

# USER PRESENCE - BASED SMART TABLE LAMP

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Final Presentation of Individual Design Project

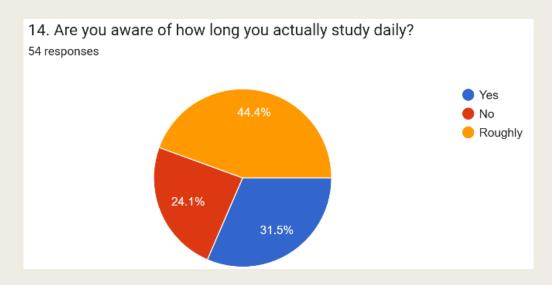
### Content of the Presentation

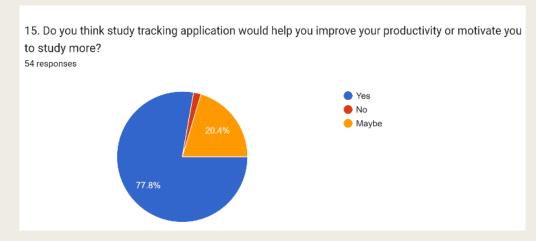
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# Problem Identification

- Manually turning the lamp on and off is inconvenient
- Lack of Study Time Tracking

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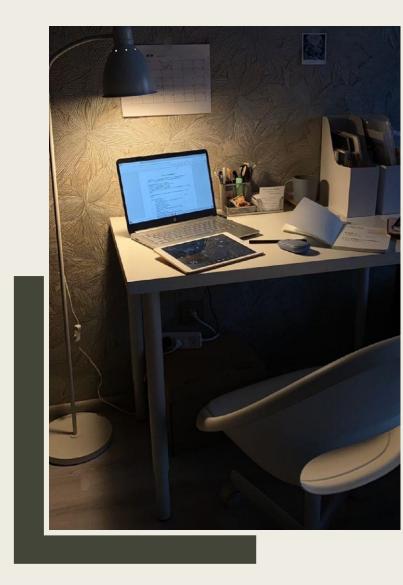








Electricity Wastage
 Lights left on when not in use causes significant electricity wastage



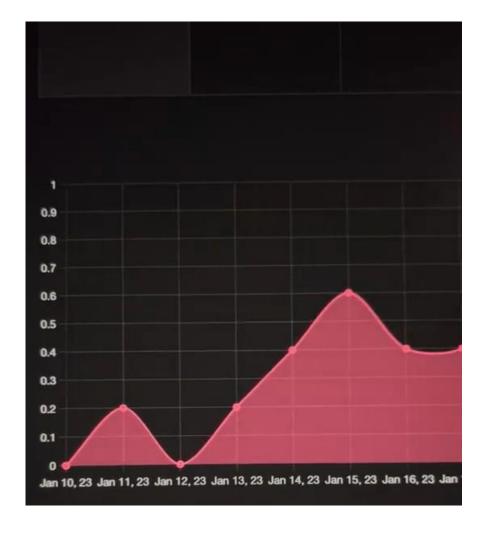
# Objectives

- 1. To design and implement a smart table lamp with automatic control based on user preferences.
- 2. To develop a user-friendly web interface for monitoring lamp usage.
- 3. To track study time and analyze user patterns.









### Literature Review

- Table lamps,
  - Provide focused illumination, reduces distractions and helps students focusing on their work.
  - Enhance the visual appeal of a study space, making it a more inviting and motivating environment that positively influences student mood and productivity.
- Night-time studying can enhance focus, memory retention, and creativity, making it beneficial when complemented with personalized study patterns.

[1][2]

Energy Consumption and Emissions in Sri Lanka

In 2022, Sri Lanka's energy-related CO<sub>2</sub> emissions reached 18 million tonnes, contributing to 0.05% of global emissions. There's a 74% increase in emissions since 2000, highlighting the need for energy-efficient solutions. [3]

Energy Efficiency of LED Lighting

LED lamps consume significantly less energy compared to incandescent or halogen bulbs, offering up to 85% energy savings.

Smart lighting systems that automatically adjust brightness reduces electricity consumption by 30%. Additionally, leaving lights on unnecessarily contributes to 5-10% of household electricity bills. [4][5][6]

# Key technologies relevant to the project

- Cloud Firestore is a real-time cloud database to store sensor readings, lamp status, and study session data.
- MQTT is a lightweight communication protocol used to transmit data from the ESP32 to Firebase efficiently.
- Node-RED is a low code programming tool that stores data using flow-based graphs and tables through a web-based dashboard.

