Design and Implementation of IoT Based Smart Lecture Attendance System at Mataram University of Technology

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Abstract— Student attendance is one of the reporting activities that exist in educational institutions. The problem that occurs in educational institutions is that when entering the lecture, many students are late and often absent, which can cause discipline where students often do absenteeism, so lecturers cannot know the number of students who attend accurately. From these problems, a solution is needed to help lecturers recapitulate attendance data. This system uses ESP32 as a data manager, RFID for data reading, and ESP32 to validate student attendance by taking pictures of faces. The data is stored on the web server using ESP32CAM to cover the shortcomings of RFID, which is still card-based, so that it can emphasize the flaws. To simplify the attendance in this study, utilizing the website as an interface to facilitate lecturers in knowing the number of students who are present, late, or absent more efficiently and accurately.

Keywords: ESP32, RFID, Absensi, IoT, ESP32CAM.

Abstrak— *Absensi kehadiran mahasisswa merupakan salah satu aktifitas pelaporan yang ada pada Lembaga Pendidikan. Permasalahan yang terjadi pada institusi pendidikan yaitu saat jam masuk perkuliuahan banyak siswa yang terlambat dan sering tidah hadir sehingga hal ini dapat menimbulkan kedisiplinan yang dimana mahasiswa sering melakukan penitipan absen, sehingga dosen tidak dapat mengetahui jumlah mahasiswa yang hadir secara akurat Dari permasalahan tersebut maka diperlukan solusi untuk membantu dosen dalam merekap data kehadiran. Sistem ini di bangun menggunakan ESP32 sebagai pengola data, RFID untuk pembacaan data dan ESP32 sebagai validasi kehadiran mahasiswa dengan mengambil gambar wajah , kemudian data disimpan pada web server penggunakan ESP32CAM agar menutupi kekurangan RFID yang masih berbasis kartu sehingga dapat mencegas kekcurangan. Dan untuk mempermudah perakapon absensi pada penelitian ini memanffatkan website sebagai interface untuk memudahkan dosen dalam mengetahui jumlah mahasiswa yang hadir, terlambat maupun yang tidak hadir secara lebih mudah dan akurat*

***Kata Kunci**: ESP32, RFID, Absensi, IoT, ESP32CAM.*

INTRODUCTION

The rapid advancement of technology in the current era of Industry 4.0 is compelling society to evolve and keep pace with the times continually. Implementing teaching and learning activities in education still relies on a manual attendance system to record student attendance on campus(Sajiah, Ransi, Nangi, & Suseno, 2022). Attendance is one part of the reporting activities within an institution.(Olivya, Praminasari, Teknik Elektro, & Negeri Ujung Pandang Jl Perintis Kemerdekaan Km, 2019). Attendance records are organized to make them easy to find and use when needed by relevant parties.(Nasir & Yanuar, 2019).

A common issue is the frequent delay or absence of students during class hours, which can lead to disciplinary violations such as proxy attendance, making it difficult for instructors to accurately track the number of attending students. (Martulandi & Setiawan, 2021)This issue is also prevalent at Mataram University of Technology. Recognizing this problem, there is a need for a solution to improve the existing attendance system, namely by creating an IoT-based class attendance system.

In this research, ESP32 is used as the primary data processing tool, RFID for data reading, and ESP32CAM for validating student attendance by capturing images of the present students. Additionally, this research utilizes a website as an interface to facilitate instructors in obtaining more convenient and accurate information about the number of students who are present, late, or absent.

Currently, RFID technology exists as an object identification method that utilizes radio waves. The identification process is performed by an RFID reader, where RFID transponder tags are placed on objects to be identified. (And & Expert, 2019)Each RFID has a unique ID number, ensuring that no two are the same (Santoso & Sari, 2019). With RFID, it is expected that each student no longer needs to manually record attendance because the

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RFID reader automatically records student attendance data in the database. Consequently, with this system in place, it can streamline the academic process.

