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Automated QR Code Attendance Tracking System for Efficient Classroom Management

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Abstract

This paper presents the design, implementation, and evaluation of a QR code-based automated attendance tracking system designed to enhance classroom management, efficiency, and participation analysis. Accurate attendance tracking is essential for monitoring student engagement and supporting academic performance; however, conventional methods, such as paper sign-in sheets or manual Learning Management System (LMS) entries, are often time-consuming and error-prone. The developed application automates this process by allowing students to scan personalized QR codes, which securely log their names, IDs, and timestamps, and produce Excel files. This system was used in three courses during the Fall 2025 semester, successfully reducing paperwork, minimizing human error, and familiarizing students with real-world applications of machine vision and data automation. A post-implementation survey of 37 students revealed that more than 80% found the system easy or very easy to use, and 70% reported completing the QR check-in process in less than ten seconds. Most of the users (78%) rated the system as reliable, while only a small percentage reported minor technical problems during initial use. In addition, the students identified key advantages, including time savings, improved record-keeping, and encouragement to remain engaged with the course content rather than waiting for the signing sheet. In general, the system demonstrated high usability, reliability, and efficiency, confirming its potential as a practical digital solution for automated classroom attendance tracking. Suggestions for future improvement included adding real-time confirmation, attendance summaries, and gamification elements to increase engagement.

Keywords: QR code attendance, classroom management, student participation, attendance tracking

1. Introduction

Manual attendance tracking in higher education is time-consuming and labor-intensive. For large classes, attendance can consume 8.93 ± 1.06 minutes per session [1], 3.6 to 4.67 instructional hours per semester. Shoewu et al. [2] reported that each student required, on average, approximately 17.8 seconds to locate their name and complete the manual attendance sign-in process. Faculty are also required to compile attendance reports for every session to analyze student participation. Student attendance has long been recognized as a crucial factor in influencing academic performance [3–5], requiring institutions to implement policies that support learning outcomes. Although many studies report a positive relationship between attendance and academic performance, recent research suggests that this link has weakened due to increased digital accessibility [6]. As technology reduces the necessity of physical presence, simple attendance counts are insufficient; classroom engagement has emerged as a critical mediating factor, emphasizing that how students attend matters more than mere presence. Attendance alone may not directly improve results, but supports performance by improving online engagement and formative assessment results [7]. Evidence from technology-enhanced courses further demonstrates that learning success depends on the

interaction between in-class participation and online learning behaviors. Traditional methods, such as circulating sign-in sheets or calling student names, are widely used, but remain inefficient and prone to errors and cheating [8]. To overcome these challenges, technological solutions have been explored. Machine vision [9] and Radio Frequency Identification (RFID) [10] systems have been successfully implemented to improve attendance accuracy and reduce manual workload. Intelligent classroom systems based on the Internet of Things that integrate RFID and facial recognition offer complementary benefits: RFID provides fast and low-cost identification but is sensitive to obstructions, while facial recognition accurately tracks student entry, exit and attendance patterns, but may be affected by lighting, posture, or facial expressions [11]. Recent advances in deep learning have further enhanced automated attendance systems. Facial recognition [12] remains popular due to its contactless nature, and AI and IoT-integrated systems that use ResNet architectures have shown that ResNet-50 outperforms ResNet-18 in accuracy and reliability in simulated and real classroom datasets [13]. Crowdsensing-based systems, such as the Attendance Management Method based on Crowdsensing (AMMoC), address inefficiencies and cheating by verifying student location data through initialization and authentication phases. Experiments indicate that AMMoC achieves high anti-cheating performance, fast processing, and minimal classroom disruption [14]. Mobile-based approaches have also been proposed, in which Android apps using GPS and NFC enable automatic attendance tracking through student smartphones, reducing the time spent on manual recording and eliminating the need for additional hardware [15].

The currently developed AtTEndance Recording (ATER) system demonstrates the feasibility of automated attendance tracking; however, it requires faculty to operate the system from personal computers, and its reliance on a smartphone as a webcam limits usability and adoption. Despite these limitations, automated systems offer several advantages, including improved faculty efficiency, reduced paperwork, opportunities for students to apply learning in machine vision, improved student-faculty communication, and a position for institutions as innovators in low-cost classroom attendance management. The aim of this study is to automate traditional attendance recording using a machine-vision-based system that integrates accuracy, efficiency, and applied learning opportunities, offering a scalable solution suitable for large classrooms, and to discuss the students' experiences. Table 1 compares the proposed system with commonly used attendance methods.

