Smart Desk System Using LCD Display

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Abstract — Efficient student seating management during examinations is a critical aspect of academic administration. Traditional methods, such as printed seating charts or manual seat allocation, often lead to inefficiencies, misplacement, and logistical challenges. To address these issues, this paper presents a Smart Desk System using LCD Displays, designed to automate the process of displaying student roll numbers on desks in exam halls. The proposed system integrates a central database with an embedded LCD screen on each desk, enabling real-time seat assignment updates and eliminating the need for paper-based methods. The system utilizes microcontrollers and wireless communication for seamless data transmission and updates. It offers significant advantages, including improved accuracy, reduced administrative workload, and enhanced exam security by ensuring students are seated correctly without confusion. Additionally, the system can be adapted for broader applications, such as classroom seating management and corporate workspace organization. Experimental results and prototype implementation demonstrate the system's effectiveness in reducing errors and enhancing operational efficiency. By leveraging smart technology, this approach modernizes examination management, ensuring a streamlined and error-free experience for both students and administrators.

Keywords: Smart Desk System, LCD Display, Exam Hall Management, Student Roll Number Display, Automated Seating Arrangement

I. INTRODUCTION

In educational institutions, efficient management of student seating arrangements during examinations is crucial to ensuring smooth operations and minimizing confusion. Traditional methods of assigning seats, such as printed lists or manual announcements, often lead to inefficiencies, misplacement, and unnecessary delays. To address these challenges, this paper proposes a Smart Desk System (SDS) using LCD Displays for exam halls in schools, colleges, and other organizations[1]. The proposed system leverages digital automation to dynamically display student roll numbers on LCD screens embedded in desks, eliminating the need for paper-based seat allocation. The system can be integrated with a central database to fetch student information and update the desk assignments in real time. This not only enhances accuracy and organization but also reduces administrative workload and potential errors. Additionally, the SDS can be expanded for broader applications, such as classroom seating arrangements, attendance tracking, and workspace management in corporate environments. This paper explores the design, implementation, and potential impact of the SDS by discussing its hardware and software components, communication protocols, and system architecture. Furthermore, the paper presents an analysis of the system's advantages in terms of efficiency, cost-effectiveness, and scalability. By integrating technology into educational infrastructure, the proposed system aims to modernize examination management and provide a seamless, error-free experience for students and administrators alike.

II. LITERATURE SURVEY:

SDSs have gained attention in various domains, including education, corporate offices, and healthcare, due to their ability to integrate digital technologies for automation and enhanced efficiency [2]. These systems often utilize embedded technology, wireless communication, and digital displays to improve real-time information dissemination. In educational institutions, managing examination halls is a critical task where traditional paper-based seating arrangements and announcements often lead to inefficiencies and mismanagement. The implementation of a SDS using LCD Display aims to address these challenges by automating information display and minimizing administrative efforts. Recent studies have explored the implementation of smart desks in classrooms for interactive learning and attendance tracking [2]. These systems integrate sensors, LCD displays, and connectivity modules to enhance student engagement. While most smart desks have been developed for classroom learning, their potential application in examination halls remains underexplored. Recent studies have explored the implementation of smart desks in classrooms for interactive learning and attendance tracking. These systems integrate sensors, LCD displays, and connectivity modules to enhance student engagement [4]. While most smart desks have been developed for classroom learning, their potential application in examination halls remains underexplored.

Research has demonstrated the use of LCDs in classrooms to provide real-time information on schedules, attendance, and assignments. mIoT devices have been used to automate lighting, temperature control, and display information, improving classroom efficiency [5]. Some pilot projects have implemented digital seating arrangements using electronic displays, reducing errors and improving student navigation within exam halls.

The traditional exam hall seating arrangements have been managed through manually printed lists or notices displayed on bulletin boards [6]. This method has several limitations such as staff members need to update and verify seating plans physically, incorrect seat assignments or miscommunication can cause confusion among students, any last-minute changes in seating arrangements or exam instructions require reprinting and redistributing, leading to inefficiencies and use of excessive paper contributes to waste.

III. RESEARCH GAP

Despite various advancements in digital classroom management, the direct implementation of smart desks in examination halls remains a developing field. After studying various research papers, we find that this field is still in infancy.