# Sources relevant to the design choices

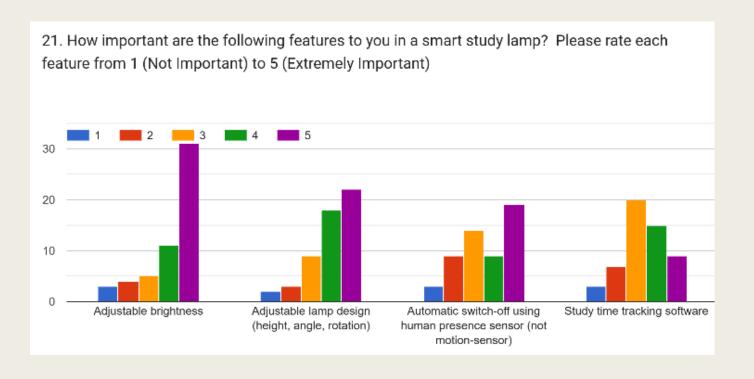
#### ■ The Pomodoro Technique

- Inspired the timer feature. A buzzer alerts the user after every 25 minutes of study to take a 5-minute break

(for the demonstration buzzer alerts after 2 minutes)

■ Based on literature review, LED strips were used to ensure better energy efficiency.

- Survey results showed brightness control was important,
  - A potentiometer was added for manual adjustment,
  - Lamp panel was made adjustable in height, angle, and rotation.
- Many users preferred automatic control,
  - Human presence sensor
     was used to switch the
     lamp off



# Market Survey

Lamp	Name	Features	Price	Available at
	EZVALO Smart Desk Lamp	APP Control Eye-Caring Auto-Dimming Led Desk Lamp 3 Color Temperature Works with Alexa & Google Assistant	LKR 17,812.89	https://www.amazon.com https://rb.gy/qmpmoe
	ZEEFO Retro LED Night Light PIR Motion Sensor Light	Light will automatically turn on when a user pass within 6 feet of the sensor, will automatically turn off after about 15-20 seconds	LKR 4,845.08	https://www.amazon.com/ https://rb.gy/bpd5t2

Lamp	Name	Features	Price	Available at
	Baseus LED Desk Lamp Auto-Dimming Table Lamp	47 " Wide Rectangular Illumination Adjustable Brightness Built-in battery staying up to 13 hrs.	LKR 10,122.34	https://baseusonline.com/ https://rb.gy/d997z4
	3 Way Dimmable Touch Lamp	Touch Control USB & USB-C Charging Ports and outlet	LKR 5,648.13	https://www.amazon.com/ https://rb.gy/8pntbj
	Xiaomi Mi Smart LED Desk Lamp	Adjustable brightness and color temperature App-controlled Lacks advanced motion detection	LKR 25,724.99	https://www.aliexpress.co m/item/32967694580.html https://www.mi.com/ae/pro duct/mi-smart-led-desk- lamp-pro/

### Potential user base and application areas

#### Students and Academics

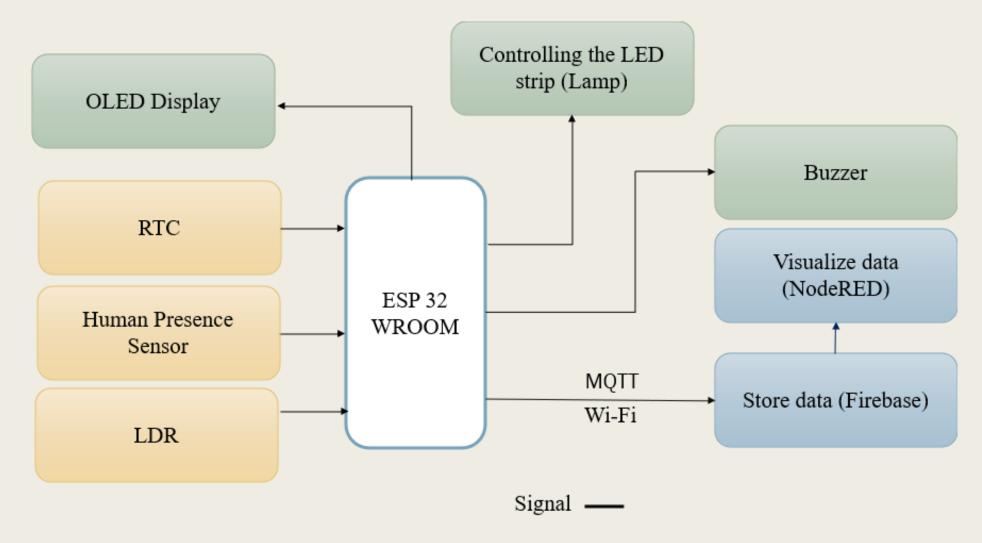
- Hostel students who share rooms can have their own lighting without bothering their roommates
- Feedbacks on lamp usage patterns can inspire better time management and study habits
- Healthcare and Elderly Care
  - Enhance safety and provide hands-free operation for people with limited mobility.
- Office and Workspace Settings
  - For busy office environments where users frequently move



