

Smart Exam Hall Assistance and Alert Systems Using IoT: A Review of Existing Approaches and Research Gaps

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Abstract: Maintaining operational order, communication efficiency, and administrative integrity during academic examinations remains a significant challenge for educational institutions. Traditional invigilation relies on manual, verbal, or physical messenger-based communication when an invigilator requires additional examination materials (such as extra answer booklets, graph papers, or replacement question sheets), technical support, or emergency assistance. This manual approach introduces communication delays, causes hall disruptions, creates unnecessary physical movement, and lacks real-time receipt verification from the central control room. To contextualize and validate a low-cost, plug-and-play IoT solution, this paper presents a comprehensive literature survey analyzing recent advancements in IoT-enabled examination monitoring, physical material delivery automation, biometric authentication, acoustic alert systems, and wireless proctoring frameworks. By comparing state-of-the-art architectures, this survey identifies critical operational gaps in existing systems—specifically their focus on candidate surveillance rather than invigilator operational support, reliance on complex mechanical actuators, and lack of closed-loop bi-directional acknowledgment. Finally, this paper details the technical framework, hardware-software co-design, bi-directional Wi-Fi handshake protocol, and implementation roadmap for an ESP32-based assistance network.

Keywords: Internet of Things (IoT), ESP32 Microcontroller, Smart Exam Hall, Assistance System, Real-Time Alert, Wi-Fi Communication, Control Room Dashboard, Academic Infrastructure

I. INTRODUCTION

1.1 Background

Academic examinations serve as the primary instrument for evaluating student competence and institutional quality across higher education systems. Conducting large-scale examinations requires seamless coordination between individual testing venues and a central administrative control room. During an active examination session, invigilators frequently encounter operational requirements, including requests for supplementary answer sheets, specialized graph paper, replacement question papers, technical troubleshooting for digital equipment, or urgent medical and security assistance.

1.2 Problem Context & Motivation

In conventional university and polytechnic settings, resolving these requests relies on manual methods—such as dispatching a physical runner or staff member from the examination hall to the central administration office. This manual paradigm exhibits several fundamental drawbacks:

- **Operational Delays:** The time elapsed between identifying a material shortage and receiving the required items can range from 10 to 15 minutes, directly subtracting from a candidate's allocated testing time.



- **Hall Disturbance:** Physical movement across testing halls creates acoustic noise and visual disruption, compromising the quiet environment required for high-stakes assessments.
- **Lack of Acknowledgment:** Invigilators have no real-time mechanism to verify whether an emergency or material request has reached the control room or whether administrative staff are actively responding.
- **Mobile Phone Restrictions:** While mobile phones could theoretically facilitate instant messaging, institutional regulations strictly prohibit smartphones inside examination halls to prevent cheating and digital leakage, leaving invigilators without a direct digital communication link.

1.3 Existing Solutions & Proposed Research Direction

Recent advances in Internet of Things (IoT) technologies, lowpower system-on-chip (SoC) microcontrollers (such as the ESP32 and NodeMCU), and serverless web dashboards offer a transformative opportunity to digitize examination hall operations. While extensive research has addressed candidate proctoring, face recognition, and biometric attendance, minimal scholarly work focuses on invigilator-to-control-room operational assistance networks. This literature survey evaluates the broader landscape of IoT examination management systems, categorizes existing research paradigms, highlights critical unaddressed gaps, and establishes the architectural justification for dedicated, low-cost assistance networks.

II. LITERATURE REVIEW

2.1 Sensing Paradigms and Taxonomy

To establish a baseline for IoT-enabled examination management, existing literature within the ingested research corpus is categorized into five distinct technical domains:

- **Material Delivery & Physical Automation:** Automated script dispensing and paper distribution.
- **Acoustic Anomaly & Environmental Alerts:** Noise and whispering threshold detection.
- **Wireless Video Supervision & Remote Proctoring:** Remote video streaming and facial recognition.
- **Automated Attendance & Gate Clearance:** RFID/NFC identity and tuition clearance.
- **RF Sensing & Space Optimization:** Mobile phone signal detection and occupancy forecasting.