Table 1: Comparison of Common Attendance Tracking Methods in Higher Education

Method	**Time per Class**	**Infrastructure Cost**	**Key Limitations**
Manual sign-in sheet [1, 2, 16]	8–10 min	None	Error-prone, proxy attendance
LMS manual entry [17]	5–8 min	LMS license	Post-class workload, delays
RFID / biometric [18–20]	$<$2 min	High	Privacy concerns, fixed hardware
QR-based system (this work)	$<$1 min	Low	Requires initial QR setup

2. System Design and Architecture

To improve efficiency and accuracy in attendance tracking, a standalone Windows application was developed, implemented, tested, and continues to be used successfully, ATER (AtTEndance Recording), which utilizes a vision tool with Quick Response (QR) codes. The system begins with a Python script, hosted on PythonAnywhere, which generates a unique QR code for each student when they enter their credentials on the provided link. As shown in Figure 1, the system minimizes administrative overhead by automating attendance recording and file generation. The ATER application, running on a laptop, allows one to upload the class list (in Excel format) and connect to a scanning tool, which is a phone camera wirelessly connected via the iVCam application, as illustrated in Figure 2.

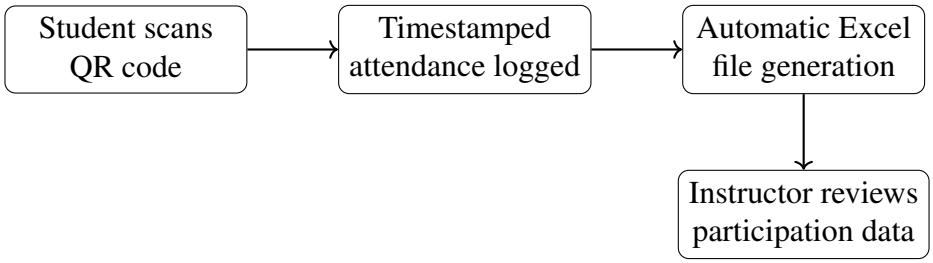

Figure 1: Workflow of the QR-based automated attendance tracking system from student interaction to instructor use.

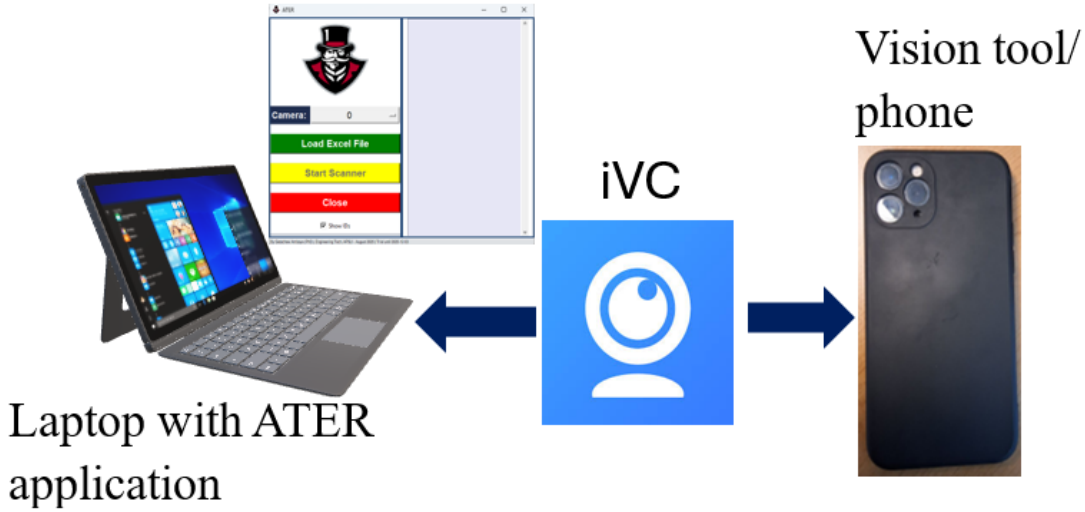

Figure 2: Current setup: Phone-to-laptop wireless connection via iVCam for attendance tracking.