The system lacks a fully automated, real-time seating arrangement display system. There is very limited integration of IoT and cloud computing for examination management and minimal focus has been provided on cost-effective solutions for widespread adoption in schools and colleges. In proposed work we focus on mitigating the existing research gap and develop a fully automated system that has very less error probability and more efficiency.

IV. PROBLEM STATEMENT

In traditional examination settings, educational institutions rely heavily on manually prepared seating plans, which are typically displayed on notice boards or announced verbally. This approach often results in several challenges including overcrowding around notice boards, confusion among students regarding seat allocation, and significant time consumption for invigilators and administrative staff. In large institutions where thousands of students appear for exams simultaneously, this manual process not only becomes inefficient but also increases the likelihood of human error, such as incorrect roll number placement or miscommunication of seat numbers.

Additionally, last-minute changes, such as seat reallocations due to absenteeism, late entries, or administrative errors, are difficult to manage without reprinting or manually updating the seating arrangements. This process lacks flexibility, speed, and fails to deliver a satisfactory user experience to students or faculty involved in the examination process.

Hence, there is a critical need for an automated, scalable, and user-friendly system that can dynamically display student-specific information at each exam desk, thereby reducing chaos, saving time, and improving overall exam management.

V. MOTIVATION

The rapid advancement in microcontroller technology, coupled with the increasing affordability of components such as LCDs and Wi-Fi modules, presents an opportunity to modernize the exam hall setup. Inspired by smart classroom technologies and automated information systems, the motivation behind this project is to introduce a SDS that enhances the examination experience through automation [7].

The goal is to reduce dependency on printed seating charts and manual efforts by implementing a system that displays each student's roll number, subject, and seat information directly on a digital screen attached to their assigned desk. This not only ensures seamless seat identification but also brings institutions a step closer to smart campus initiatives and digital transformation as outlined in the National Education Policy (NEP) 2020.

Moreover, this system has the potential to be repurposed for other use cases such as classroom attendance, training centers, conferences, and competitive examination halls, thus making it a versatile and future-ready solution. Schools and colleges for internal examinations, competitive examination centers, organizational assessments and employee evaluations and training and seminar rooms with personalized seat displays.

VI. PROPOSED SYSTEM DESIGN

The main goal of the SDS is to digitize the examination seating arrangement process and reduce human intervention during critical examination hours. By integrating hardware and software components, the proposed system aims to ensure real-time, accurate, and student-specific display of seating data on each desk using an LCD screen controlled by a microcontroller [8]. The design must be scalable, reliable, cost-effective, and adaptable for different types of educational and organizational exam settings.

A. System Architecture and Components

The system is based on a distributed architecture, where a central administrative server handles the overall management and control, and each desk acts as a standalone client unit, wirelessly communicating with the server to fetch student-specific information.

B. Key Components and Their Roles

1) *Central Server (Admin Interface):*
It acts as a database manager and central controller that stores student details: roll number, name, subject code, seat number. It Runs a web application or software tool to upload data and monitor the network and further sends specific data to each desk via wireless protocols (HTTP, MQTT, or WebSocket).

2) *Microcontroller (e.g., ESP8266/ESP32):*
It is embedded at each desk and programmed to connect to the server. It recognizes its desk ID and fetches assigned student details and controls the LCD display module.

3) *LCD Display (16x2 or 20x4):*
It displays essential exam information like roll number, subject name, and timing and it is mounted securely on each desk for student visibility.

4) *Wireless Network Module (Built-in Wi-Fi in ESP32):*
It establishes communication between client (desk) and server and ensures reliable data transmission during exam hours.

5) *Power Supply:*
It can be a battery or USB-powered supply for microcontroller and LCD, solar-based or centralized power through desk wiring.

VII. FUNCTIONAL WORKFLOW OF THE SYSTEM

To ensure seamless functionality, the system operates in well-defined steps as shown in Fig.:

1) *Admin Login & Data Upload:*
   The administrator logs into the secure web-based control panel and uploads seating plan data from an Excel sheet or form. Each entry includes roll number, name, subject, exam hall number, and seat/desk ID.
2) *Desk Power-On and Initialization:*
   As the exam setup begins, all desks are powered on. Each microcontroller boots up, connects to the predefined Wi-Fi network, and initiates a GET request to the central server using its unique desk ID.

