Pixie

High Level Design

Abby Brown, Ethan Lau, Dani Nah, Alexa Zeese

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1. Introduction

Picture this: you're a broke college student, it's 3 A.M., and the only thing you've written on your paper is your name. Your desk is a chaotic battlefield of notebooks, half-empty coffee cups, and procrastination-induced despair. Your dilemma has been brought about by your lack of experience juggling the numerous responsibilities dumped on you, which you now realize requires careful time management and prioritization – skills you have yet to develop. And the deadline? It's creeping closer with each passing second, and your motivation is on life support. But wait, despairing scholar, because salvation is at hand!

Introducing Pixie, the perfect desktop companion! Pixie is a pint-sized desk friend that combines both functionality and charm – helping you focus and manage your responsibilities while bringing some cheer to your study environment. Resembling a miniature computer, it brings the perfect touch of liveliness to bring back the pep in your step. Pixie can provide you with focus features such as study timers, critical notification syncing, day/night (wake/sleep) display modes, and more! Adding to the smart focus tool, Pixie is also a canvas for your creativity. Easily select your favorite pixel art to personalize your desktop buddy. Pixie also has a variety of other features that can rescue you from the clutches of procrastination and light up your late-night study session like never before!

2. Problem Statement and Proposed Solution

Present-day technological devices boast unprecedented advancements, offering swift access to the latest news, information, and trends at the tap of a personal device's screen. While this newfound convenience has the potential to enhance and accelerate the work experience, college students often grapple with distractions and procrastination induced by these devices. Compounded by students' limited experience in managing real-world responsibilities, these technological advancements can become a significant source of distraction and procrastination. Moreover, uninspiring and drab workplaces can exacerbate issues, leading to decreased motivation and productivity. These factors collectively make it challenging for a substantial number of students to effectively juggle multiple deadlines and tasks, often resorting to the common practice of pulling all-nighters to complete assignments.

To help prevent the temptation of becoming sidetracked by a cell phone during study sessions, we propose a device designed to provide the user with necessary information independent from their phone. The Pixie Display aims to create a more conducive environment for students to work or study. Perhaps its most fundamental and prime feature, the Pixie's LED display serves as a smart desk light that automatically turns on and off based on the user's wake/sleep hours. Additionally, the LED display can be programmed to light up in response to sound queues, like clapping, providing visibility in the middle of the night without the need for reaching for a phone. This approach sets the stage for a productive day by promoting proper rest and discouraging late-night phone usage.

Pixie goes beyond just a conventional light source; it also serves as an enjoyable platform for showcasing pixel art. The user can choose from a handful of previously downloaded images to display on their screen during work hours.

In the midst of active study sessions, Pixie can serve as a valuable study timer. Many contemporary students employ diverse study techniques, such as the Pomodoro method, advocating specific time blocks dedicated to focused work, followed by a 5 to 10 minute break. Additionally, Pixie can showcase the date, time, weather, and synchronize critical email notifications, ensuring users remain connected to productivity-oriented applications while steering clear of distractions from media or gaming apps.

3. System Requirements

3.1: Feature Requirements

Pixie will have the following features in order to help the user be more productive with their school work. These features will be implemented into the original design of the Pixie display, and if time and money allow, additional features may be added.

3.1.1 Screen Display:

The screen of the device is the primary visual interface between the Pixie and its user. It will show pixelated art and widget notifications. It will also provide light, study timers, and date/time/weather data. To display all of these features, a Liquid Crystal Display will be used. The LCD will interact directly with the microcontroller, to display the user desired output.

Screen Type: LCD
Screen Size: 5” display
Features on Display:

- Settings screen: bluetooth pairing, choose display brightness, setting timers, selecting pixelated art, etc.
- Show pixelated art
- Brightness adjusted upon user selection
- Brightness turned on when user claps, activating night light feature
- Display date/time/weather
- Display activated timers
- Display specific synced notifications
- Adjust to day/night display light modes

3.1.2 Push Buttons:

A mini keypad provides a local interface for the user to navigate and change the functionality of Pixie. This is where the user will interact with the screen display settings that have previously been mentioned under the screen display section.
Push Button Type: Raised Key Cap Buttons
Total Buttons required: Six (6)
Connection to the main board/ESP32

Push Button purposes:

- Navigate to settings screen, arrow down/up to each settings feature, select settings
- Bluetooth pairing
- Increase/Decrease display brightness
- Set timers
- Select pixelated art
- Increase/decrease volume of speaker/alarm noise

3.1.3 Microphone:

A microphone is used to listen for sound cues. The auditory cues provide hands-free illumination of the display at night. Sound cues may include clapping or saying “Hey Pixie” or some other activating cue that the user can speak to illuminate the night light screen display feature.
The microphone will be placed on the front or side of the display to obtain best range for listening for the auditory cue.