MATERIALS AND METHODS

This research falls under the category of research and development (R&D). Research and Development (R&D) is a research method used to produce specific products and test their effectiveness. (Wahid & Yudhistira, 2019)The stages of research using the Research and Development (R&D) method, as depicted in Figure 1, include the following:

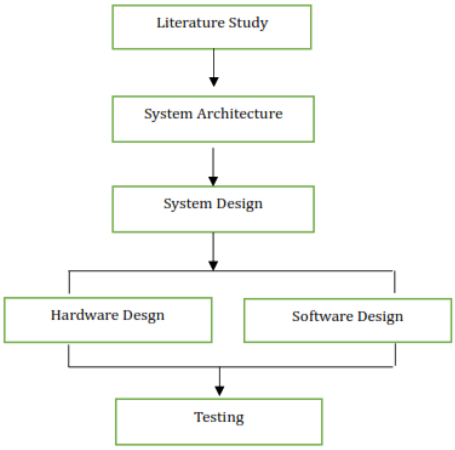

Figure 1. Research Methods

1. Literature Review

Related studies on RFID-based attendance systems have been conducted by (And & Expert, 2019). They applied Radio Frequency Identification (RFID) technology to library visitation data. This research incorporated RFID technology as a connector between RFID readers and a database based on Arduino for recording library visitation data. Additionally, according to a study conducted by (Kusumo, Muthohir, & and Rakasiwi, 2022), they implemented RFID in the attendance and payroll system for employees (A Case Study at PT. Kartika Utama Semarang). They developed an information system application to streamline attendance and payroll management for PT. Kartika Utama Semarang employees. However, in previous studies, there hasn't been any research combining both ESP32 and ESP32CAM technologies.

a. ESP32

The ESP32 is a successor or development outcome of the NodeMCU ESP8266, where the ESP32 is a low-cost hardware device in the form of a microcontroller System on Chip (SoC) produced by Espressif Systems. (*ESP32 Hardware Design Guidelines About This Document*, 2022)

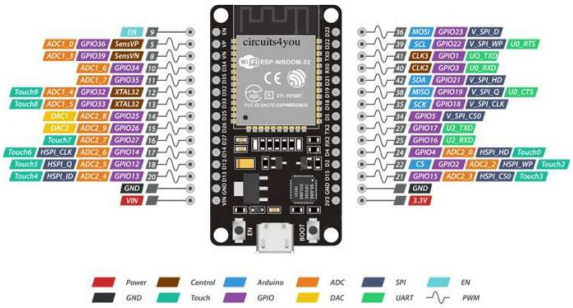

Figure 2 skema pin ESP32

The ESP32 is one of the integrated microcontrollers known for its full features and good performance. It employs the Tensilica Xtensa LX6 dual-core or single-core microprocessor with a clock rate of up to 240 MHz. The ESP32 comes integrated with built-in antenna switches, RF balun, power amplifier, low-noise receive amplifier filters and power management modules. It includes a CPU core and a faster Wi-Fi module, offers more GPIO pins, and supports Bluetooth Low Energy. Consequently, the ESP32 is highly suitable for use in projects related to the Internet of Things (IoT). (*ESP32 Series Datasheet 2.4 GHz Wi-Fi + Bluetooth ® + Bluetooth LE SoC Including*, 2023) .

b. ESP32CAM

Figure 3. ESP32CAM

ESP32CAM is a Wi-Fi/Bluetooth development board that utilizes the ESP32 microcontroller and a camera module. It also features several GPIO pins and provides additional connections for an external antenna. However, it has a drawback in that it lacks a USB port for program uploading. To upload programs, we need to use an FTDI module.(Arrahma & Mukhaiyar, 2023)

c. Radio Frequency Identification RFID

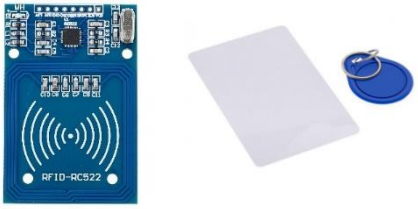

Figure 4 RFID Reader and RFID Card

Radio Frequency Identification (RFID) is an identification method that uses radio waves. The identification process involves an RFID reader and an RFID transponder (RFID tag). (Ferdiansyah, Rahman Sujatmika, & Ummami, 2023)RFID tags are attached to objects to be identified. Each RFID tag has a unique ID number, and there are no two RFID tags with the same ID number. How it works is that the RFID reader reads the ID number on the RFID tag to identify the object or item.(Hidayat, Yudi Limpraptono, & Ardita, n.d.)

d. LCD

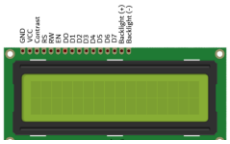

Figure 5. Liquid Crystal Display (LCD)

