary cross-platform user interface, leveraging responsive web technologies to deploy role-specific portals for administrators, teachers, and students. This interface handled client-side operations—including authentication, QR code scanning, and course configuration—through an intuitive design optimized to accommodate varying levels of user digital literacy (Norman, 2013).

The backend layer executed the core business logic via stateless, modular RESTful APIs that securely processed user authentication, validated QR codes, enforced geofencing constraints, and triggered automated, real-time parent notifications (Sommerville, 2016). Data persistence and structural organization were managed by a relational MySQL database containing user profiles, attendance logs, and system configurations. To guarantee optimal query execution and data consistency across the platform, the database schema strictly enforced indexing and referential integrity (Elmasri & Navathe, 2015).

Figure 3

The Multi-Layered System Architecture of the Geo-Attendance Tracking System

Research Locale. The study was conducted in Suzhou, China, an advanced technological and educational hub featuring a diverse mix of public, private, and international schools. This urban environment provided an ideal locale to evaluate the effectiveness, usability, and adaptability of the QR-based attendance tracking system, while the city's commitment to technological innovation facilitated a comprehensive assessment of user acceptance and operational impact across varied institutional settings.

Research Respondents. The participants included students aged 12 and above, parents, teachers, and school administrators in Suzhou. The research was implemented in three phases: a Development Phase to gather technical requirements, a Validation Phase involving 51 students and their parents to test functionality, and an Acceptance Phase involving 102 students, 98 parents, and 38 teachers. Participants were chosen using purposive sampling to ensure they met specific inclusion criteria, such as smartphone access and enrollment in participating schools.

Research Instrument. The study evaluated the acceptability of the QR-Based Attendance Tracking System (QRATS) using a structured questionnaire based on the Technology Acceptance Model (TAM). The instrument was designed to measure four critical constructs: perceived usefulness, perceived ease of use, attitude toward use, and behavioral intention. To ensure the system's evaluation aligned with current trends in educational technology, the questionnaire was contextualized to the tracker's specific features and reviewed by experts for content validity, drawing on established frameworks

of user behavior in educational QR systems (Wang et al., 2020; Kumari & Kumar, 2024).

To ensure data internal consistency, reliability was assessed using Cronbach's Alpha, with a minimum threshold of 0.70. Participant responses were captured using a 5-point Likert scale. The resulting mean scores were interpreted according to the following established ranges shown in Table 1.

Table 1
Level of Technology Acceptance Description Scale for Qualitative Mean Score Assessment

Range of Mean Scores	Level of Acceptance	Verbal Description
4.20 – 5.00	Very High	Always Evident
3.40 – 4.19	High	Often Evident
2.60 – 3.39	Average	Sometimes Evident
1.80 – 2.59	Low	Rarely Evident
1.00 – 1.79	Very Low	Never Evident

Data Gathering Procedure. The study followed a structured data collection process beginning with formal approvals from the Research Ethics Committee, the Suzhou City Ministry of Education, and participating school administrators. Informed consent and assent were obtained from all participants, ensuring they were fully briefed on the study's purpose, procedures, and how their information would be utilized. Data collection occurred across different research phases, with interviews and surveys conducted with signed consent and scheduled to minimize respondent burden. The feedback gathered during these stages directly informed the iterative refinement of the system's design and features.

Ethical Considerations. This research adhered to strict ethical standards and was formally approved by UIC-REC under protocol number GS-ER-03-25-0242. Core ethical principles—including user safety, privacy, and research integrity—were maintained throughout the system's development and testing of the system. To safeguard participant identity, all personal identifiers were anonymized and stored on encrypted platforms. In compliance with the Philippine Data Privacy Act of 2012 and relevant local regulations, all anonymized digital records are securely retained for 5 years, after which they will be permanently deleted to ensure long-term data protection.

RESULTS AND DISCUSSION

The development of the QR-Based Attendance Tracking System followed the Agile methodology, utilizing its iterative, seven-phase approach—planning, designing, developing, testing, deployment, reviewing, and launching—to adapt efficiently to evolving requirements (Pressman & Maxim, 2015; Sommerville, 2016). During the planning phase, the PIECES framework systematically evaluated institutional challenges across six domains: performance, information, economics, control, efficiency, and service. This assessment identified critical operational gaps in traditional manual systems, such as data errors, high administrative costs, and low transparency.