3.1.4 Speaker:

The speaker will provide audio to alert the user when a timer has ended. This will operate for the study timers and sleep timers that the user will be able to set. It will be placed on the top of the display or bottom by the keypads depending on the configuration of the final design. It will communicate through the ESP32 to know when the count-down on the clock has reached zero and an alarm should sound.

3.1.5 Study/Sleep Timer:

The device has the ability to set timers. Setting a timer for study purposes will enhance focus, allowing study break time to take place after the timer goes off. Furthermore, just like all timers, this feature may be used as an alarm for sleeping as well. Users can also choose from a default list of study methods (e.g., the Pomodoro method) that will automatically set the timers.

Internal clock: ESP32 timer functionality.

3.1.6 Notifications:

Another feature of the Pixie is that specific notifications from the users email, assignments app, group project messages, phone call alerts, etc. will be displayed on the Pixie screen.

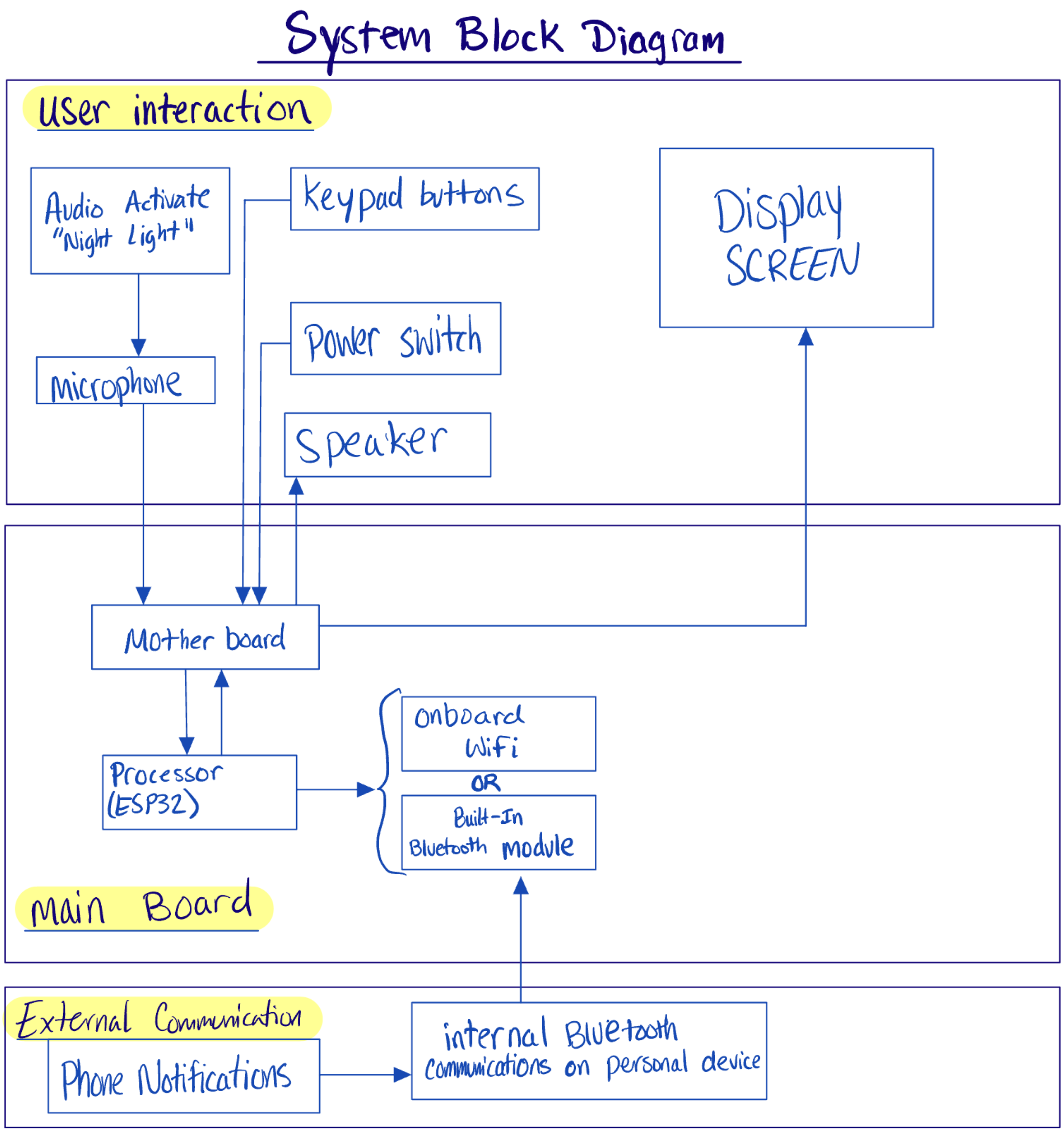
The notifications will be connected to the display from the user’s phone via bluetooth or WiFi modules. Bluetooth pairing will require tapping into the ESP32’s built- in Bluetooth radio. Depending on the complexity of the solution, WiFi to sync notifications to the display may be a more efficient option.

