PERSONALIZED INTERACTIVE SMART DESK WITH RANDOMIZED QUESTION DELIVERY BASED ON STUDENT ID FOR ENHANCED LEARNING ENGAGEMENT

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***Abstract**: In response to the growing need for enhanced classroom management and security, this paper introduces an upgraded smart desk system with integrated video streaming and advanced features for a more controlled and interactive learning environment. The proposed system utilizes the ESP32-CAM for real-time video surveillance, which is streamed via the internet to a local webpage for continuous monitoring. Each student desk is equipped with an RFID tag system for identification, a TFT capacitive touch display for exam instructions and question presentation, and a sound sensor to detect unauthorized communication.This comprehensive approach aims to improve exam integrity, enhance student engagement, and streamline classroom management. Overall, the proposed system enhances functionality, security, and user interaction, addressing limitations of the existing system and offering a more robust solution for classroom management.*

Keywords: *Embedded; IoT; ESP32 Cam; Smart Desk*

I. INTRODUCTION

The proposed system integrates the ESP32-CAM for video streaming, allowing for continuous real-time monitoring of the classroom. This feature enhances security and oversight by enabling invigilators to observe student activities remotely through a local webpage. This capability addresses potential issues with cheating or unauthorized behavior during exams.Each student desk is equipped with an RFID tag system for automatic identification. When students use the RFID tags, identities are quickly and accurately recorded, streamlining administrative tasks and ensuring that student data is reliably captured without manual input.The system employs a TFT capacitive touch display at each desk to present exam instructions and questions. This interactive display allows for dynamic presentation of exam content, including options to select question sets and view questions one by one with a specified time limit, thus improving the overall exam experience.To prevent unauthorized communication, the proposed system incorporates sound sensors at each desk. These sensors detect any conversations or disruptive noises, triggering warnings to students and alerts to invigilators, thereby maintaining exam integrity and reducing the likelihood of cheating.

II. FUNCTIONAL OVERVIEW

1. Student Identification: When a student arrives at a desk, the student taps the RFID card on the reader. The microcontroller reads the card, identifies the student, and displays the assigned seat number on the TFT display.
2. Exam Administration: The TFT display presents exam instructions and questions. Students can interact with the display to select question sets, view questions one by one, and submit the answers.
3. Sound Monitoring: The sound sensor constantly monitors the ambient noise level. If it detects excessive noise or conversations, it triggers a warning on the TFT display and alerts the invigilator through the buzzer and the web page.

4. Video Surveillance: The ESP32-CAM captures real-time video footage of the classroom, which can be accessed remotely by invigilators through the web page. This allows for visual monitoring of student behavior and detection of any suspicious activity.
5. Data Storage and Analysis: Data collected by the devices, such as student attendance, exam performance, and sensor readings, is stored in the cloud. This data can be used for analysis and to improve the exam administration process.

Things you need:

To create the smart desk you need the following stuff

- ESP32 Micro controller
- ESP32 CAM Module
- Sound Sensor
- TFT display
- Buzzer
- RFID Reader
- RFID Tag x 2
- Power Supply
- Arduino IDE

III. DESIGN

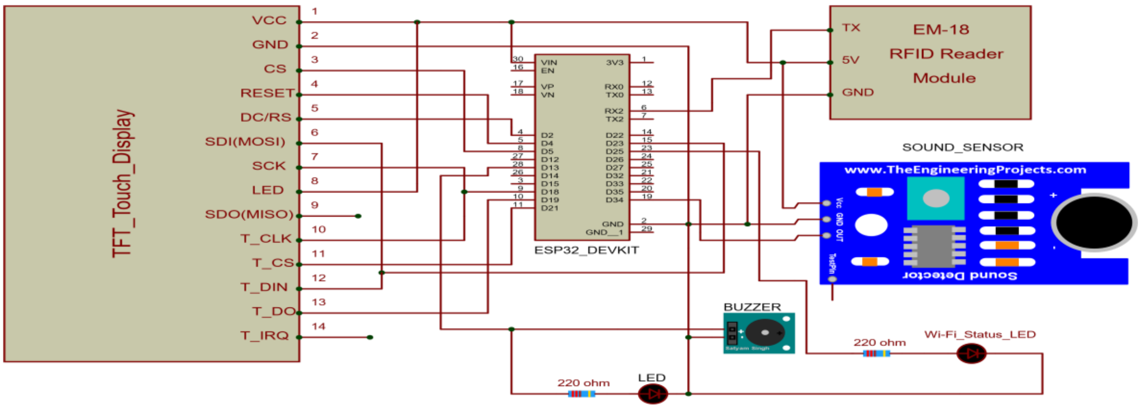

Fig.1 Circuit Diagram of Smart Desk

- This circuit integrates multiple components, including a **TFT Touch Display**, an **RFID Reader (EM-18)**, a **Sound Detector Module**, an **LED indicator**, and a **Buzzer**. These components are interconnected using a microcontroller (likely an ESP32 or Arduino). Below is a breakdown of how each module functions within the design:

1. TFT Touch Display

The TFT Touch Display is connected to the microcontroller through SPI (Serial Peripheral Interface) communication. A 2.4" TFT LCD module consists of a bright backlight (4 white LEDs) and a colourful

240X320 pixels display. It also features individual RGB pixel control giving a much better resolution than the black and white displays. A resistive touch screen comes pre-installed with the module as a bonus and hence Finger presses can be easily detected anywhere on the screen.

Features and Specifications

- 2.4" TFT LCD with Touch screen
- Pixels: 240X320
- Operating Voltage: 3.3V
- Operating Mode: SPI and 8-bit mode
- Interface IC: 74LVX245
- SD card option available for displaying bitmap images
- Can be easily interfaced with Arduino (Library available)

Table.1 Description of TFT Touch Display

PIN Name	**Description**
GND	Power and signal ground pin.
Vin (3-5V)	Power pin that can be connected to 3V-5V DC. It comes with reverse polarity protection.
Vout (3.3V)	The 3.3V output from the onboard regulator.
CLK	SPI clock input pin.
MISO	SPI Master In Slave Out pin (used mostly by the SD card and also for debugging TFT).
MOSI	SPI Master Out Slave In pin (used to send data to the SD card or TFT).
CS	SPI chip select pin.
D/C	SPI data/command selector pin.
RST	Optional reset pin (TFT has an auto-reset circuit, but manual reset is possible via this pin).
Lite	PWM input to control the backlight (default is ON when pulled high). Can be controlled using PWM or turned off by pulling low.
IM3, IM2, IM1, IM0	Interface control set pins (used for advanced configurations).

PIN Name	Description
Card CS (CCS)	SD card chip select pin (used for reading from an SD card).
Card Detect (CD)	SD card detection pin (floats when the SD card is inserted, grounded when the SD card is removed).

2. RFID Reader (EM-18)

Radio-Frequency Identification (RFID) Sensor technology utilizes electromagnetic fields to identify and track tags attached to objects. Unlike barcodes that require line-of-sight scanning, RFID operates wirelessly, allowing for quick and seamless data capture. Each RFID tag contains a unique identifier that can be read by a compatible reader within range.

It is a wireless identification technology that uses radio waves to transfer data from the card tag to an RFID reader and identify the object presence.

Just like the bar code technology, RFID is used to identify objects, persons, by reading the card tag. This is better than the bar code because the bar code can sometimes be damaged or unreadable.

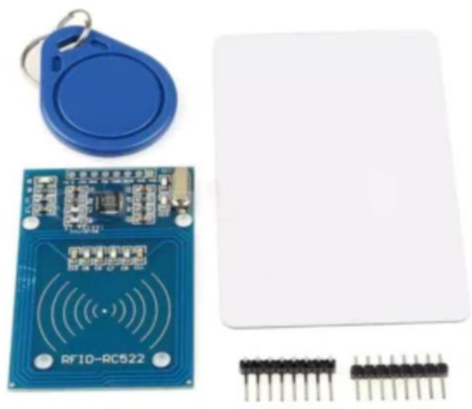

Fig.2 RFID Reader

This RFID module is a 125KHz card reader mini-module which is design to reading code from the 125KHz card tag.Companies mainly use it to access authorized employees, attendance systems, and for personal identification.

3. Sound Detector Module

The sound sensor is one type of module used to notice the sound. Generally, this module is used to detect the intensity of sound. The applications of this module mainly include switch, security, as well as monitoring. The accuracy of this sensor can be changed for the ease of usage.

This sensor employs a microphone to provide input to buffer, peak detector and an amplifier. This sensor notices a sound, & processes an o/p voltage signal to a microcontroller. After that, it executes required processing.

This sensor is capable to determine noise levels within DB's or decibels at 3 kHz 6 kHz frequencies approximately wherever the human ear is sensitive. In smartphones, there is an android application namely decibel meter used to measure the sound level.

Sound Sensor Pin Configuration

This sensor includes three pins which include the following.