Liquid Crystal Display (LCD) is a data display device that uses liquid crystals to display data, including text, numbers, and images. The physical form of an LCD can be seen in Figure 5. (Setyawan & Ayunda Murad, 2021)

e. Buzzer

Figure 6. Buzzer

A buzzer is an electronic component that can generate sound vibrations in the form of sound waves. The buzzer produces sound vibrations when supplied with a certain amount of electrical voltage by its specifications, shape, and size. Typically, buzzers are used as alarms due to their ease of use; simply by providing input voltage, the buzzer will generate sound vibrations in the form of audible sound waves. (Santoso & Kristianto, n.d.)

f. Presence tool flow

The workflow of this attendance device discusses how the device that will be created operates. The attendance device to be built utilizes RFID and Camera sensors based on the Internet of Things. The operation of the device is depicted in Figure 7 below.

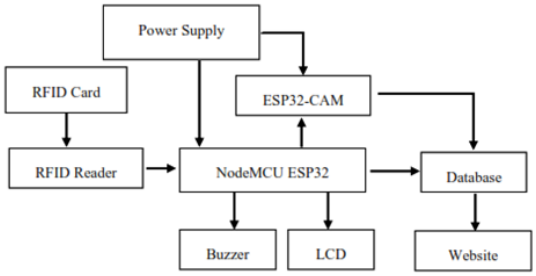

Figure 7. Block Diagram

1. Perancangan perangkat keras

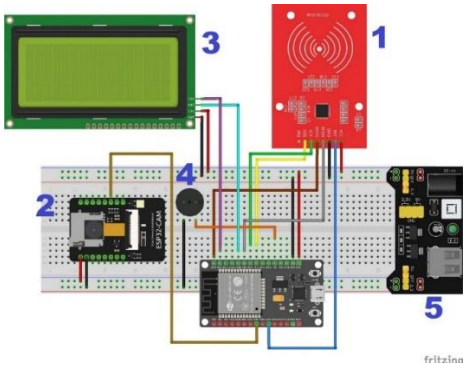

Figure 8. Tool wiring

In the created block diagram, the NodeMCU ESP32 functions as the central controller for all connected devices. It receives data from the RFID Reader, which is then transmitted to the server. Additionally, this device issues commands to other devices as per the programmed instructions.

Here are the functions of each device:

1) The RFID reader is responsible for retrieving the distinct identification number from each student's RFID card. Technical abbreviations are defined in the first usage. Upon detecting the number, it is transmitted to the NodeMCU ESP32 via various pins, including SDA [Pin D5], SCK]Pin D18], MOSI [Pin D23], MISO [Pin D19], RST [Pin D27], 3.3V [Pin 3.3V], and GND [GND].
2) The ESP32-CAM is used to capture a photo or image of the student who is marking their attendance to validate their presence, and then it's sent to the server. The pins used are as follows: UOR [Pin 32]
3) The LCD itself serves the purpose of displaying information about the device mode, Wi-Fi connection status, and attendance status details. The pins used are SDA [Pin D21], SCL [Pin 22]
4) The buzzer here functions as an indicator. When the RFID Reader successfully detects the unique number on the RFID Card or when a successful attendance is recorded, the buzzer will automatically sound. Pin + [Pin D4]
5) The Power Supply here functions as a voltage conductor or a source that delivers energy or power to activate the system. ESP32, ESP32-CAM, LCD, and Buzzer. Pin 5V [Pin 5V+], GND [Pin GND-]

The PIN diagram on the ESP32 connects it to other devices. The PIN diagram can be seen in the figure 2

After designing the circuit, the next step is to assemble the components with the RFID Sensor and its supporting elements, such as ESP32CAM, LCD, Buzzer, and the circuit board, as shown in the illustration Figure 8

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2. Software Design

software design is one of the stages in creating a system. Software design includes the design of software that will be used to support the needs of the attendance device to be created. The design also includes the navigation structure of the software to be developed as follows.