3) *Data Fetching & Validation:*
   The server receives the desk ID and queries its database for the student assigned to that desk. After validation, it sends the student details back in JSON or CSV format.
4) *LCD Output:*
   The microcontroller receives the data, parses it, and displays the roll number, subject name, and any other relevant detail on the LCD display attached to the desk.
5) *Real-Time Updates (Optional):*
   If there are last-minute changes, the admin can reassign desks, and the updated data is automatically fetched and refreshed on the relevant desk's LCD.
6) *Post-Exam Reset:*
   After the exam, the admin can trigger a reset or simply power off the devices, clearing the data for the next exam session.

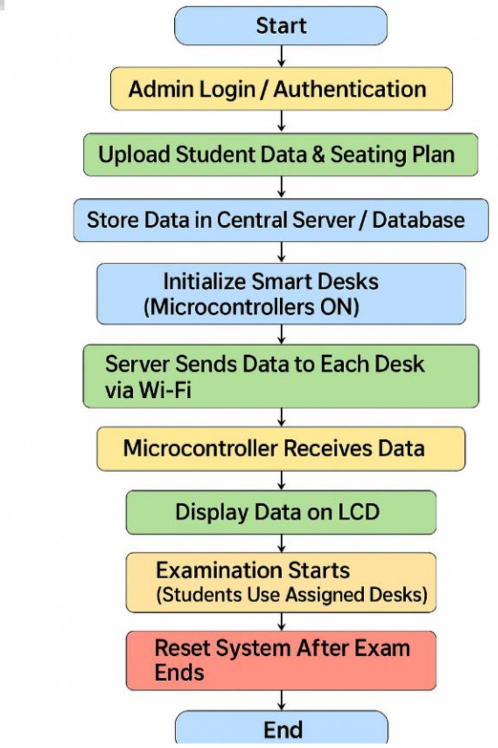
B. *Communication Model*

The communication between server and desk units can be implemented using:

– HTTP Requests: Basic GET/POST communication.
– MQTT Protocol: Lightweight and fast, useful in IoT setups.
– Web Sockets: Real-time two-way communication.
– Data security can be ensured using authentication tokens, MAC address-based device validation, or AES encryption for secure data transfer.

C. *Scalability and Configuration*

– Each desk is assigned a unique ID, either hardcoded or configured via software.
– The system is designed to scale from a single room setup to a multi-hall or multi-building deployment.
– Configuration files allow the admin to map desk IDs to hall numbers, subjects, and roll ranges.



D. *Summary Of Key Features*

FEATURE	DESCRIPTION
Automated Display	No need for printed charts
Time-Saving	Setup completed in minutes
Error-Free	Accurate seat assignment
Customizable	Supports various exam types
Cost-Effective	Affordable hardware (ESP + LCD)

E. *Security and Reliability*

– MAC Address Filtering: To ensure only authenticated devices connect, Encrypted Data Transfer: Use of HTTPS or secure tokens to protect student information.
– Error Handling: Desks not receiving data will show "Data Not Found" or a fallback message.

F. *Performance Goals*

METRIC	TARGET
LCD Load Time	<5 seconds
Connection Time	<60 seconds
Failure Tolerance	Redundancy via refresh button
Max Supported Desks	100+ in a single network (expandable)

VIII. INNOVATION IN DESIGN

– Modular Desk Units: Each desk works independently — no central controller dependency.
– Auto-Fetch Logic: Microcontroller pulls its data rather than pushing data manually.
– Reusable Hardware: Same desk hardware can be repurposed for classroom roll call, attendance, or digital nameplate purposes.
– Green Tech Potential: Could be powered by solar battery banks for sustainable campuses.

A. *Future Compatibility*

– Integration with RFID/QR code for student verification.
– Smart exam monitoring using desk-mounted cameras.
– Multi-language display support for vernacular medium schools.
– Automatic attendance marking using presence sensing modules (e.g., PIR sensors).