The framework's findings directly informed the system's functional and non-functional requirements, which were designed to be centralized, scalable, and user-friendly to meet long-term institutional goals and improve student punctuality (Kumari & Kumar, 2024; Maleriado & Carreon, 2020). To resolve the identified gaps, the system integrated QR codes for rapid attendance capture (Adithya, 2024; Sopan et al., 2024), automated parent notifications to strengthen school-home collaboration (Alpasan et al., 2021; Lewis & Sauro, 2023), GPS-based geofencing for location-based verification (Viswanath et al., 2023), and process automation to minimize educators' administrative workloads (Mohammed & Zidan, 2023).

During the design phase, the system was architected as a modular, secure, and scalable tool tailored to the high-tech educational landscape of Suzhou, China. As illustrated in Figure 4, this layered architecture comprised a responsive web-based frontend for multi-device accessibility, a RESTful API-driven backend for core business logic, and an indexed MySQL database optimized for user profiles, attendance logs, and geolocation metadata.

Figure 4

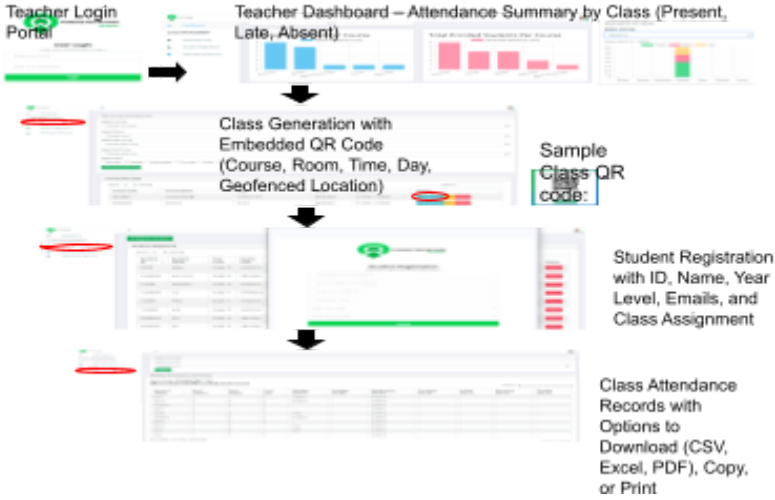
The Administrative Infrastructure and Registration Modules of the Geo-Attendance Tracking System

The system integrated key features—including automated QR-based attendance, GPS validation, and real-time reporting—to reduce manual errors and maximize operational efficiency. By leveraging geofencing technology, the platform restricted attendance logging to a 10-meter radius of the classroom to ensure location accountability, while automated email notifications were delivered to parents to enhance home-school communication, student punctuality, and accountability. To maintain data security and usability, role-based access control was implemented: administrators managed system configurations and high-level reports; teachers generated geofenced classes and validated records; students scanned unique QR codes via secure, OTP-verified portals; and parents received real-time alerts. This structured approach protected sensitive data in compliance with privacy protocols while ensuring an intuitive stakeholder experience.

Development was executed through iterative Agile sprints to maintain alignment with institutional needs based on continuous stakeholder feedback. Sprint 1 focused on establishing the core administrative infrastructure, which included developing secure administrator login portals, teacher registration modules with integrated email verification, and interfaces for course configuration and scheduling. As illustrated in Figure 5, the resulting dashboard provided aggregated data summaries, including course counts and teacher assignments. Initial teacher feedback during this phase was directly integrated into subsequent cycles to refine and optimize the course registration interface.

Figure 5

The Integrated Teacher Portal for Geofenced Class Generation and Attendance Monitoring



Sprint 2 focused on the deployment of teacher-specific login portals and automated class-creation modules. To ensure strict location accountability, each class was assigned a geofenced boundary using GPS coordinates, with the specific class parameters—including time, day, and room—embedded into a unique, teacher-generated QR code that served as the reference point for geolocation validation. As illustrated in Figure 6, the portal allowed teachers to establish classes and register students using core demographic and parental contact data. Furthermore, the system provided real-time attendance monitoring through tabular and graphical dashboards to enhance transparency. Based on pilot feedback, the interface was refined during this cycle by integrating confirmation modals for class creation and tooltips on course status labels to improve location-detection usability.