The current implementation of ATER follows a straightforward software workflow (see Figure 3 for the current interface). The student's name and A-numbers are hidden in the provided figures. First, the user selects the appropriate camera from the system and imports the class roster from an Excel file. During attendance scanning, students present their unique QR codes to the camera, and once

recognized, the system marks them as present in real-time, with the option to hide the student ID or A-number if required. At the end of the session, the instructor closes the interface to automatically generate two Excel reports: a Daily Output File (see Figure 4a), which includes the student name, ID, and timestamp of each scan with each class meeting stored in a new worksheet, and an Overall Attendance File (see Figure 4b), which aggregates attendance throughout the semester by adding each new session as a separate column. This workflow demonstrates the feasibility of the system and establishes a strong foundation for transitioning to a dedicated classroom-ready station.

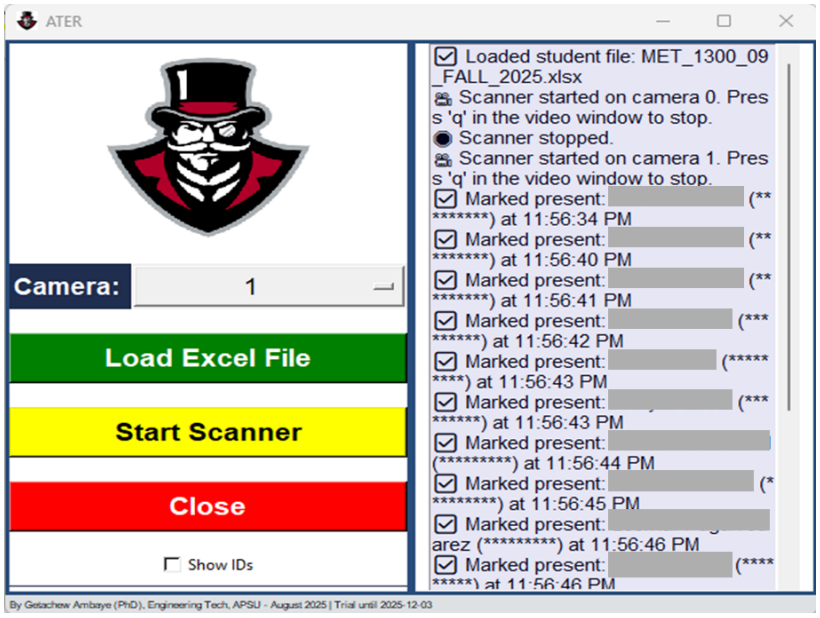

Figure 3: Current Software Interface and Functionality

a)

CRN	ID	First_Name	Last_Name	Time	Status
1109	*******34	F*********	L********	09:37:55 AM	Present
1109	*******37	A********	Y***	09:38:58 AM	Present
1109	*******46	A****	S******		Absent
1109	*******45	B****	P******	09:39:46 AM	Present
1109	*******62	C****	H*******		Absent
1109	*******27	D***	B*****		Absent
1109	*******84	D****	S****	09:37:41 AM	Present
1109	*******90	E******	S*******	09:36:02 AM	Present
1109	*******50	E***	W*******	09:39:08 AM	Present
1109	*******26	E****	W***	09:39:33 AM	Present
1109	*******04	G******	W*******		Absent
1109	*******27	J*****	O*****	09:41:02 AM	Present
1109	*******62	J*****	B*****	09:40:44 AM	Present
1109	*******56	K*****	F******	09:40:50 AM	Present
1109	*******05	M*******	F********		Absent
1109	*******25	S*****	D******	09:36:22 AM	Present
1109	*******14	S*****	H******	09:36:08 AM	Present
1109	*******54	T*****	F******		Absent
1109	*******05	T*****	S*********	09:40:25 AM	Present
1109	*******53	T*****	S***		Absent
1109	*******73	T******	V*****	09:37:46 AM	Present

2025-08-26 | 2025-08-28 | 2025-09-04 | 2025-09-11 | 2025-09-16

b)

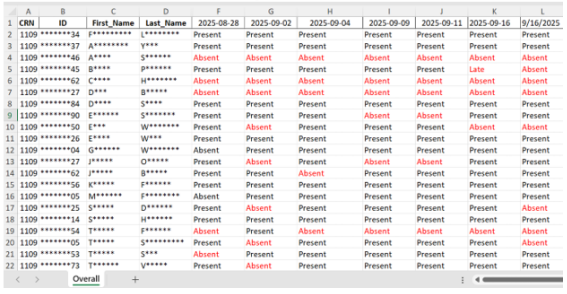

Figure 4: Automated attendance reports: a) Daily Output File, where each session is recorded in a new worksheet, b) Overall Attendance File, which compiles students' attendance participation across the semester.