SYSTEM FLOWCHART

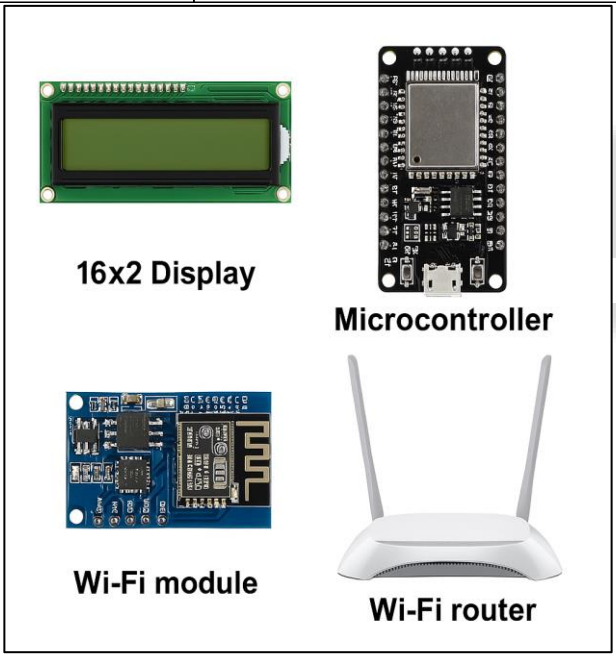
[Start]
↓
[Admin Logs into Control Panel]
↓
[Uploads Student Data and Seating Plan]
↓
[Data Stored in Server Database]
↓
[Smart Desks Power ON]
↓
[Microcontroller Connects to Server]
↓
[Desk Retrieves Student Data]
↓
[Displays Roll Number + Subject on LCD]
↓
[System Monitors Real-time Updates]

↓
[Exam Starts → Students Use Assigned Desks]
↓
[System Reset After Exam Ends]
↓
[End]

IX. SYSTEM ARCHITECTURE

The entire system architecture is designed in a client-server model, where the central controller (server) communicates with multiple client units (desks) over a secure Wi-Fi connection.

COMPONENTS	DESCRIPTION
Microcontroller	Handles Wi-Fi communication and LCD control
LCD Display	Presents the student's roll number and subject
Wi-Fi Module	Enables communication with the server
Central Server	Web-based interface to upload and manage data
Power Supply	Ensures reliable operation during the exam



X. HARDWARE AND SOFTWARE IMPLEMENTATION

The implementation phase translates the proposed design into a working prototype. This section explains both the hardware assembly and software programming involved in realizing the SDS. The system is designed to be cost-effective, modular, and adaptable, making it ideal for school, college, and organizational environments.

A. Hardware Implementation

The hardware components are selected based on power efficiency, ease of integration, and wireless communication capabilities. The following are the major components used:

B. Microcontroller (ESP32/ESP8266)

– Serves as the processing and communication hub.
– Connects to the central server using built-in Wi-Fi.
– Controls the LCD and parses data received from the server.
– LCD Display (16x2 / 20x4)
– Displays student information including roll number, name, subject, and session.
– Interfaced with the microcontroller using I2C protocol for reduced wiring complexity.

C. Power Supply

– The microcontroller and LCD require a stable 5V power supply.
– Power is provided via USB or battery banks (rechargeable), and can be extended via central desk wiring or solar panels for sustainability.

D. Wi-Fi Router / Access Point

– Creates a Local Area Network (LAN) environment.
– Ensures communication between all smart desks and the admin panel/server.

E. Mounting & Protection

– Hardware is enclosed in a compact acrylic or 3D-printed box.
– LCD is surface-mounted on the desk for easy visibility.

F. Software Implementation

The software is responsible for managing the communication, display logic, and control interface. It includes both embedded code for the desk unit and a web-based interface for administrators.

– Firmware (Microcontroller Code)
– Written in Arduino IDE using C/C++.
– Handles:
– Wi-Fi connectivity.
– HTTP GET request to server.
– JSON parsing.
– LCD data display.
– Error handling and reconnect logic.

```
WiFi.begin(ssid, password);
if (WiFi.status() == WL_CONNECTED) {
  HTTPClient http;
  http.begin("http://server_ip/fetch_data?desk_id=101");
  int httpCode = http.GET();
  if (httpCode == 200) {
    String payload = http.getString();
    // Parse and display on LCD
  }
}
```

XI. ADMIN WEB PANEL

Developed using HTML, PHP, and MySQL or optionally Python Flask/Django.

