ECE 445

SENIOR DESIGN LABORATORY

PROJECT PROPOSAL

ClassroomClarity

A Portable Teacher Support Hub

Team No. 21

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Abstract

This document provides a detailed description of our project, ClassroomClarity, to further explain the ideas mentioned in our RFA. In this proposal, we will go over a high-level breakdown of the physical and circuit design, the success requirements, as well as the ethics and safety of our project.

Contents

1 Introduction

The following sections provide an overview of the problem we are focusing on, as well as our solution to said problem.

1.1 Problem

Within the classroom there are two sides to learning: students and teachers. For students, it is critical that they can ask questions in order to fully participate in the learning process. However, many students are too anxious to raise their hands or when they do the teacher is so engrossed in their lecture that they go unnoticed. For teachers, they not only have to stay aware of the classroom while teaching the material but also gauge student understanding to lead a successful lesson.

While there are online tools such as Mentimeter, these platforms require professors to use time outside of class to create slides and also take up screen space on the lectern. Another issue with the variety of sites used for student engagement is that there is no uniformity for the students. Cell phones and laptops can become clogged with numerous bookmarks for these applications for different classes. Lastly, professors may need an easily detectable, portable, physical alert to remind them to look at questions that students have posted, which cannot be provided by online means.

Professors and students can benefit from a tool that will easily show them how the class is handling material and any questions that may arise. A hub that is consistent between classes will simplify the learning experience for both students and professors.

1.2 Solution

Our solution is a physical hub for the teacher and a phone app for the students that works together to bring clarity into the classroom. The hub includes indicator lights that will visually relay how the students are reporting their understanding of the class material through the app. The app will also provide options to the students on how they would like to submit a question: The “raise-hand” feature, which will notify a professor when a student wants to vocally ask their question, or a text submission which will display on the hub’s screen. Any submitted questions will be added to a queue which the teacher can scroll through and clear answered questions using a dial and a button, respectively. In addition, the teacher has the option for the hub to vibrate when a question is asked to remind the teacher to look at the hub. There is also an option to put the hub on silent mode where instead of vibrating, another LED will light up when a question is asked. The hub will also have a specific passcode that must be entered into the app to control who has access to the hub.

1.3 Visual Aid

Figure 1 shows an in-context diagram of the ClassroomClarity hub system. The central hub connects via Bluetooth to the phone application. The app collects data on student understanding and engagement by allowing students to select their level of understanding. It also provides a space to submit questions. This data is sent to the hub which displays the first question in the queue and reflects the average engagement level with the LED display. The hub, when it receives question data, will either vibrate or light an LED depending on the selected mode. The central hub also has a button and dial which allows the teacher to scroll through the question queue and clear answered questions.

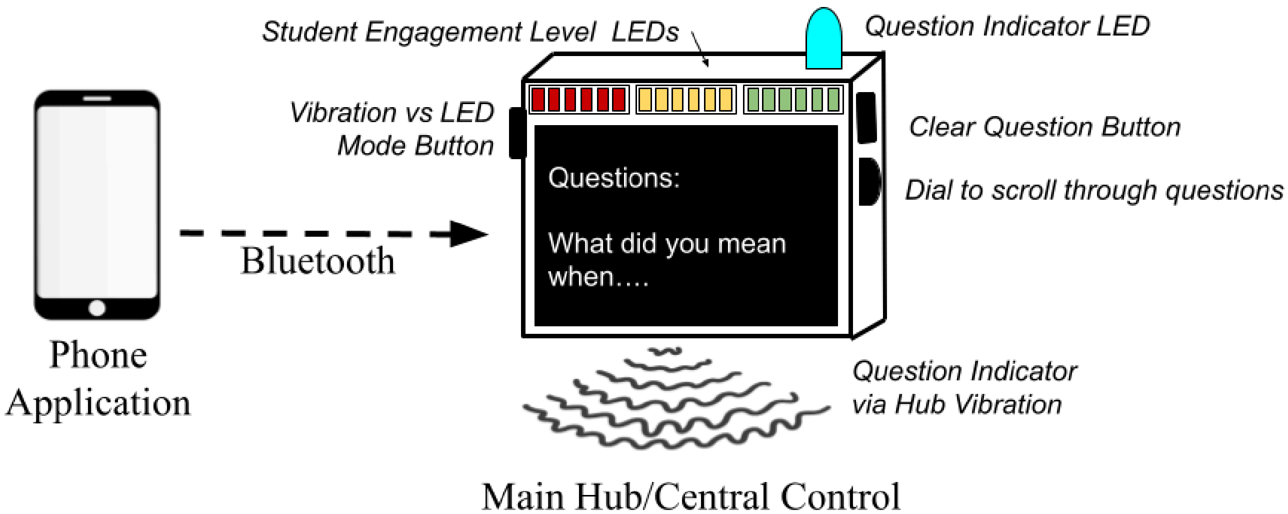

Figure 1: High-level diagram of the ClassroomClarity design

1.4 High-Level Requirements

In order to deem the project successful, we want to reach the following goals.