3.2 Power Requirements

Pixie will be powered by a wall adapter supplying 5V DC. For first time installation and setup, the user will power on the device by plugging in the adapter, and switching on the power. The user will then hold down on a separate button to place the bluetooth module into pairing mode, which will allow the user to connect Pixie to their phone. Once installation is complete, the user can fully use all of Pixie's capabilities. From this point onwards, the user will also be able to interface with the mini keypad to change simple functions and settings such as display brightness and volume.

4. System Block Diagram

4.1 Overall System



4.2 Subsystem 1: Physical User Interface Requirements

The first subsystem of Pixie encompasses the hardware interface between the user and the display as well as the display itself. This system includes the physical components which the user will provide inputs to change the functionality of the Pixie. Specifically, these components include the mini keypad, the on/off switch, the microphone, and the power adapter. The keypad should have 6 buttons, at least 1 cm^2 (typical keyboard size), to allow for ease of location and use. The keys should be pushbuttons. The on/off switch should be a toggle switch, matching the typical on/off switches in most electronic devices. The microphone will communicate with the board once it hears the voice activation, such as “Pixie ON”, to illuminate the screen. The power adapter will be selected to plug into US outlets and will be of Type A on the transformer side and have a barrel connector for routing the supply voltage to the display. The cord of the adapter should be at least 1.5m in length to allow for a reasonable amount of reach between the wall outlet and the location of the display.

In terms of the screen itself, the Pixie will use a single 4-5” display; the screen will have no touch functionality in favor of tactile buttons. The screen must have variable brightness control to implement features like “night-light,” so the display is not glaring at night. In addition, the screen must have a relatively high resolution and color accuracy in order to display things such as pixelated art designed for the screen, weather, and time so they are easily viewable at a glance by the user. Plus, the screen needs to have a high enough refresh rate (24 - 60 Hz) for animations, including timers.

4.3 Subsystem 2: Main Board

The main board will serve as the “hub” of this build. Meaning, it will be responsible for taking in user inputs and controlling the output devices. In terms of inputs, the board will need to be able to interpret inputs from the microphone, power switch, and keypad. Then, the board will have to translate this input data into the proper commands to control the output devices, namely the speaker and display. In addition, using its onboard wifi and bluetooth capability, the main board is responsible for 1) transmitting and receiving data with the connected smartphone and 2) receiving local time, weather, and any other relevant local information.

4.4 Subsystem 3: External Communication

The external communication will take the smartphone notifications and send the signals from the phone’s bluetooth module to the board's internal bluetooth module. The module will then communicate with the rest of the motherboard to display the notifications on the screen for the user to see.

4.5 Subsystem 4: Future Enhancement Requirements

The Pixie allows for a lot of future enhancements. First, the display interface can be changed to touch screen to allow easier user interaction. Since there are already speakers integrated into the device and wifi/bluetooth modules on the board, the Pixie can have future capabilities of playing music from the user's personal smartphone through the speakers on the Pixie. Additionally, the future of Pixie could have its own app for smartphone users. The app will allow users to create their own art to display on the Pixie.