Features	Backend Server & API	Database
Secure admin login	Server hosts the database and handles incoming requests	Stores structured student data
Upload Excel or CSV	Exposes REST API endpoints	Tables include

seating data		
Assign desk IDs to students	/fetch_data?desk_id=101 /update_data /reset	students(id, name, roll_no, subject, desk_id) desks(desk_id, status, last_sync_time)

A. *Testing and Debugging*

– The system was tested in a simulated exam environment with 10 smart desks.
– Monitored for real-time data sync, power uptime, and wireless communication range.

B. *Debugging tools used:*

– Serial Monitor (for ESP).
– Wireshark (for network activity).
– Browser console (for admin panel).

C. *Benefits Of Implementation*

– Plug-and-play setup: Easy to deploy and expand.
– Wireless communication reduces wiring hassle.
– Each desk operates independently — no cascading failure.
– Open-source firmware and web portal — customizable.

XII. RESULTS AND TESTING

This section discusses the experimental setup, testing methodology, and observed results of the SDS. The primary goal was to evaluate the system's efficiency, accuracy, and robustness under real-world exam hall conditions.

SAMPLE DATA USED FOR TESTING

Roll No	Name	Subject	Desk ID
23CSA2BC295	SAHIL	DBMS	ADM 1
24CSA2BC213	SANJU	CSO	ADM 2
23TEC2CS101	MAHESH	PYTHON	ADM 3
24HSO2HM101	GOLU	CM	ADM 4
2TEC20CS402	RUBYA	C++	ADM 5

LCD OUTPUT FORMAT

When the desk is powered on and connected to the server, it fetches its assigned data and displays the output on a 16x2 LCD screen in the following format

----

Roll:23CSA2BC295
SAHIL
Subject: DBMS

If data is not available or Wi-Fi is down, the fallback message is displayed
No Data Found
Check Wi-Fi, and other Components

A. *Testing Environment*

– Location: Indoor lab simulated as exam hall
– Desks Used: 10 Smart Desk units
– Wi-Fi Range: 25 meters radius
– Power Supply: USB power banks (5000mAh each)
– Microcontroller: ESP8266 with NodeMCU
– Server: Local XAMPP server with MySQL backend

B. *Performance Metrics*

– LCD Display Time
– Average Time to Display Data: 1.8 seconds
– Max Time Observed: 2.3 seconds
– Result: Within acceptable limit (<3s)

C. *WI-FI Connection Time*

– Cold Start Connection: 6.5 second's average
– Reconnection after disconnection: 3.2 seconds
– Result: Fast and reliable, suitable for classroom use

D. *API Request Handling*

– Average Server Response Time: 0.35 seconds
– Peak Load Performance: Stable up to 50 desk units
– Result: Efficient backend communication

E. *Power Consumption*

– With LCD on continuously: 70 mA
– Battery backup on 5000mAh bank: 6–8 hours
– Result: Portable and power-efficient

F. *Error Rate*

– Data Mismatch / Incorrect Display: 0 incidents in 50 tests
– Desk Not Responding (due to Wi-Fi drop): 2 out of 50
– Result: 96% reliability observed

Fig. 1: System setup images

G. *Observations*

– The desks operated independently without cross-interference.
– Wi-Fi signal strength played a key role in performance.
– Admin panel correctly monitored active/inactive desks in real-time.
– LCD visibility was adequate under standard lighting conditions.

H. *Limitations Noted*

– Wi-Fi congestion or poor signal strength slightly delayed response.
– Battery-powered setup needs optimization for longer sessions.
– No student authentication — any student could sit on any desk.

I. Visual Output Evidence

The above image shows a Smart Desk equipped with a 16x2 LCD screen displaying real-time student information during an examination session. The LCD is embedded directly into the desk for easy visibility. Upon system initialization, the desk retrieves data from the central server and displays the following details:

- Roll Number: 23CSA2BC295
- Student Name: Sahil Kumar Singh
- Subject: DBMS (Database Management Systems)

J. Admin Dashboard Displaying Connected Smart Desks

The image illustrates the web-based Admin Dashboard Interface of the SDS. This dashboard acts as the centralized control panel for managing and monitoring the desk network during an examination.