1. Questions can be sent from the phone app to the hub question queue, which should be able to hold at least 5 questions, such that at least 1 question should be displayed by the central hub if the queue is not empty.

2. When a question is received by the hub, the hub should vibrate for 1 second and light the indicator LED within 1 minute of receiving it. LEDs should turn off within 1 minute of the question queue becoming empty.

3. Students can select their understanding level on the app and the LEDs on the hub should change within 1 minute of the selection to match the new average level of understanding.

2 Design

2.1 Block Diagram

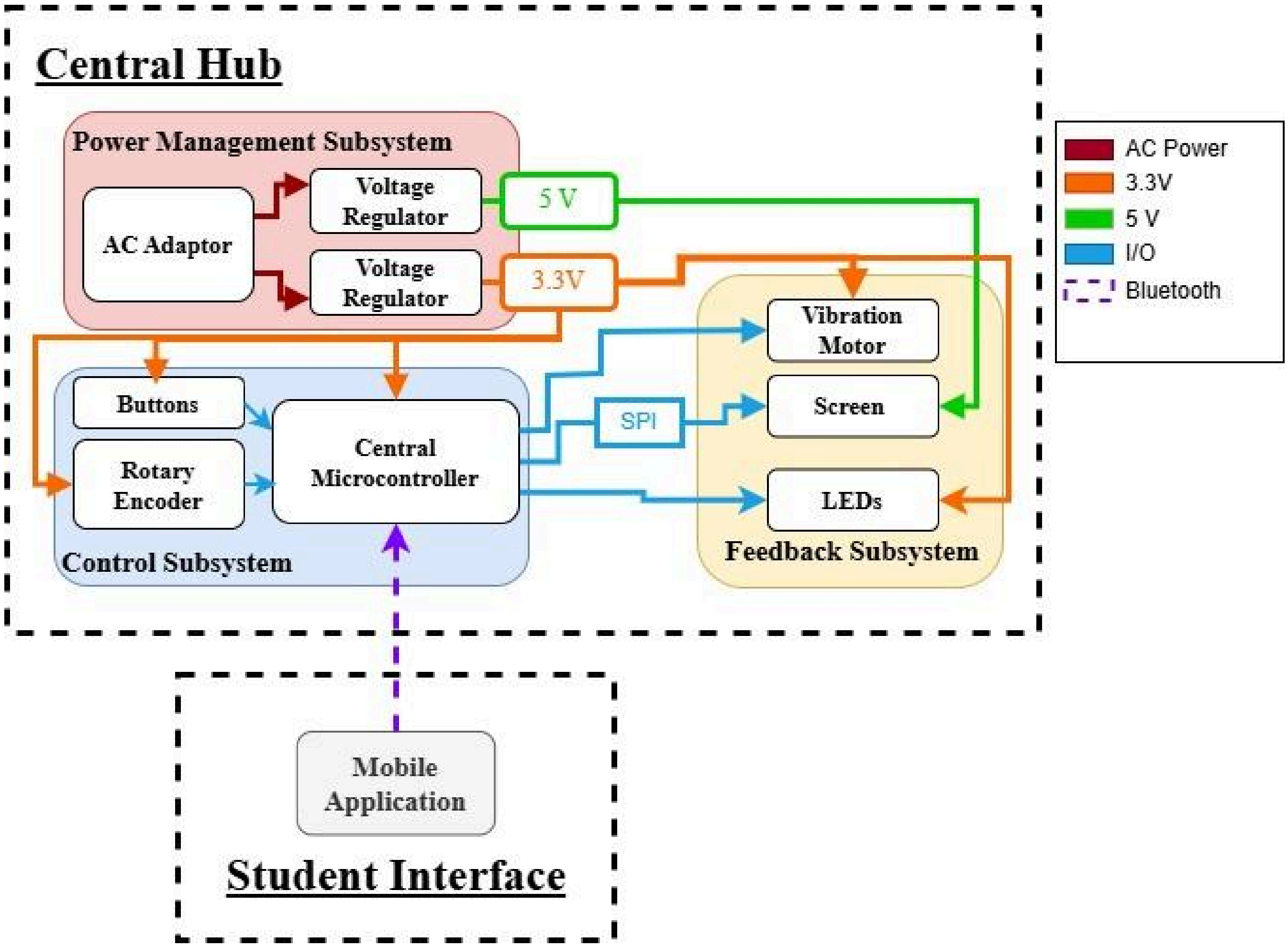

Figure 2: Block Diagram of ClassroomClarity System

2.2 Subsystem Overview

The following section will provide a description of each subsystem and detail its purpose and functionality.