Table 1. COMPARATIVE ANALYSIS OF REVIEWED RESEARCH STUDIES

[Ref.]	Year	Approach / Technology	Main Contribution	Key Finding / Metric	Limitation
[1]	2022	NodeMCU + FPM10A Fingerprint + Stepper/Servo Motors	Biometric verification with motorized script delivery	Reduced distribution time from 12 min to 2–3 min	Mechanical paper jams on full answer booklets
[2]	2024	ESP32-CAM + FTDI + Ngrok Reverse Tunnel + Python CV	Low-cost real-time video streaming & facial recognition	Browser-accessible WAN video proctoring	Ngrok latency jitter & Wi-Fi bandwidth dependency
[3]	2024	ESP32-CAM + RC522 RFID + KY038 Sound Sensor + Google Sheets	Multi-sensor fusion for acoustic and visual alerts	Instant GPIO interrupt image capture to cloud	KY038 false alerts from ambient hall noise
[4]	2026	ESP32 + RC522 RFID + LM2596 Buck Converter + FastAPI	High-throughput RFID attendance logging	100% logging accuracy; 2.0s cloud latency	Passive RFID cards vulnerable to cloning
[5]	2025	Arduino Uno + Analog RF Sensor + ESP8266 + LCD	Centralized mobile phone RF signal detection	Real-time RF signal spike alert to dashboard	Cannot detect mobile phones in Airplane Mode
[6]	2022	ATmega328 + PN532	Combined tuition fee	Zero NFC card reading	Requires wired serial



		NFC + MAX232 DB9 Serial + MySQL	clearance & gate admittance	collisions at entrance	link to local server
[7]	2018	IR Beam Counters + AI Regression + Campus VLAN DB	AI-driven campus-wide classroom space optimization	Attendance prediction RMSE = 0.16; >10% cost saving	High initial infrastructure deployment cost

2.2 Material Delivery, Acoustic & Video Surveillance

Automation of examination material handling has been explored primarily through mechanical and biometric integration. Tabassum et al. [1] engineered an automated examination management system utilizing a NodeMCU (ESP8266) microcontroller interfaced with an FPM10A optical fingerprint scanner and a motorized paper delivery mechanism. The physical dispensing system deployed a 28BYJ-48 stepper motor with a ULN2003 driver and a servo pusher to physically elevate and dispense examination scripts upon successful fingerprint verification. While reducing distribution time from 12 minutes to 2 minutes, mechanical paper feeders proved highly susceptible to paper jams when handling full-sized answer booklets.

Monitoring the ambient acoustic environment inside examination venues is critical for preventing unauthorized communication. Amali et al. [3] developed an IoT examination hall monitoring system combining an ESP32-CAM module, an MFRC522 RFID scanner, and a KY038 sound comparator sensor. Upon detecting acoustic anomalies crossing a decibel threshold, the KY038 sensor triggers a hardware GPIO interrupt on the ESP32-CAM, capturing an image and posting an alert to Google

Sheets via HTTPS. However, analog sound sensors lack directional filtering and frequently trigger false positive alerts from ambient room noise.

Visual surveillance has transitioned toward low-cost wireless edge-computing nodes. Omodunbi et al. [2] developed an IoT surveillance system utilizing an ESP32-CAM board programmed via an FTDI adapter. The ESP32-CAM streams real-time video feeds over LAN/WAN via Ngrok reverse tunneling, enabling administrators to monitor hall activities through web browsers while processing frames through a Python face recognition pipeline.

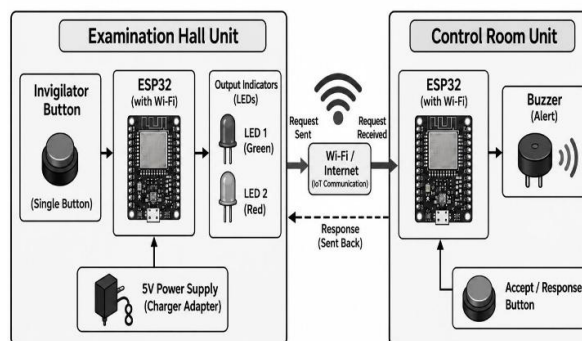


Fig. 1. System block diagram of the smart exam hall assistance and alert network illustrating the sender node, wireless IoT link, and control room receiver station.