2.1 Result and Discussion

The feedback survey was administered in paper format on the last day of class during regular class time, after the students had used the system for a semester. The system was implemented in three courses and a total of 37 students completed the in-class survey. Most of the respondents were first-year students (approximately 73%), followed by second-year (16%) and third-year (11%) students. The majority used the QR-based attendance system two times a week, primarily through mobile devices, while only a few with printed QR code paper, indicating good accessibility and ease of adoption.

In terms of usability, students generally found the system straightforward to use, with more than 80% describing it as either "easy" or "very easy." About 22% experienced minor technical difficulties, such as occasional scanning errors or slow response times during the first 2 weeks, often due to incorrect steps in obtaining their unique QR codes. Additionally, the challenge was that they placed their phone too far away or very close to the camera, which meant that only a portion of their QR code would be visible. After a few attempts, they were able to estimate where to place their phone over the camera. Most of the participants considered the system reliable in recording attendance, and around 70% completed the QR check-in process in less than ten seconds, reflecting the efficiency and responsiveness of the system.

As illustrated in Figure 5, most users rated the system as easy or very easy to use, and most reported no significant technical problems. Figure 6 further confirms the strong performance of the system, showing that most users found it reliable, with a quick and consistent check-in process.

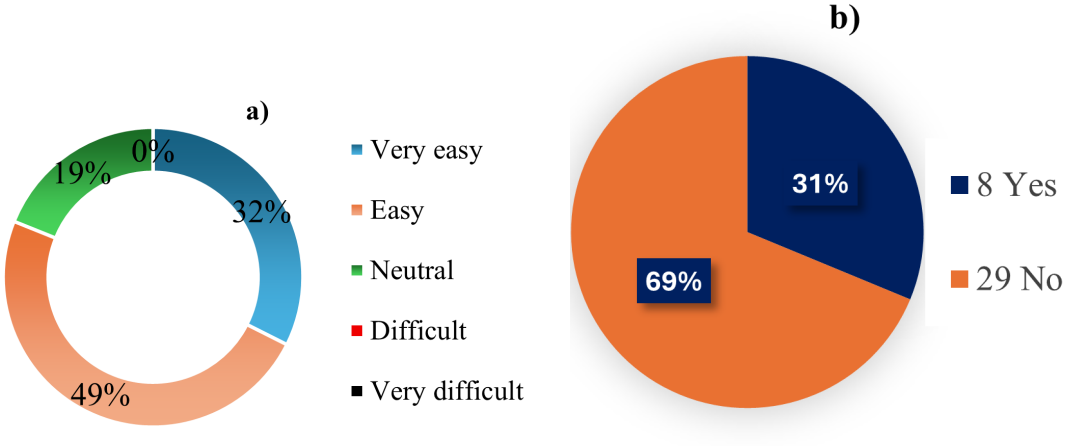

Figure 5: a) User usability response toward the developed attendance tracking system, b) Frequency of technical issues reported during system usage.

2.2 Learning Impact and Assessment

The students' opinions on the effect of the system on motivation and attendance were mixed. Although many remained neutral on its impact on attendance consistency, about one-third agreed

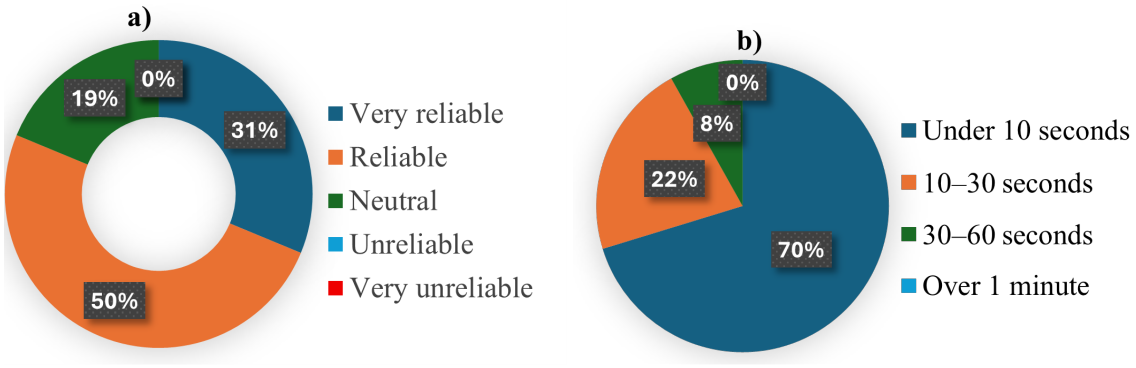

Figure 6: a) User evaluation of system reliability in recording attendance, b) Average time required for QR code check-in process.