2.2.1 Power Management Subsystem

The power management system provides power to all components of the hub and is essential for the device's functionality. The system consists of an AC wall power adapter and two voltage regulators. The wall adapter will provide power to the voltage regulator, which steps down the voltage to the appropriate level. The system then provides the corresponding voltages to both the control and feedback subsystems to power elements such as the microcontroller and screen.

2.2.2 Control Subsystem

The control system of the hub is critical to functionality as it must receive, process, and send data. The ESP32-PICO-V3 [3] system-in-package device will keep a log of questions that is received via Bluetooth LE from the student interface and send these questions to a screen. It will accept external signals from a button and a rotary encoder to scroll through and clear questions displayed on the screen. It will also accept signals from a second button to make decisions on the current mode set. The control system is also responsible for communicating with the vibration motor so the hub knows when to vibrate.

2.2.3 Feedback Subsystem

The feedback subsystem contains all components of the hub's design that provide visual and tactile feedback to the users. It consists of a TFT LCD display and a series of colored LEDs for visual feedback and a vibration motor for tactile feedback. The purpose of this subsystem is to engage the professor in an easily digestible manner. The screen allows a professor to view any questions submitted by students while the LEDs display the current engagement level of the class or indicate when a question has been asked. The display will communicate with the microcontroller via SPI. The vibration motor acts as a more aggressive alert to catch the professor's attention for those who are a bit more oblivious.

2.2.4 Student Interface

The student interface consists solely of the application the student will download onto their phone. This application will allow the device to connect to the main hub using Bluetooth after the student inputs the hub's associated code. The app itself will have two functions: poll student engagement and submit questions. To poll student engagement, there will be a ranking system which allows the student to select how they are currently feeling about the topic. Students can also submit questions either by typing in the text submission box or by pressing the "raising their hand" button. This collected data will then be sent to the central hub using the Bluetooth connection.

2.3 Subsystem Requirements

2.3.1 Power Management Subsystem

1. The AC adapter must supply at least 1.2A to the hub and the necessary 5V +/- 0.1V for the voltage regulators to step down.

2. The adapter must be able to safely provide a stable supply of power at the very least the length of one lecture (50 minutes).
3. The voltage regulator must take the input from the battery and output 5V and 3.3V.

2.3.2 Control Subsystem

1. Must be able use Bluetooth to get data from multiple uses of the application and use said data to initiate notification signals within 1 minute.
2. Must use SPI to communicate with the screen to display questions to the professor.
3. Must be able recognize the button presses, what action they signal, and then perform said action within 30s of the action.

2.3.3 Feedback Subsystem

1. Screen must be able to display at least 1 student question.
2. LEDs must light up corresponding to the average class engagement level data within 1 minute of receiving any new data from the application.
3. Screen must have at least a 10 Hz refresh rate for displaying and scrolling through questions.
4. The teacher should be able to scroll through all the questions in the question queue.

2.3.4 Student Interface

1. App has a scale of buttons to collect student understandment levels which will send an update to the hub within 1 minute of change.
2. App can connect its device to the hub's Bluetooth.
3. App induces a text input option for students to submit a question. Once the student presses the submit button, the question should be sent to the central hub within 1 minute if the hub queue isn't full. If the hub's storage is full, then the submission should be sent once there is available space in the queue.

2.4 Tolerance Analysis

The biggest failure point for this project is if power is not properly delivered to the different components of the hub. Failure can occur if incorrect power conversions are made, leading to either too much or too little power to the components. This can cause the circuit to simply not function, or it can lead to much larger issues due to overheated components or blown capacitors.

Careful calculations are required to find suitable conversion rates based on the peak voltage ratings of the components.