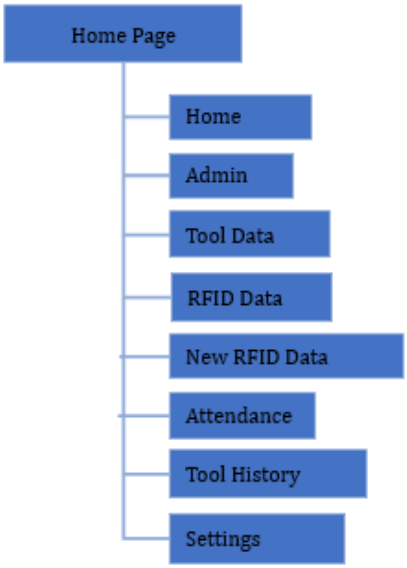

Figure 9 Softwere Design

3. Flowchart

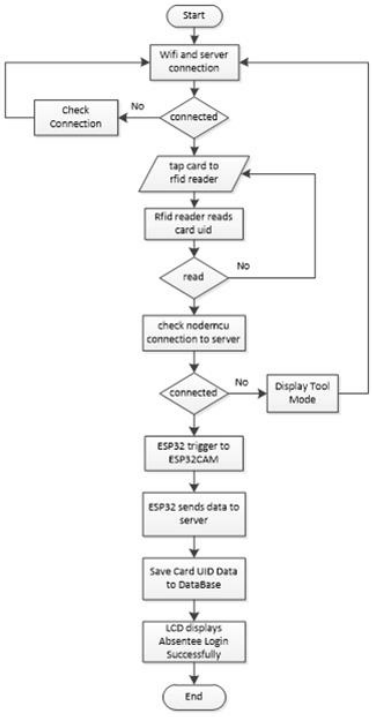

Figure 10. Flowchart ESP32

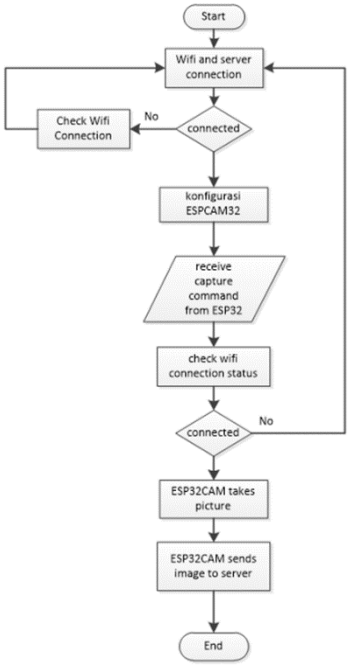

Figure 11 Flowchart ESP32CAM

In the research design, wireless communication is employed between the ESP32 and the Web Server, with the communication interface design as follows: Data obtained from the RFID Reader sensor input on the ESP32 is in the form of an associative array, which is then packaged in JSON format and subsequently transmitted to the Web Server using an API transmission method. The data will be stored in the database.

RESULTS AND DISCUSSION

The result of the device design consists of a collection of components that have been assembled to assist in student attendance activities. The input data is from the RFID reader sensor, and the output is displayed on an LCD screen that shows the device mode, Wi-Fi connection status, and a webpage displaying the incoming or present attendance data.

1) Attendance and Web Tools

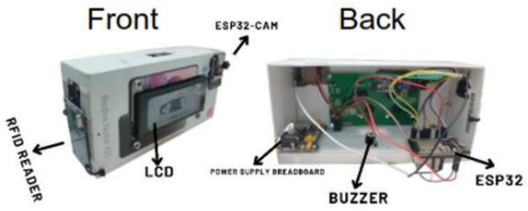

Figure 12. Design Results of the Tool

2) Tool Testing

a) Connection Testing

In this testing, the steps involved include turning on the hotspot and server, connecting the ESP32 and ESP32-CAM alternately using USB to the laptop, and then opening the serial monitor in the Arduino IDE application. Here are the results of the testing that has been conducted.

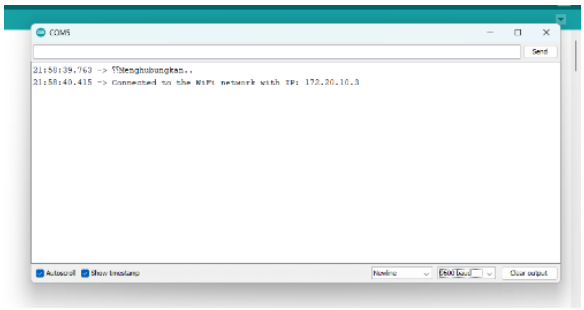

Figure 13. Tool Connection

b) Tool Mode Testing

The testing of this device mode is divided into two parts: testing the device mode under Add conditions and testing the device mode under Scan conditions. The purpose of this device mode testing is to determine whether the previously designed device yields the expected results.