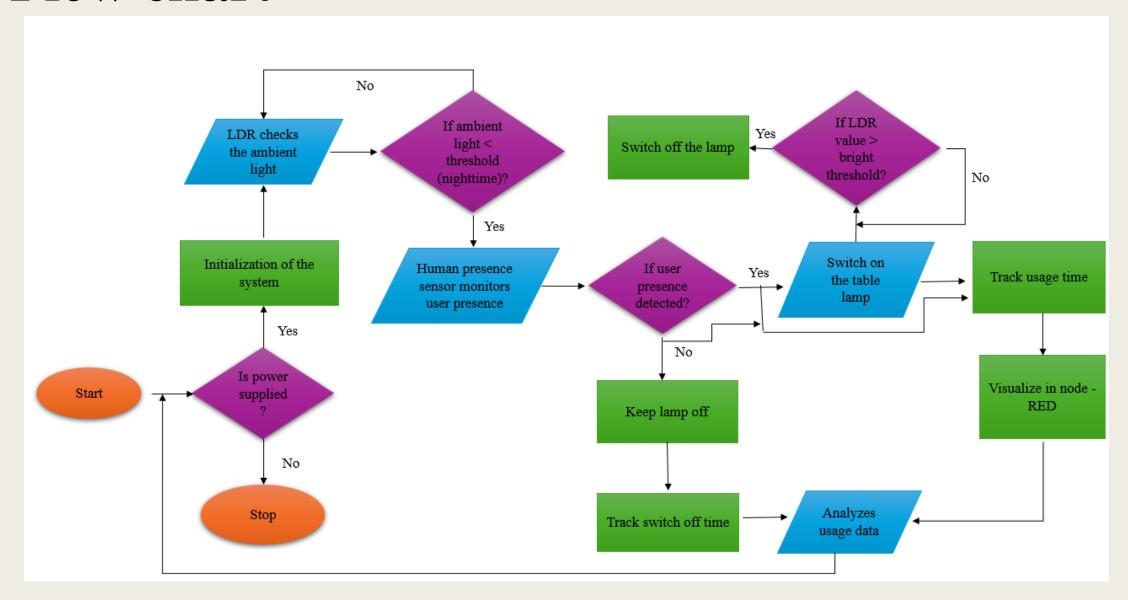




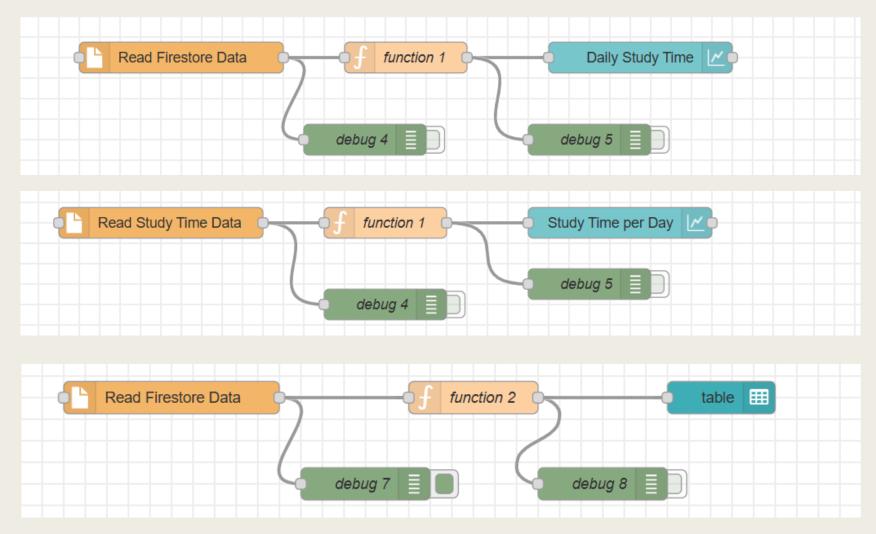
# System Design



# Flow chart

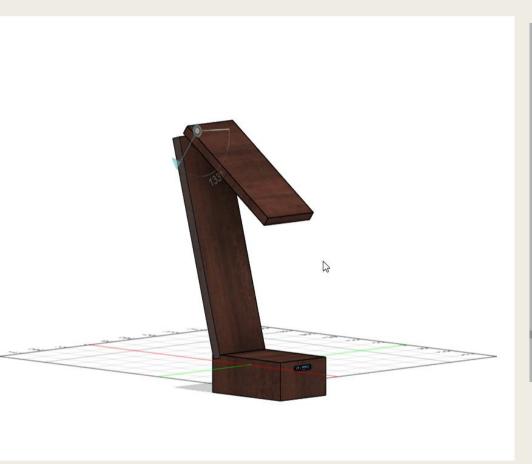


#### Flows of the Node-RED Dashboard for Study Time Analysis



\*\* Assumed that the user was studying throughout the time they remained seated at the table