Table 1: Voltage requirements for Hub components

Component	Peak Voltage	Peak Current
Microcontroller (ESP32-PICO-V3) [3]	3.3V	233mA
TFT LCD (MSP4022) [4]	5V	100mA-500mA
Vibration Motor (ROB-08449) [5]	3.3V	50mA
LED - Blue [6]	3.2V	20mA

Table 2: Maximum ratings for relevant Hub components

Component	Max Voltage	Max Current
Voltage Regulator (LM317T (NAT)) [7]	40V	1.5A
Rotary Encoder (ECW1D-C24-CC0024L) [8]	10V	10mA
Push Button (D6C90 F2 LFS) [9]	32V	100mA

By analysing the peak voltages given in Table 1, the AC adapter must supply at least 5V to the circuit for functionality. This voltage is well within the maximum ratings for all components in the circuit, some without significant peak values were included for their maximum ratings in Table 2. Next, it is important to ensure the adapter will be able to provide adequate current to the circuit. The TFT LCD had inadequate documentation for its peak current so a range was found by comparing some similar models. The highest current will be chosen from the range to ensure sufficient current can be drawn. To simplify calculations, all LEDs are assumed to be blue as this color has the highest peak requirements. These estimates will result in a higher total current requirement than what is likely necessary, but leaves room for adjustment since this current can be stepped down. This is found by the following equation:

$$I_{total} = I_{microcontroller} + I_{screen} + I_{motor} + I_{LEDs} \quad (1)$$

$$I_{total} = 233mA + 500mA + 50mA + 19 * 20mA \quad (2)$$

$$I_{total} = 1.163A \quad (3)$$

The total current calculated in Equations 1-3 gives a value that is within the bounds of the chosen voltage regulator. Now, with the voltage and current requirements known, a proper ac adapter, such as the WSU050-1500-R [10], can be chosen with confidence that it fits the ratings required to properly supply the circuit and ensure successful project completion.

3 Ethics & Safety

This section holds a brief discussion of the ethics and safety related to the project and how we plan to uphold them. The code of ethics this discussion draws from is a combination of the IEEE Code of Ethics [1] and the ACM Code of Ethics and Professional Conduct [2]. As engineers tasked with innovation, we understand the impact we can have on the lives of the communities we serve. That is why we strive to reach the highest standards of safety and ethics, such as the following:

1. **To treat all people fairly and respectfully, which includes not discriminating, harassing, or injuring others [1],[2].**

   Throughout the course of this project, we will be working as a team to create the final product. In order to work the most efficiently and produce the best results, we must strive to listen to each other and respect any and all ideas that are shared. So far in the project we have made efforts to uphold this by taking turns speaking during meetings so that all voices are heard. We have also put into action a choosing process that is based on facts and proof to ensure personal bias doesn't create an unfair decision making process.

2. **To seek, accept, and offer honest criticism by acknowledging and correcting errors while remaining true to the facts and data available to us [1]**.

   We understand that as individuals we do not know everything, which is why we plan to enter this project with an open mind to new ideas and to listen to the advice we are given. One of the main sources of critiques for the project will likely come from our weekly TA meetings. As such, we plan to guarantee that at least one member every week will take notes during the meeting so we can be sure to review and correct any mistakes that were brought up.

   All of the team members will also be keeping a lab notebook that will contain all the data gathered throughout the project. This will provide us with a base to refer to in order to guarantee that the shared information remains true.

3. **To continue to develop our technical skills and to only accept tasks that we are prepared and qualified for [1].**

   So far, we have already made strides to improve the technical skills we will need for this project. The full team has completed both the KiCad and soldering assignments which will provide good experience for when we build our PCB. Similarly, in preparation for designing the PCB, we all attended Dylan Wagner's presentation to hear advice from someone working in the industry.

As the project progresses, we expect to come across more areas where we lack experience but are necessary for the project; therefore, we plan to continue learning by researching experts in those areas and reading about what they have to say about the topic. We will also ask for advice from the TAs and professors to learn from their experience as well.

Many statements in the code of ethics refer to avoiding harm or injury, which is why we have carefully considered safety in the context of our project and the ways we can ensure safe conditions:

1. As with any device that uses electricity, we must be careful with connections to ensure no accidental shocks occur. That is why we will be choosing a certified power adapter that will be used to connect the device to power. Also, we plan to enclose all the circuitry within a plastic container so that users don't have access and to serve as a barrier between the device and the environment.
2. To make sure interaction with the device remains respective of all users, we will be adding device authentication in the form of an auto generated password students must input into the app that regenerates when the hub is turned on. This password will keep any outside disruption from interacting with the hub.
3. To maintain privacy for our users, the students are only required to input the name that will be displayed to the professor when they ask a question. We also will not be storing any of the inputted data between hub ON/OFF cycles so those inputted names will not be stored on a database.

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