that it helped improve academic performance. When asked about reducing proxy or fraudulent attendance, responses were divided, some believing that it effectively minimized such incidents, while others felt that its impact was limited. This suggests a potential improvement in the security features of the unique QR code system.

The students also highlighted several advantages of the system, including time efficiency (78%), improved record-keeping (68%), fairness and transparency (46%), and environmental benefits due to reduced paper use (43%). Many appreciated how the system streamlined class sessions by eliminating the need for manual roll calls.

For future enhancement, students recommended features such as real-time attendance confirmation, personalized attendance summaries, reminders, gamification or reward elements, and integration with academic performance tracking. Some also suggested adding options for viewing or correcting attendance records and improving the reliability of QR recognition.

Overall, satisfaction with the system was high, with 57% of students reporting being satisfied or very satisfied and none expressing dissatisfaction. The majority supported continued use of the system, highlighting its practicality, user-friendliness, and contribution to efficient classroom management.

In general, students gained meaningful exposure to practical technologies, including computer vision, introductory programming, and Internet of Things (IoT) system competencies that are increasingly essential in contemporary engineering education and workforce preparation. Students were introduced to the underlying operation of the system, including the structure of QR codes and generation standards, and generated their own uniquely formatted QR codes under instructor guidance. They actively interacted with the scanning process, reviewed logged attendance data, and were introduced to audio feedback mechanisms designed to distinguish between valid and invalid QR code scans.

Beyond its functional purpose, the system served as an instructional tool that exposed students to applied machine vision concepts and real world Python based implementation. Rather than treating attendance as a compliance task, this approach reframes automated attendance as a lightweight

instructional infrastructure that preserves class time while supporting participation in technology-rich learning environments. Table 2 presents the trends observed in instructional efficiency and student participation following the implementation of the QR-based attendance system.

Table 2: Observed Instructional Effects of QR-Based Attendance Implementation

Observed Outcome	Evidence from Deployment
Reduced administrative load	Attendance completed in under 10 seconds for most students
Improved instructional flow	Elimination of roll call and sign-in delays
Student technology exposure	Hands-on interaction with machine vision and data automation
Perceived fairness & transparency	80% of students cited improved fairness

The study protocol was reviewed according to institutional policies regarding human subject research. The survey was conducted anonymously, participation was voluntary and no personally identifiable information was collected beyond standard course related attendance data. All procedures were in accordance with institutional guidelines for ethical research practices.

3. Conclusion and Future Work

This paper presented the design, implementation, and evaluation of a QR code-based automated attendance tracking system that streamlines attendance management through real-time data capture and automated record generation. The system effectively minimizes manual effort, reduces errors, and provides structured, easily interpretable Excel-based participation reports. The survey feedback from the students confirmed the high usability, reliability, and efficiency of the system. More than 80% of the users found it easy to operate, 78% rated it reliable and most completed checks in under ten seconds. In addition, the participants appreciated its time-saving nature, improved record-keeping, and environmental benefits resulting from the reduction of paper use. Overall, the system was well-received and demonstrated strong potential as a modern digital solution for classroom management. Although some users suggested enhancements such as real-time confirmation, attendance summaries, and improved QR recognition, these represent opportunities for further development rather than system shortcomings.

This study involved 37 students from a single institution, which may limit the generalizability of the findings. While the results provide meaningful preliminary insights, future work will expand implementation to larger and multi-institutional samples to strengthen external validity. Survey responses were analyzed using descriptive statistics to summarize overall trends; future studies with larger samples will incorporate more advanced statistical analyses to further validate the findings. In addition, future development will focus on integrating the platform with institutional Learning Management Systems (LMS), developing cloud-based dashboards for real-time monitoring, and incorporating automated notifications and other scalable features to enhance system functionality and broader adoption.

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