# 3-Dimensional view



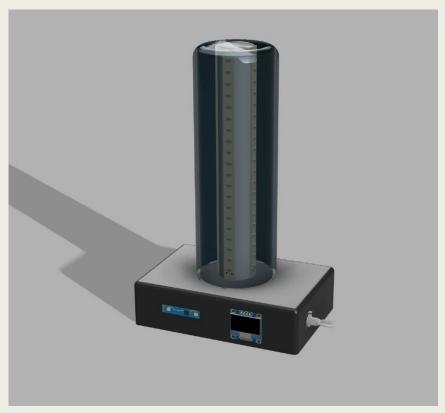
Side view



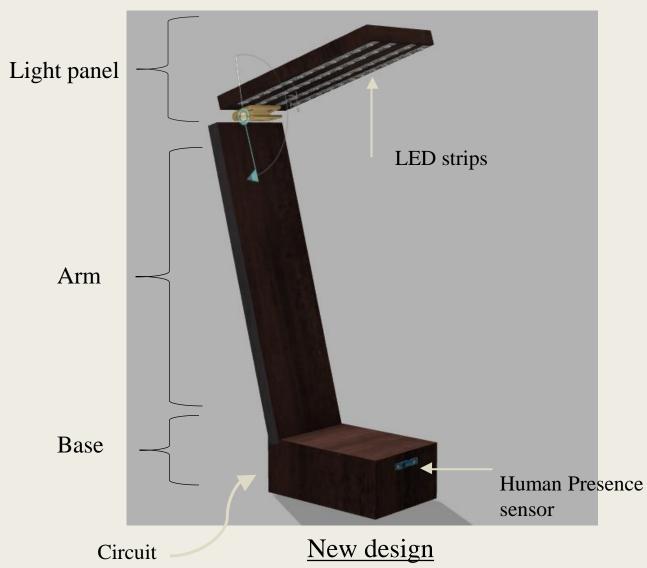
Front view



# Critical Design Decisions



Previous design



#### ■ Focused Light Projection

The lamp is designed to direct light to a specific area instead of spreading it everywhere.

#### Wooden Casing

to minimize heat transfer as the LED strips generate some heat when powered for long periods.

maintaining an aesthetic look.

#### Adjustable Panel

Allow the user to change the lighting angle for different tasks.

#### Dual Power Options

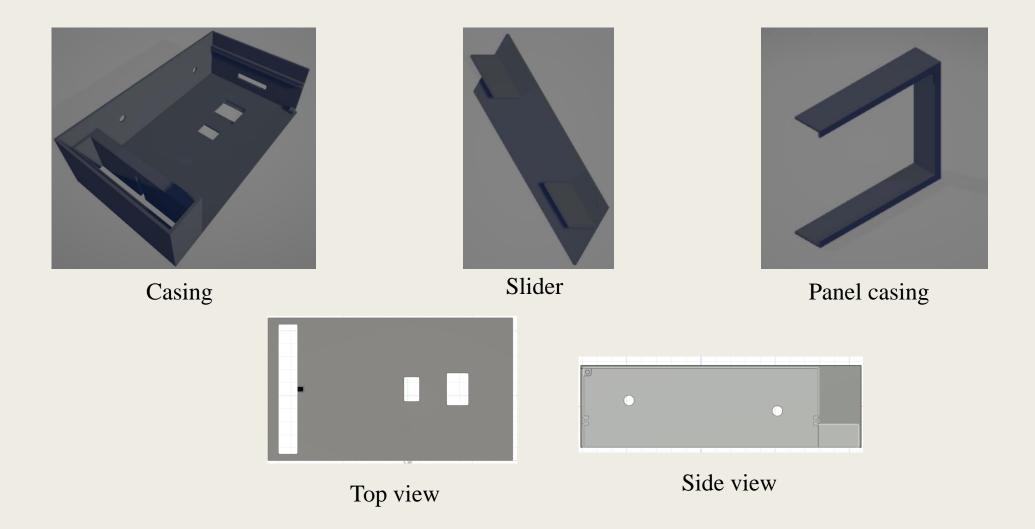
To increase portability and ensure the lamp can work even during power outages.