Fig.3 Sound-Sensor-Module

Pin1 (VCC): 3.3V DC to 5V DC

Pin2 (GND): This is aground pin

Pin3 (DO): This is an output pin

The working principle of this sensor is related to human ears. Because human eye includes a diaphragm and the main function of this diaphragm is, it uses the vibrations and changes into signals. Whereas in this sensor, it uses a microphone and the main function of this is, it uses the vibrations and changes into current otherwise voltage.

Generally, it includes a diaphragm which is designed with magnets that are twisted with metal wire. When sound signals hit the diaphragm, then magnets within the sensor vibrates & simultaneously current can be stimulated from the coils.

4. ESP 32 CAM

ESP32 is a low-power and low-cost system on a chip microcontroller that is integrated with Wi-Fi & Bluetooth. This development board is manufactured simply by ESPressif. Several variants have been launched & announced since the release of this ESP32 board. These boards have different CPUs & capabilities, and all of them can share a similar SDK & are mostly code-compatible.

The ESP32 CAM module is an ESP32-based low-cost full-featured microcontroller with an integrated small-size OV2640 camera module & microSD card socket. This module integrates Bluetooth, WiFi, and BLE

Beacon with two 32-bit high-performance LX6 CPUs. The frequency adjustment range of this module ranges from 80MHz to 240MHz. It adopts a stage pipeline architecture, a Hall sensor, an on-chip sensor, a temperature sensor, etc. The ESP32-CAM includes 16 pins where pins with the same functionality are grouped equally.

The ESP32-CAM module is based on ESP32 which is a low-power and small-size camera module. This module comes with an OV2640 camera & provides an onboard TF card slot. The 4MB PSRAM of this board is used for image buffering from the camera into video streaming, allowing for higher image quality without causing the ESP32 to crash. This board has an onboard LED to flash & numerous GPIOs for connecting peripherals.

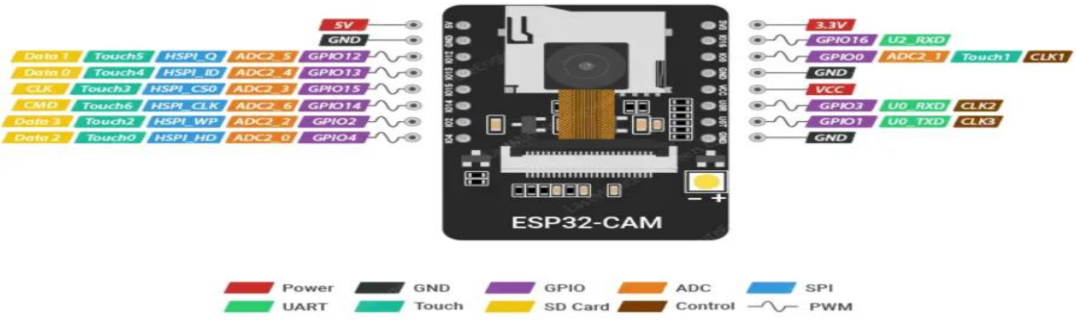

Fig.4 ESP32 Cam Pin Configuration

5. Microcontroller (ESP32/Arduino)

The ESP-WROOM-32 is a highly integrated microcontroller module designed by Espress if Systems, widely known for its application in Internet of Things (IoT) and embedded systems. At its core, the module features a dual-core Tensilica LX6 processor that operates at speeds up to 240 MHz, providing ample computing power for multitasking and complex operations. The inclusion of 520 KB SRAM and external flash memory options, typically 4 MB, makes it suitable for data-intensive applications and real-time processing.

One of the standout features of the ESP-WROOM-32 is its integrated connectivity options. The module supports 2.4 GHz IEEE 802.11 b/g/n Wi-Fi, enabling robust wireless communication over local and internet networks. Additionally, it incorporates Bluetooth dual-mode functionality, allowing for both Classic and Low Energy (BLE) connections. This makes it ideal for IoT applications requiring seamless device-to-device or device-to-cloud communication.

The ESP-WROOM-32 is equipped with a rich set of peripherals, including 34 programmable GPIO pins, multiple SPI, I2C, UART interfaces, and ADC (12-bit) and DAC (8-bit) capabilities.