During Sprint 3, students were enabled to log in using the email registered by their teacher and a One-Time Password (OTP), receiving personalized QR codes via email upon successful authentication. This process was specifically designed to ensure secure check-ins and prevent impersonation or "proxy attendance". As shown in Figure 7, the login interface incorporated OTP verification and email-based QR delivery, providing a robust layer of multi-factor authentication. This enhanced security framework protected sensitive student data from unauthorized access, aligning with contemporary

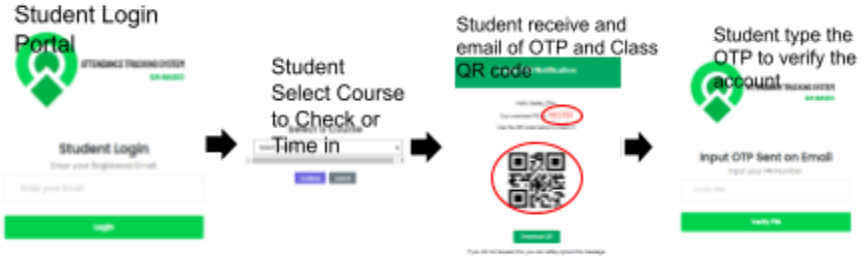
standards for secure educational monitoring (Shrivastava, 2024; Sopan et al., 2024). The OTP mechanism successfully verified student identity during the implementation phase, ensuring that only authenticated users could generate and utilize tracking credentials. This restricted access maintained data integrity and supported higher levels of student accountability (Kumari & Kumar, 2024)

Figure 6

The Student Authentication Interface and Multi-Factor Secure Login Portal

Figure 7

The Student Multi-Factor Authentication and OTP Verification Portal

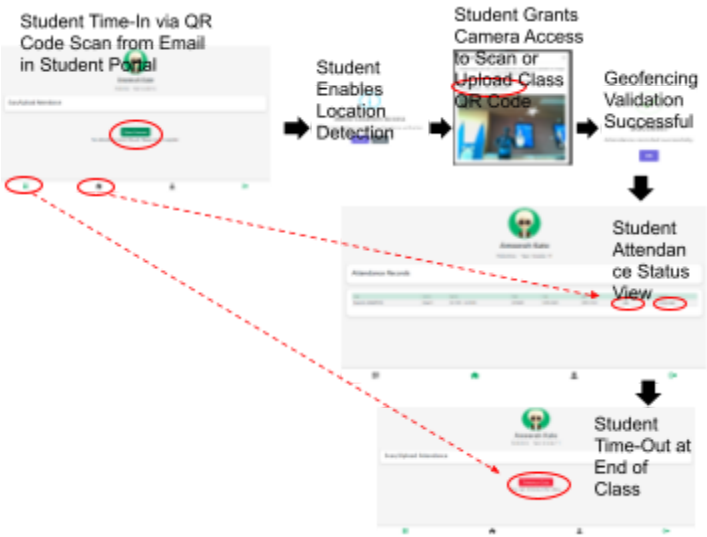


Sprint 4 executed the geolocation validation logic, which verified if students were within a 10-meter radius of the designated class coordinates at check-in. Attendance status (Present, Late, or Absent) was determined by cross-referencing real-time GPS data and punctuality timestamps against preset parameters. As illustrated in Figure 8, this "time-in" process validated location and time simultaneously, ensuring records were based on verified physical proximity and timing in accordance with established geofencing guidelines (Babatunde et al., 2022; Viswanath et al., 2023).

The automated classifications were instantly reflected on teacher and student dashboards, demonstrating high system responsiveness and data transparency. Furthermore, a "time-out" feature was integrated to track departures, aligning with digital time-tracking best practices that combine timing and geolocation to improve student compliance, institutional accountability, and data accuracy (Babatunde et al., 2022; Sopan et al., 2024).

Figure 8

The Real-Time Geofencing Validation and QR-Based Check-in Interface



The final development sprint introduced automated email notifications to parents, providing real-time updates on student attendance status and location. As illustrated in Figure 9, this feature enhanced institutional transparency and

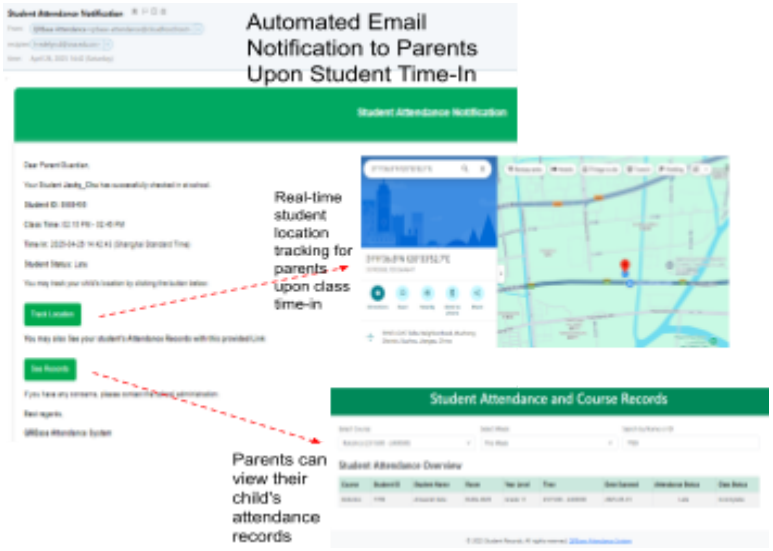
strengthened home-school connections by delivering immediate alerts containing specific attendance data, GPS-validated locations, and secure links to comprehensive attendance records.