12V adapter (for continuous use)

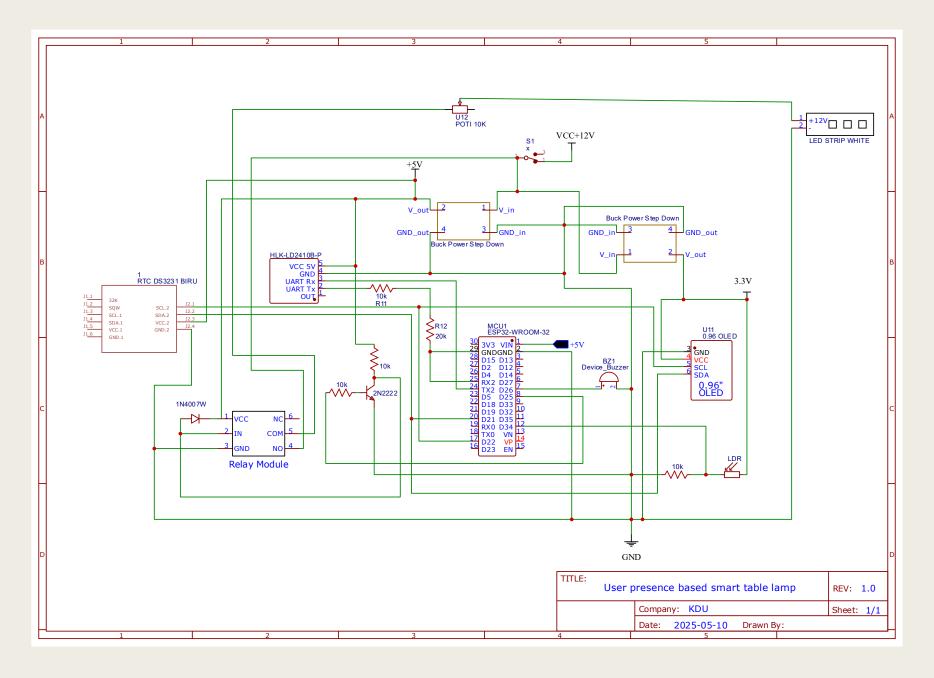
12V battery pack (for backup use).

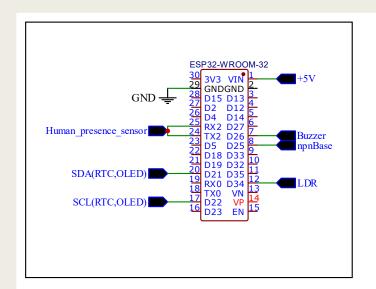
■ The lamp projects light over approximately 1 meter with a 180-degree spread.

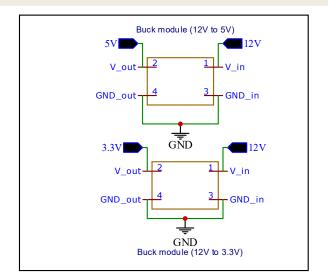
### Base enclosure 3D view

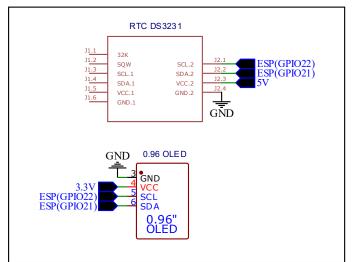


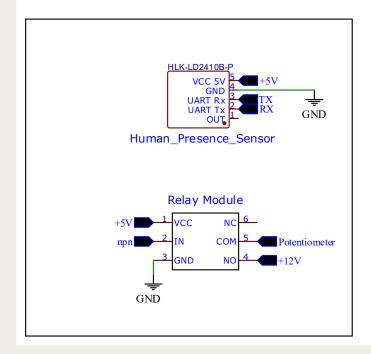
# Circuit Design

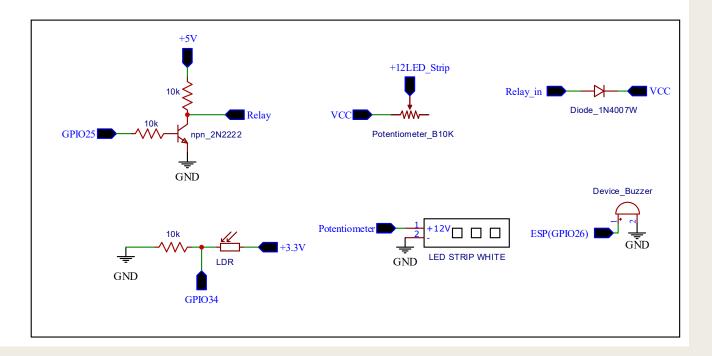






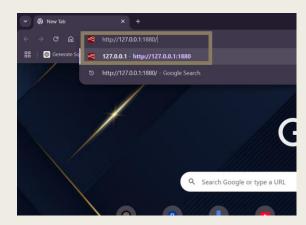






# Software Implementation

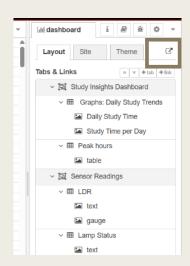
```
Ricrosoft Windows [Version 18.0.22631.5189]
(c) Ricrosoft Corporation. All rights reserved.
(c) West Corporation.
(c) West Corp
```