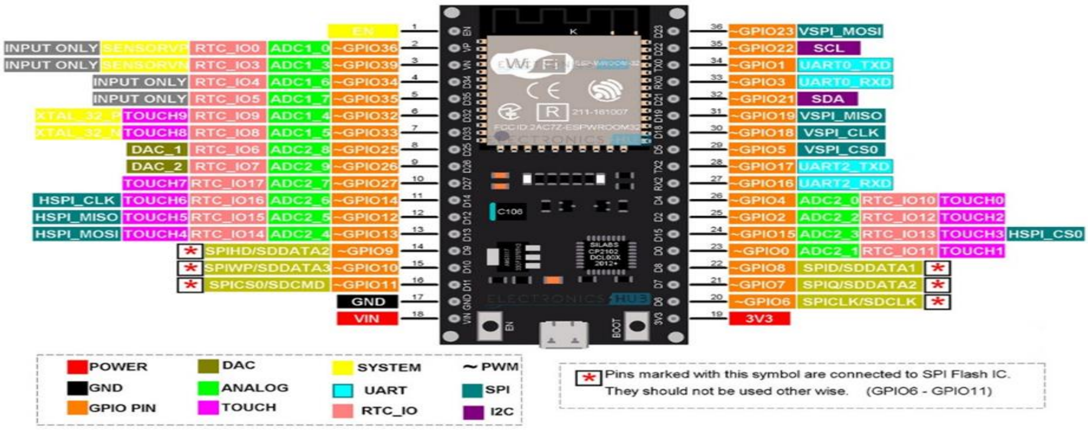

Fig.5 Pin Description of Micro Controller

6. **RFID TAG**

Fig.6 RFID Tag

- Radio Frequency Identification (RFID) tags work by using radio waves to transmit and receive data:
- RFID reader sends signal: The RFID reader sends out radio waves through an antenna.
- Tag absorbs energy: The tag absorbs the radio waves and uses the energy to power up.
- Tag sends data: The tag sends a wave back to the antenna, which is then translated into data.
- Backend system processes data: The backend system receives the data, decodes and validates it, and matches it with relevant information in a database.

7. **Arduino IDE**

The Arduino IDE provides a user-friendly interface for programming Arduino boards, making it accessible to beginners and experienced developers alike. It supports a wide range of Arduino-compatible boards, including the popular Arduino Uno, Nano, Mega, and others, as well as third-party boards based on the Arduino platform. The IDE is available for Windows, macOS, and Linux operating systems, allowing users to develop Arduino projects on preferred platform.

One of the key features of the Arduino IDE is its simplicity and ease of use. The IDE includes a text editor with syntax highlighting and auto-completion features, making it easy to write and edit code in the

Arduino programming language, which is based on Wiring and C/C++. Users can write sketches (Arduino programs) using familiar programming constructs such as functions, variables, loops, and conditional statements.

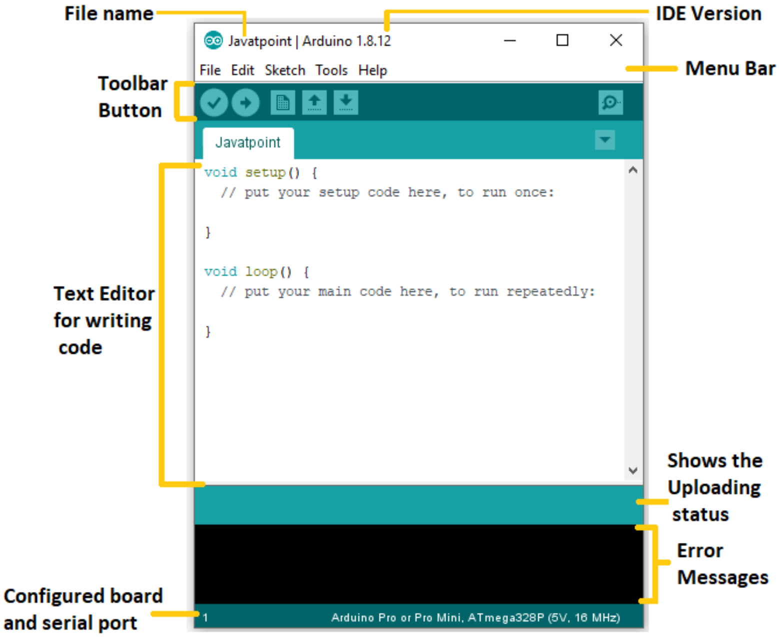

Fig.7 Arduino IDE

The Arduino IDE includes a built-in compiler and uploader toolchain, allowing users to compile the sketches into machine code and upload it to the Arduino board with a single click. The IDE automatically detects connected Arduino boards and selects the appropriate settings for compiling and uploading code. Additionally, the IDE provides access to a vast library of pre-written code examples and libraries, allowing users to quickly get started with projects and leverage existing code for common tasks and functionalities.