During the validation phase—which involved 51 student-parent dyads across three pilot schools in Suzhou—the focus was on notification accuracy and delivery reliability. Initial testing revealed minor email delivery delays, which were resolved through email retry mechanisms and server optimizations to secure a reliable communication loop. Validation findings indicated that parents highly valued the immediacy of the alerts, which fostered greater student accountability.

This functionality aligned with contemporary educational technology standards by providing location-verified updates that supported safety, proactive communication, and robust school-home partnerships. Furthermore, preliminary feedback indicated that this increased transparency led to a noticeable reduction in student tardiness and absenteeism, demonstrating that automated, visible tracking effectively cultivated a culture of punctuality within Suzhou's high-tech educational landscape

Figure 9

The Parent Engagement Portal for Automated Notifications and Real-Time Location Tracking



Following the successful integration of the system modules, a technical validation phase involving 51 student-parent dyads across three pilot schools in Suzhou, China, verified the precision of the 10-meter geofencing radius and resolved initial email delivery latencies through server optimization. Systemic acceptability was subsequently evaluated using the Technology Acceptance Model (TAM) among a purposive sample of 102 students, 98 parents, and 38 teachers, yielding an exceptional overall mean score of 4.82 (SD=0.37). Within the specific TAM constructs, Perceived Ease of Use averaged 4.80—driven by the simplicity of attendance tracking (mean = 4.91) despite minor interface navigation variances related to user digital literacy (mean = 4.70)—while Perceived Usefulness matched at 4.80, reflecting enhanced administrative workflow productivity (mean = 4.86). High mean scores for Attitude Toward Use (mean = 4.84) and Behavioral Intention (mean = 4.85) demonstrated a strong collective commitment to continued platform adoption (mean = 4.88), which correlated empirically with a notable reduction in student tardiness and absenteeism.

To translate these positive user perceptions into sustainable institutional practice, a multi-phased Strategic Implementation Plan was established to secure long-term administrative buy-in and maintain training continuity via targeted onboarding sessions, video tutorials, and user manuals. Institutionally, this framework mandates embedding digital attendance requirements into formal school policies and data privacy protocols while prioritizing campus connectivity infrastructure assessments to ensure stable GPS validation. To guarantee operational continuity and minimize external vendor dependency, the strategy outlines the specialized training of internal IT personnel for daily maintenance, supported by centralized helpdesks, data analytics monitoring, and scalability funding mechanisms designed to replicate the deployment across additional cohorts.

This research provides distinct theoretical and practical advancements to the domain of educational technology. Theoretically, it extends the Technology Acceptance Model by establishing that geolocation verification and real-time stakeholder communication serve as vital external variables directly influencing user attitudes and behavioral intentions within high-tech educational environments. Practically, the Geo-Attendance Tracker delivers a scalable, centralized architecture that effectively minimizes manual errors, mitigates proxy tracking, and solidifies the critical school-home partnership through secure, location-verified monitoring.

CONCLUSION

This study successfully engineered and evaluated an Agile-developed QR-Based Attendance Tracking System (QRATS) that integrated GPS-based geofencing and real-time parent notifications to replace inefficient manual monitoring methods. Technical validation of the 10-meter geofencing radius and automated alerts demonstrated enhanced data integrity, increased institutional transparency, and a quantifiable reduction in student tardiness and absenteeism. Psychometric evaluation utilizing the Technology Acceptance Model (TAM) in Suzhou, China, confirmed exceptional user acceptance, with an overall mean score of 4.82 (SD=0.37). While pilot testing validated geofencing precision and notification reliability, potential replication in low-resource environments highlights the necessity of robust network architectures to ensure long-term scalability and sustainability.

To maximize institutional impact, it is recommended that institutions fully adopt and standardize this system across all departments while formalizing digital attendance policies, optimizing campus internet connectivity, and providing necessary mobile hardware. Future iterations should enhance parent portals with historical analytics and direct messaging features to further solidify school-home collaboration. Finally, future research should explore integrating biometrics and artificial intelligence predictive modeling to detect latent absenteeism trends, maintain security, and ensure the platform's long-term technological relevance.

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