1 ADD Tool Mode

Testing in this mode is conducted using the prototype device that has been previously created. The purpose of testing in Add mode is to determine whether the device successfully reads and adds the UID from the RFID card and RFID tag to the system, as well as to ascertain whether all the hardware components used are functioning properly.

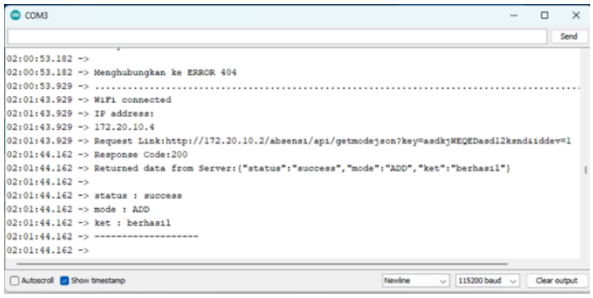

Figure 14. ADD Tool Mode

2 Scan Tool Mode

The steps performed are nearly identical to the testing conducted in the 'Add' mode, wherein this 'Scan' mode testing is also done using the previously created attendance device prototype. The device is fully assembled in this mode, with all cables connected between the hardware components. During the testing, the ESP32 is connected to the laptop via a USB cable, while other hardware components are connected using a breadboard power supply and a nine-volt adapter. This testing is intended to determine whether the RFID reader successfully reads both registered and unregistered UIDs

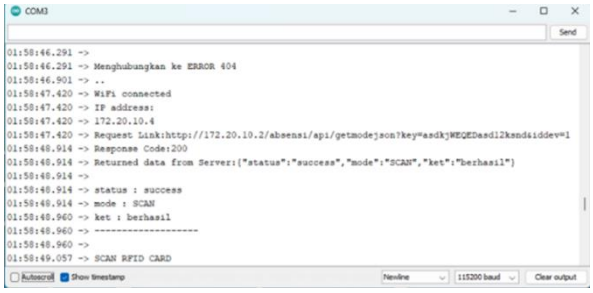

Figure 15. Scan Tool Mode

3) Website Display

The result of this software design includes the design of the software that will be used to support the needs of the attendance device to be created. The result also includes the design of the navigation structure of the software that has been created as follows.

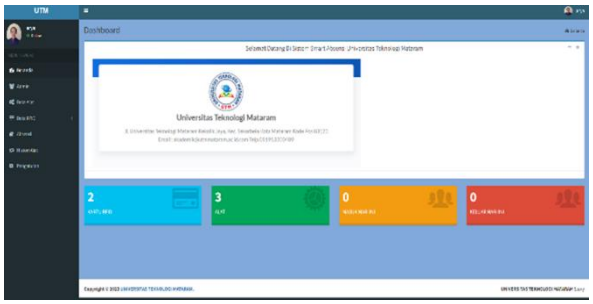

Figure 16. Software design results

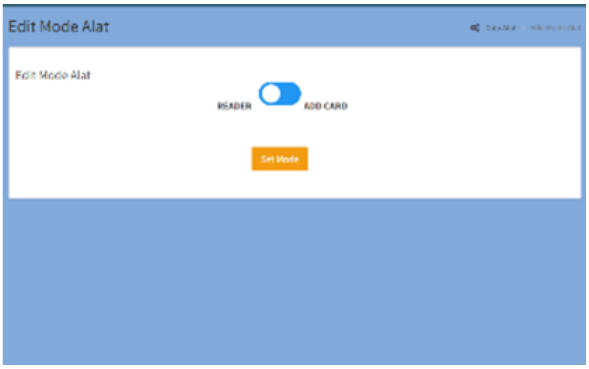

Figure 17. Setting Tool Mode

On the New RFID Card Page, it successfully accommodates and displays the UID read by the tool in add mode successfully or not. Here are the results of what was done.