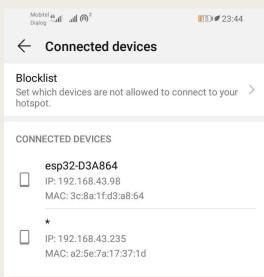


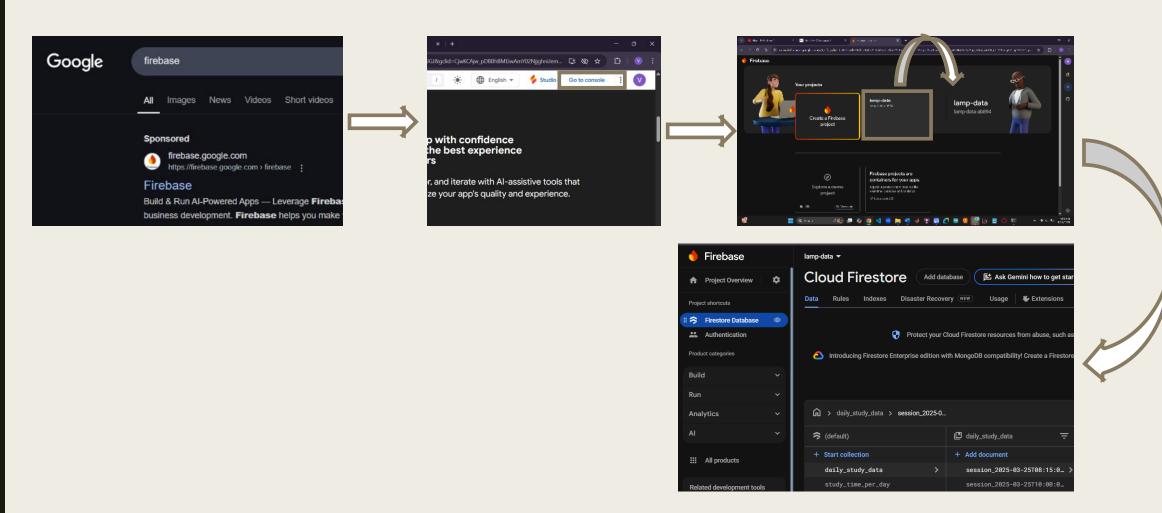
Steps to open the node-RED dashboard

```
Windows IP Configuration
Ethernet adapter Ethernet:
   Media State . . . . . . . . . . . . . . . Media disconnected Connection—specific DNS Suffix . :
Ethernet adapter Ethernet 3:
   Connection-specific DNS Suffix . :
   Link-local IPv6 Address . . . . . : fe80::c59b:a99b:1000:6b06%25
   IPv4 Address. . . . . . . . . . : 192.168.56.1
   Subnet Mask . . . . . . . . . . : 255.255.255.0
   Default Gateway . . . . . . . :
Wireless LAN adapter Local Area Connection* 3:
   Media State . . . . . . . . . . : Media disconnected Connection-specific DNS Suffix . :
Wireless LAN adapter Wi-Fi:
   Connection-specific DNS Suffix . :
                                           151:960f%20
   Link-local IPv6 Address . . . . .
   IPv4 Address. . . . . . . . . . . . 192.168.43.235
   Default Gateway . . . . . . . : 192.168.43.1
```

Arduino IDE for Wi-Fi connectivity







Steps to Access and Set Up Cloud Firestore in Firebase

Purpose	Software
3D design	Fusion
	Solidworks
Database	Cloud firestore
Web interface	NodeRED
Circuit design	Easyeda
Code	Arduino IDE
Run node-red	Command window