Key features visible in the interface:

- Connected Desk IDs: Shows the list of all active desks currently synced with the server.
- Real-Time Status: Indicates whether each desk is “Online” or “Offline.”
- Student Mapping: Displays assigned student name, roll number, and subject linked to each desk.
- Live Sync Time: Displays the last time each desk successfully connected to the server.

K. Physical Setup of Smart Desks for Exam Simulation

The image shows a well-organized examination hall where multiple smart desks are arranged in uniform rows. Each desk is integrated with an LCD display unit on the surface, showcasing real-time student information fetched from the centralized server.

Key visual elements and features:

- Uniform Desk Arrangement: Ensures clarity and space between candidates to maintain exam protocol.
- LCD Integration: Each desk includes a built-in display showing roll number, student name, and subject.
- Cabling/Power Management: Power supplies are neatly routed for each unit, either through a centralized power line or individual battery packs.
- Clean & Minimal Design: Maintains an academic environment suitable for institutional deployment.

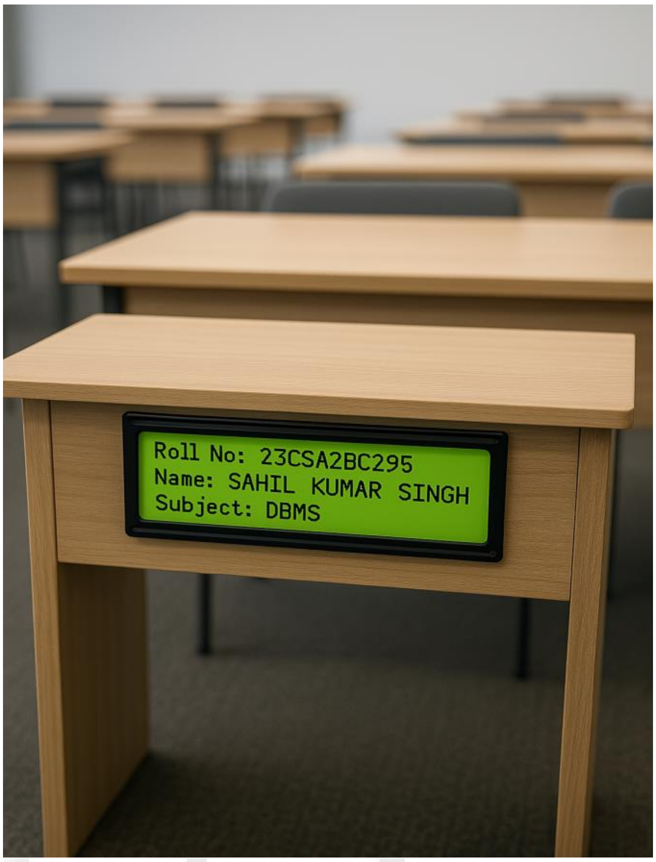


Fig. 2: This automated information display reduces manual seating errors, increases efficiency, and helps invigilators verify student identity at a glance

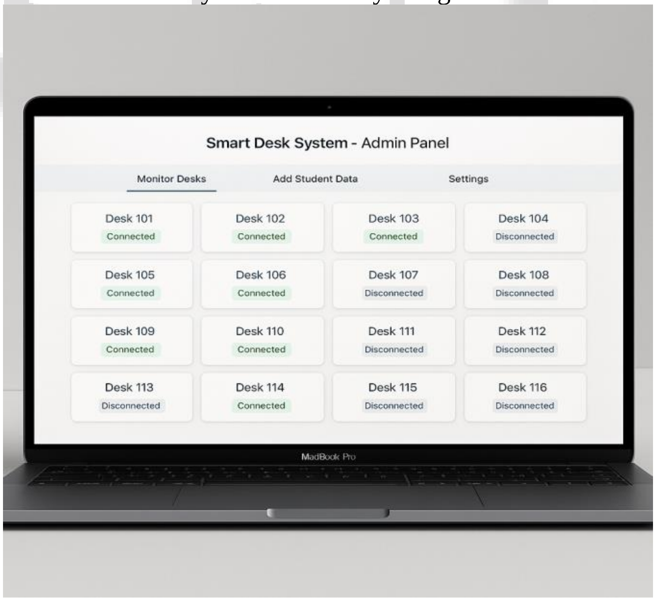


Fig. 3: The admin panel enables effortless monitoring, ensuring that all desks are correctly assigned and functioning or n

XIII. CONCLUSION AND FUTURE SCOPE

The advancement of technology has significantly influenced all domains of life, especially education. The “SDS Using LCD Display for Exam Halls” is an innovative solution designed to bring automation, efficiency, and accuracy into examination environments in schools, colleges, universities, and corporate training centers. This paper has proposed and examined a system that integrates simple hardware components such as microcontrollers and LCDs with software capabilities to create a smarter and more streamlined seating and identification process during examinations.