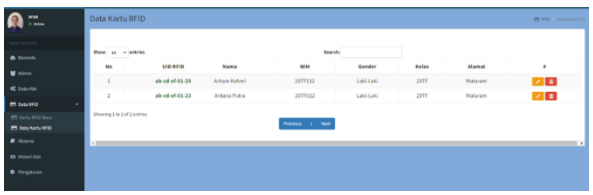

Figure 18. New RFID card page view

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4) Results and Image Format

```
//init with high specs to pre-allocate larger buffers
if(psramFound()){
  config.frame_size = FRAMESIZE_UXGA;
  config.jpeg_quality = 10;  //0-63 lower number means higher quality
  config.fb_count = 2;
} else {
  config.frame_size = FRAMESIZE_SVGA;
  config.jpeg_quality = 12;  //0-63 lower number means higher quality
  config.fb_count = 1;
}
```

Figure 19. Image Formatting Programming

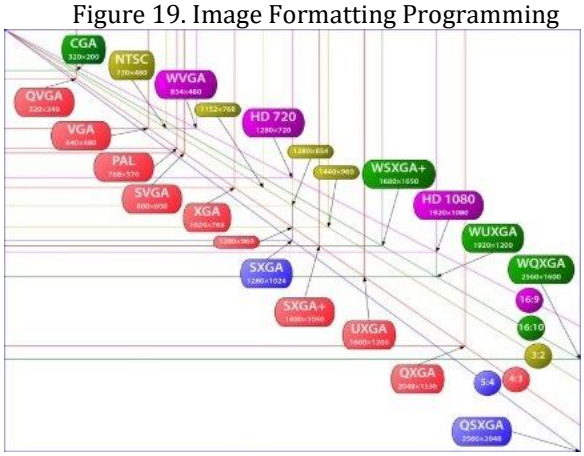

Figure. 20 Image Type and Size

In the image above, the size or frame size of the ESP32CAM is set to JPEG format with a VGA size, which is 640×480 pixels. This frame size is used to ensure that the ESP32CAM works optimally when sending multiple images in a relatively short period. During the device testing with this format and frame size, it can be observed that the ESP32CAM takes 1 to 2 seconds to transmit the image to the Web Server, depending on the internet connection speed. However, in certain conditions, the ESP32CAM may experience overheating, causing it to fail to transmit images.

5) Attendance Results on the Website

The following attendance result data on the web server is stored in the database

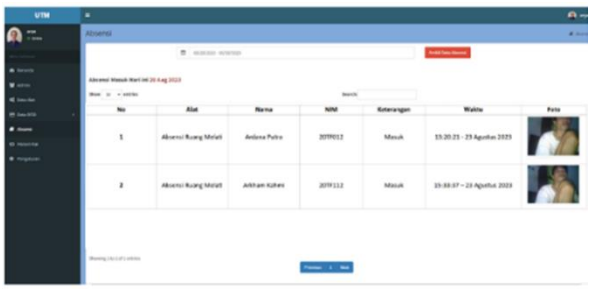

Figure 21. Attendance Entry Results

The attendance data displayed on the Web Server includes several pieces of information such as name, student ID (NIM), entry status, attendance time, and a photo of the attendee.

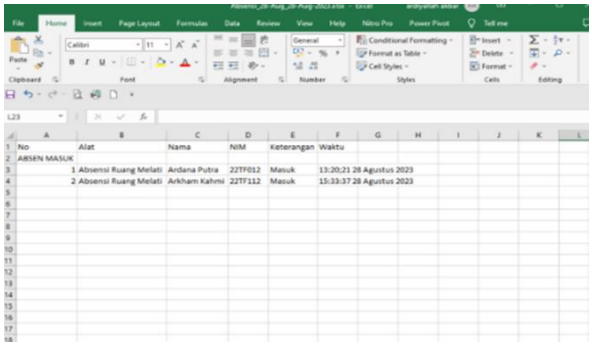

Figure 21. Attendance summary

CONCLUSION

Based on the testing results and discussions, the attendance device built using ESP32CAM and RFID sensor functions well as planned. Regarding the RFID sensor reading test, the sensor can effectively detect RFID cards. The photos taken by ESP32CAM will be stored in the database in JPEG format. However, during the student attendance process, there should be a delay of approximately 1 to 2 seconds between each attendance event to ensure that the images captured by ESP32CAM are not corrupted. The website designed for communication between the ESP32 and the Web Server was successfully implemented. Data from the ESP32 obtained from the RFID Reader sensor is structured as an associative array, then packaged in JSON format, and subsequently sent to the Web Server using an API transmission method. This data is then stored in the database.

Furthermore, the attendance data displayed on the Web Server includes several pieces of information, such as name, student ID (NIM), entry status, attendance time, and a photo of the attendee. This data is also stored in the database. One limitation of the prototype attendance system using RFID and a camera is that it cannot print attendance records with photos. Therefore, it is hoped that in future development, this capability can be added to allow for the printing of attendance records along with the corresponding photos.

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