2.2 Biometric Attendance, Gate Clearance & Mobile Detection

Identity verification represents a mature domain in academic IoT literature. Adu & Olawunmi [4] implemented a smart attendance system pairing an ESP32 with an RC522 RFID reader and an LM2596 DC-DC buck converter. The system communicates with a FastAPI Python web backend, using middleware to write attendance timestamps directly to cloud-hosted Google Sheets with 100% data logging accuracy and a 2.0-second cloud synchronization latency.



In gate admittance verification, Ahiara & Okey [6] built an NFC-IoT monitoring system using an ATmega328 microcontroller and a PN532 NFC module (13.56 MHz) to validate student tuition payment records in a MySQL database prior to exam hall entry. To address unauthorized cellphones, Nalawade et al. [5] engineered a centralized mobile detection system using analog voltage sensors connected to an Arduino Uno and ESP8266 to detect RF signal spikes during active cellular transmission. At the campus scale, Sutjaritham et al. [7] deployed predicting classroom attendance with an RMSE of 0.16 and optimizing room allocation.

2.3 Identified Research Gaps

A critical analysis of the literature reveals several fundamental operational gaps:

- **Surveillance Bias vs. Operational Assistance:** Existing literature overwhelmingly prioritizes candidate monitoring (detecting cheating via video [2], sound [3], or RF signals [5]). Virtually no attention is given to operational assistance for invigilators, who manage physical materials, paper shortages, and hall emergencies.
- **Mechanical Dispensing Friction:** Automated material dispensing setups [1] attempt to replace human handling with motorized actuators. In real-world examination halls, paper thickness variations, humidity, and static electricity cause frequent multi-sheet feeding errors and mechanical paper jams.

IR beam counters and AI regression models across 9 lecture halls,

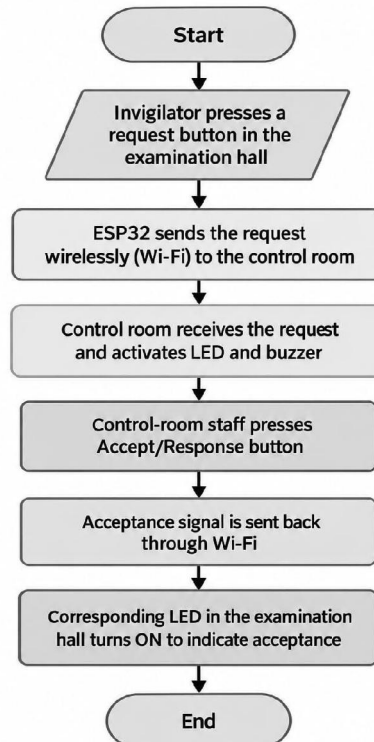


Fig. 2. Operational flowchart of the bi-directional Wi-Fi handshake sequence for examination hall assistance request and control room confirmation.

3. Cause frequent multi-sheet feeding errors and mechanical paper jams.

4. **Lack of Bi-Directional Acknowledgment:** Sensor-based alert systems [3, 5] operate as one-way alert pipelines: a sensor triggers, and an alert is logged on a remote dashboard. They lack a bi-directional acknowledgment mechanism where control room staff can send a confirmation signal back to the examination hall.



5. Mobile Phone Restrictions: Invoking mobile apps or smartphone messaging inside an examination hall violates strict anti-cheating regulations. Dedicated, single-purpose hardware units powered by standard USB adapters bypass mobile phone restrictions completely.

III. CONCLUSION AND FUTURE SCOPE

This literature survey paper contextualizes smart examination assistance systems within the broader landscape of academic IoT research. By evaluating existing studies across material automation, acoustic monitoring, video surveillance, and RFID attendance, this paper demonstrates that prior research heavily favors candidate surveillance over invigilator operational support. Future research must focus on multi-hall scalability via MQTT brokers, prioritybased interrupt queuing, and LoRaWAN long-range fallbacks to ensure communication resilience during campus network outages.

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