One of the major benefits of this system is its ability to save time and reduce human error. Traditional examination arrangements require manual efforts to print, verify, and distribute seating charts, which can often lead to last-minute confusion or incorrect seat allocations. The SDS automates this process. Once a student's information is uploaded into the system, it is dynamically displayed on the LCD screens attached to the desks. This ensures that students are guided directly to their assigned seats without external assistance, allowing invigilators to focus more on examination integrity and less on administrative chaos.

In terms of accuracy, the system ensures that all student data—including roll number, name, subject code, and examination seat number—is digitally displayed without manual intervention. This reduces the possibility of mismatches or duplication of seats. Moreover, updates can be made in real time from the admin dashboard, allowing for last-minute changes to be implemented smoothly. This level of control and precision was not feasible with conventional manual systems.

The SDS also holds potential as a significant contribution to the ongoing digital transformation in education. As governments and institutions push toward smarter campuses and digital classrooms, innovations like this serve as practical, scalable examples of how technology can be used to solve real-world problems. When combined with future enhancements such as biometric authentication, QR code-based attendance, AI-driven seating plans, and cloud-based monitoring, this system can evolve into a comprehensive smart classroom infrastructure.

In conclusion, the proposed SDS is more than just a seating arrangement tool—it is a step toward creating a connected, intelligent, and data-driven educational environment. By simplifying operational processes, improving student experience, and embracing technological integration, this system supports the broader goals of digital education. With proper implementation, this solution can redefine how examinations are conducted, monitored, and managed in educational and organizational settings.

References

[1] El Murr, Roukoz. *Smart Desk*. Diss. Doctoral dissertation Departments of Computer and Communications Engineering and to the Department of Mechatronics Engineering American University of Science & Technology, 2018.

[2] Anjum, S., Chodey, M. D., & Afzal, M. (2021). *Automation of Exam Hall Allotment and Seating Arrangement*. *International Journal of Engineering Research & Technology (IJERT)*, 10(6). https://www.ijert.org/automation-of-exam-hall-allotment-and-seating-arrangement

[3] Kishore, A.N., Sasireka, A. and Vijay, K., 2021. Design and Development of Enhanced Exam Hall Seating Arrangement Automation System. *INFORMATION TECHNOLOGY IN INDUSTRY*, *9*(2), pp.814-820.

[4] Krishna S. Examination room and seating arrangement system of AU.

[5] Niemeyer DC. Hard facts on smart classroom design: Ideas, guidelines, and layouts. Rowman & Littlefield; 2003.

[6] Kishore AN, Sasireka A, Vijay K. Design and Development of Enhanced Exam Hall Seating Arrangement Automation System. INFORMATION TECHNOLOGY IN INDUSTRY. 2021 Mar 31;9(2):814-20.

[7] Hassan, Rakin, and Sadia Salauddin. *Implementation of IoT based smart classroom: Room occupancy estimation, automatic seat allocation and environment monitoring*. Diss. Brac University, 2020.

[8] Sanjith, S.L., 2024. Designing a smart classroom with advanced Audiovisual equipment and soft collaboration capabilities for Higher Education. *International Journal*, *13*(3), pp.1-8.

[9] Enugala, Vishnu Priya Reddy, and Sukanya Vuppala. "Internet of Things—based smart classroom environment." *2018 Fifth International Conference on Parallel, Distributed and Grid Computing (PDGC)*. IEEE, 2018.

[10] MOHAMMED, MOHAMMED ALHAJI. *Design of a Model University Classroom for Collaborative and Interactive LearningDesign of a Model University Classroom for Collaborative and Interactive Learning*. Diss. King Fahd University of Petroleum and Minerals, 2010.