5. High Level Design Decisions

5.1 Physical User Interface Decisions

This user interface system encompasses the hardware interface between the user and the display, including input devices and the power supply. We are using a 6 button, mini keypad to integrate each of the different functions. The easiest way to implement such a keypad is through a 6-key "macropad," such as the Sikai Case 6-key macro keyboard with a customizable knob. The 6 buttons will allow the user to select pixelated art, start/stop the quick timer, and configure a sleep/study mode, while the knob will be used to control the screen brightness. To integrate these functions, we will use a state machine so that each button's functionality is dynamic. That is, the functionality of each button will change depending on what is currently being displayed on screen. For example, when the user presses the button to create a timer, the brightness up/down buttons change to be timer increase/decrease buttons, and create a timer button is reconfigured to become the timer start/stop button.

However, with the addition of the knob on the keypad chosen, the knob requires a single use. By adding the knob to the keypad, we cut back on device cost. The knob will allow the user to adjust the screen brightness at any instance without having to click through display button settings, getting to the screen brightness option, and using state machine integration. The knob allows the screen brightness to be adjusted no matter what is displayed on the screen.

The power adapter has been chosen to be type A with a transformer that has a barrel connector in order to route the supply voltage to the display, with a cord length so that users have flexibility in positioning Pixie. The power switch is a circular metal pushbutton switch with an addressable LED ring (red, green, and blue LEDs); this LED ring can be used as a debugging indicator, such as red for software failure, green for on, and blue for bluetooth pairing mode.

5.2 On-board Software Decisions

The software subsystem uses the ESP32 MCU to mesh inputs from hardware and WiFi for proper functionality of the Pixie. This program will be using RTOS to handle interrupts and the scheduling of tasks. The decision to use RTOS for programming the ESP32 MCU is to ensure that tasks are executed within specified time constraints. This is particularly important when dealing with hardware inputs and WiFi communication, as delays could lead to performance issues or even system failure. Additionally, RTOS enables prioritizing tasks so that when Pixie is multitasking different functions, we can make sure that higher priority tasks like WiFi/Bluetooth communication protocols get executed first.

6. Open Questions

For our power supply, the power draw is not clear for the 5V DC battery since it hasn't been implemented yet. Will most likely implement a power adapter as a battery will unecessarily take up a large portion of space.

Connecting user phone notifications to the device via bluetooth will cause some concerns and questions to be answered. A reference document for an arduino bluetooth module tutorial is attached at the end of this document. Along with designing the main board for the device, the bluetooth module will be the first feature built to determine further requirements and feature functionality. The main concern is to get the bluetooth notifications working, and testing it with the rest of the features on the system.

7. Major Component Costs

- LCD display
    - $40.18
- Microphone
    - $2.94 for 1 microphone
- Mini keypad
    - $16.99 for 1
- Speaker
    - $2.60 for 1
- Power Switch
    - $9.59 for 1
- Power Adapter
    - $17.50 for 1
- Microcontroller
    - ESP32-C3
        - $8 for 1
    - ESP 32 MCU
        - $15 for 1
- Board Design
    - $50
- 3D printed housing
    - Free through EIH at ND

Total Estimated Cost: $162.80

8. Conclusions

Pixie emerges as a charming desktop companion designed to tackle the challenges faced by college students, such as distractions, a lack of motivation, and stagnant study environments.

This device combines functionality with charm, offering key features like pixel art, sound-activated lighting, a study timer, widgets displaying date/time/weather, day/night mode, and synced notifications. These features empower students to effectively manage their study time. Our team will select readily available and feasible technologies for the power source, display monitor, Bluetooth, microphone, and speaker.

The primary tasks for our team involve configuring the microprocessor for audio signals, programming the keyboard, interfacing the display with the microprocessor, and implementing Bluetooth and Wi-Fi connectivity. The customization of the 3D printed housing and pixelated art further enhances the user experience. Pixie transforms dull study spaces into productive sessions, offering a solution that brings life and efficiency to academic pursuits.

9. References

Bluetooth module for arduino:
https://www.makerguides.com/arduino-and-hc-05-bluetooth-module-complete-tutorial/