IV.WORKING

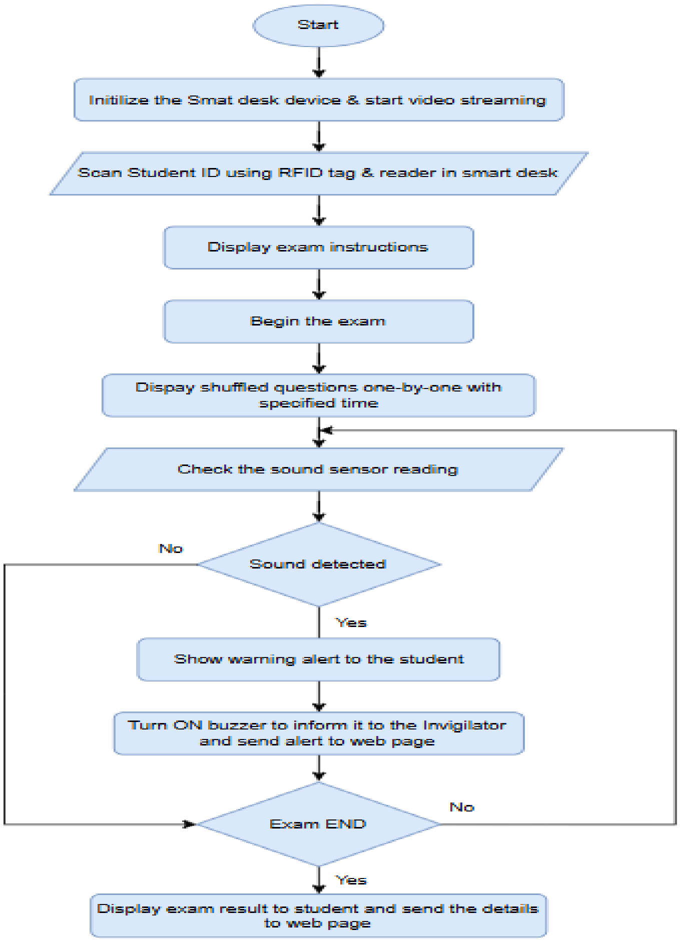

Fig.8 Flowchart of Smart Desk

1. Start: The process begins here.
2. Initialize the Smart Desk Device & Start Video Streaming: The system initiates the Smart Desk Device and starts the video streaming from the ESP32-CAM.
3. Scan Student ID using RFID tag & reader in smart desk: The student scans the RFID card on the reader, and the system records respective ID.
4. Display exam instructions: The TFT display presents the exam instructions to the student.
5. Begin the exam: The exam starts. The system displays shuffled questions one by one with a specified time limit.
6. Check the sound sensor reading: The system continuously monitors the sound sensor readings.
7. Sound detected: The system checks if the sound level exceeds a predefined threshold.
8. No: If no sound is detected, the system proceeds to the next question.
9. Yes: If sound is detected, the system triggers the following actions:

10. Show warning alert to the student: A warning message is displayed on the TFT display to alert the student about the noise.
11. Turn ON buzzer to inform it to the invigilator and send alert to web page: The buzzer sounds to alert the invigilator, and an alert message is sent to the web page for remote monitoring.
12. Exam END: The system checks if the exam time has elapsed.
13. No: If the exam is not over, the system goes back to step 5 to display the next question.
14. Yes: If the exam is over, the system proceeds to the final step.
15. Display exam result to student and send the details to web page: The system displays the student's exam result on the TFT display and sends the details to the web page for record-keeping.
16. Overall, this flowchart illustrates the step-by-step process of how the exam system functions, including student identification, question presentation, sound monitoring, and result display.

V.CONCLUSION

The proposed Classroom Response System (CRS) leverages Low-Power IoT technology to create an interactive, energy-efficient, and secure classroom environment. By incorporating components such as the ESP32 microcontroller, keypad, LCD display, RFID system, ESP32-CAM for video streaming, TFT capacitive touch display, and sound sensors, the system significantly enhances student engagement, participation, and exam integrity.The integration of real-time student feedback and monitoring features empowers both instructors and students, fostering a more responsive and collaborative learning environment. The use of RFID tags for automatic student identification streamlines administrative tasks, while the real-time video streaming feature ensures continuous classroom monitoring, increasing security during exams.The inclusion of sound sensors contributes to maintaining exam integrity by detecting unauthorized communication, thus ensuring a fair and focused assessment environment. Furthermore, the emphasis on low-power components ensures the system's sustainability, making it an efficient and cost-effective solution for modern classrooms.

In conclusion, this system offers a comprehensive solution to address the challenges of student engagement, classroom management, and exam monitoring, providing a valuable tool for enhancing the educational experience while promoting security and efficiency.

VI. REFERENCES

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