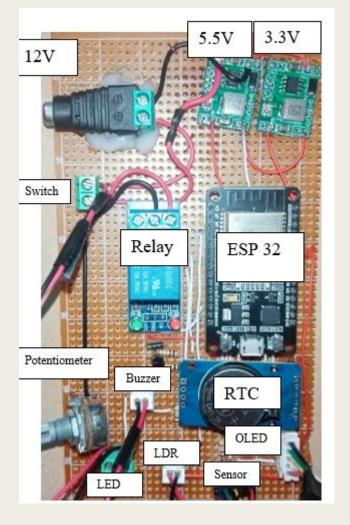
Softwares used

# Final views and Operation











#### LDR after calibration

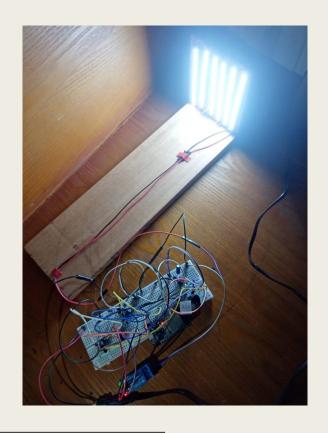
```
code_2_with_thresholds | Arduino IDE 2.3.4
          de 2 with thresholds ino
                #define LD2410 BAUD RATE 256000
               MyLD2410 sensor(sensorSerial);
              const int distanceThreshold = 75; // Set to 0.75m (75cm)
const int minMovingSignal = 80; // Adjust based on testing (higher = less sensitivity)
               const int minStationarySignal = 60; // Adjust for non-moving detection
                Serial, begin (SERIAL BAUD RATE);
                 sensorSerial.begin(LD2410_BAUD_RATE, SERIAL_BN1, RX_PIN, TX_PIN);
                   Serial.println("Failed to communicate with the sensor.");
       18:23:01.075 -> • No human detected.
      18:23:02.121 -> No human detected.
18:23:03.085 -> No human detected.
       18:23:04,107 ->  No human detected
       18:23:06.083 -> . No human detected.
       18:23:08.113 -> • Human detected near the table!
       18:23:10.089 -> • Stationary human detected near the table
          :23:12.092 -> Muman detected near the table!
```

Human presence detection sensor after calibration

# Results and Discussion

#### Calibrations and results

- Darkness detection threshold: **600** (calibrated based on the testing environment)
- Bright threshold: 2500
- Lamp activation condition: The lamp turns on when the darkness threshold is reached AND the brightness threshold is not reached
- User presence detection threshold: **0.75m**







# SIMULATIONS





OLED Displays human detection status, minutes studied, and current LDR value

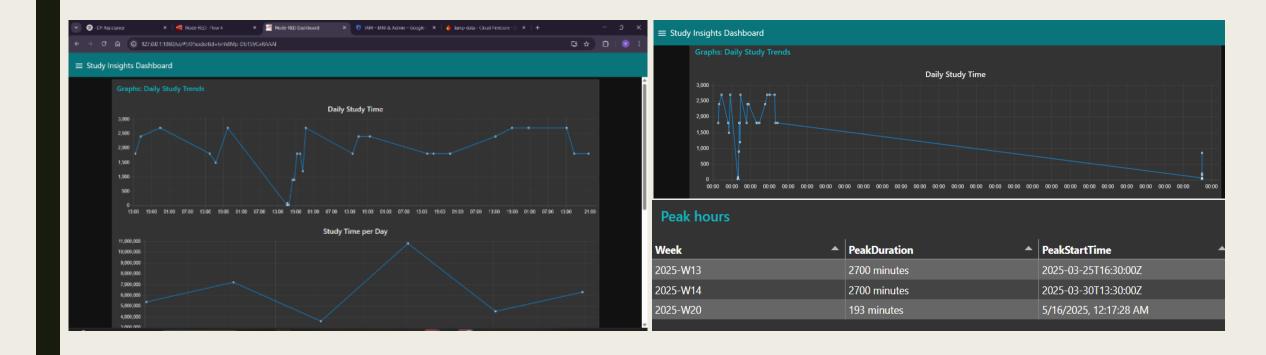
After every 25 minutes, a buzzer alerts the user to take a break simulating Pomodoro technique (for the demonstration the buzzer alerts every 2 minutes).

Every 1 second, the system checks if a human is within range using human presence sensor.

If conditions are met, it updates status and study time begins.

MQTT is used to send messages about human presence ("entered"/"left") to the broker (via Firebase).

#### Node-RED Dashboard



# Problems Encountered and Solutions

Issue	Solution
The PIR sensor could only detect motion, so it wasn't reliable for knowing if someone was there throughout a time period.	Switched to the microwave radar sensor, which can continuously detect human presence.
The sensor's pins are very close together (1.27mm), making it hard to solder.	Use pin connectors with the precise gap between pins without soldering
The openings for external components like the potentiometer and DC jack were not aligned correctly in the initial 3D-printed enclosure design.	The enclosure openings were adjusted manually by heating and widening the holes using a soldering iron.
The human presence sensor has its own software for tuning, but the TTL converters didn't work for it.	Tested example codes from some library and calibrated the sensor manually.
The radar sensor gave false readings, varying the detected distance continuously, and sometimes detected non-human objects also.	Reduced the sensor's sensitivity, ignored non-human targets, and set the code to detect only human within a specific distance.

# Possible further improvements

- A more compact circuit design using a PCB to reduce size and cost.
- The relay module was CAN be replaced with an IRLZ44N MOSFET, and buck converters with L7805 voltage regulators.
- A smaller microcontroller chip may be used instead of the full ESP32 board.
- Dual power options including USB and battery were considered, along with a charging reminder system.
- Mobile app integration was also suggested to improve user convenience.

# Cost Estimation

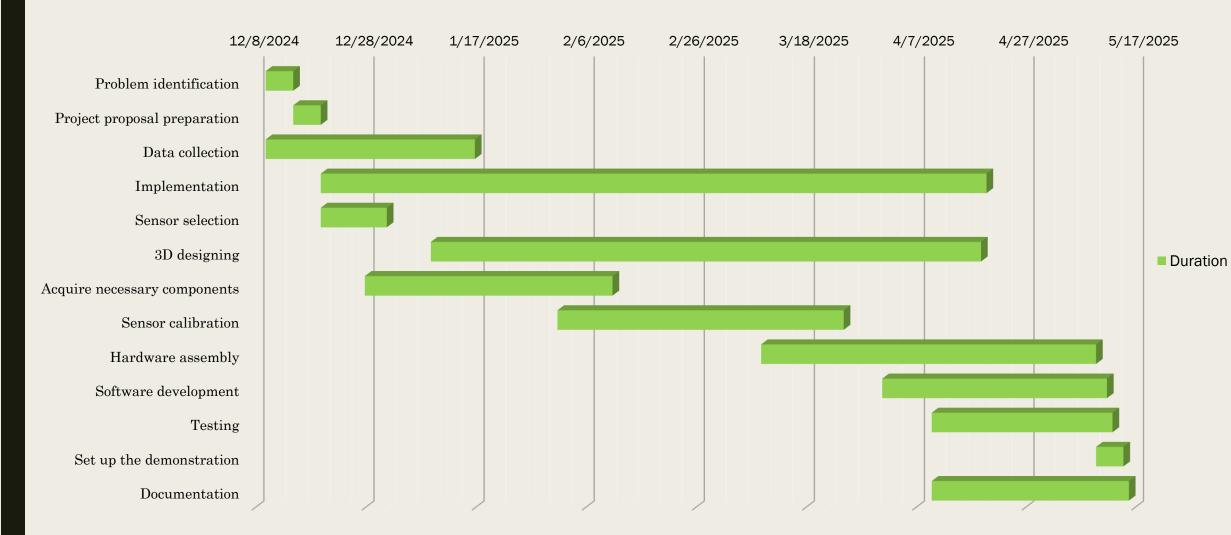
Component	Cost (lkr)
Human presence sensor	1,400
ESP-WROOM-32 microcontroller	1,300
LED Strip	200
12V 2A SMPS adaptor	650
OLED screen	500
1 Channel Relay module	350
Real Time clock memory module	380
Step down Buck module *2	300
Vero board (dot board)	220
LDR, Buzzer, Switch, DC Jack Barrel Connector,	30 + 40 + 10 + 60 + 30
Potentiometer (10k)	= 170
Miscellaneous Components	500
3D print	2500
Total	8470/=



### Cost-saving measures implemented

- The lamp was not fully 3D printed due to cost constraints. Wood was used for the panel and link parts to reduce expenses.
- Only the base enclosure was 3D printed using grey PLA+, with 100% infill for strength.
- The base of the enclosure was first made using wood to cut down costs.
- Wood-finish filaments were avoided as they were nearly twice the price.
- A wooden-texture sticker was added to the enclosure for a uniform appearance.

### Gantt Chart



### References

- [1] "Why Studying at Night is Best Scholarly Blog," *scholarly.so*, Aug. 18, 2023. <a href="https://scholarly.so/blog/why-studying-at-night-is-best">https://scholarly.so/blog/why-studying-at-night-is-best</a>
- [2] A. Dixit, "Benefits Of Table Lamp For Study Woomdecor Buy Home Decor Items Online," *Woomdecor Buy Home Decor Items Online*, Aug. 07, 2024. https://www.woomdecor.in/blog/benefits-of-table-lamp-for-study/?srsltid=AfmBOoppceVcz1BaXyDMGYQewu3dADfwtLJIFIEeSYoRkfBivofDhM-9 (accessed Feb. 09, 2025).
- [3] "Sri Lanka Countries & Regions," IEA. https://www.iea.org/countries/sri-lanka
- [4] "Fact Sheet WIRELESS SENSORS FOR LIGHTING ENERGY SAVINGS Wireless Occupancy Sensors for Lighting Controls." Available: https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/Wireless-Sensors-Guidance.pdf
- [5] Valentín Bladimir Palacios-Intriago, D. D. Rezabala-Cedeño, and W. L. Vera-Cevallos, "LED lights and their impact on energy savings in a residential environment," *International journal of engineering & computer science*, vol. 7, no. 1, pp. 8–11, Aug. 2024, doi: https://doi.org/10.21744/ijecs.v7n1.2306.
- [6] "2017 U.S. Energy and Employment Report," *Energy.gov*. https://www.energy.gov/policy/articles/2017-us-energy-and-employment-report



# THANK YOU