Cover Page

Capstone Project Proposal

My Smart Lamp

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Abstract

This project developed a custom smart lamp designed to improve users' quality of life by addressing common health concerns such as anxiety, sleep disturbances, and difficulty focusing. The lamp used input from users, including sleep schedules, work periods, and stress indicators—to create lighting environments that promote mindfulness and mental well-being. Users interacted with a simple interface to select lighting modes corresponding to desired states: Sleep/Wind Down, Focus, or Calm. Drawing from scientific research and personal analytics, the system leveraged the proven psychological effects of lighting to support healthier habits. The smart lamp integrated principles of computer science and engineering to deliver a user-friendly tool that encourages positive lifestyle changes.

Introduction

In today's world, mental health issues such as anxiety, poor sleep quality, and difficulty focusing are increasingly common. According to a study by the sleep foundation, "Seventy to 96 percent of college students get less than eight hours of sleep each weeknight… insufficient sleep has been linked… to weight gain and obesity, cardiovascular disease, and type 2 diabetes" (Harvard Summer School, 2023; Sleep Foundation, n.d.). Poor sleeping habits can negatively affect physical and mental well-being, placing stress on individuals of all ages. While Lighting has been shown to significantly affect mood and mental states, it is often overlooked as a tool for well-being. This project addresses this gap by developing a 3D printed smart lamp that uses responsive lighting to promote better sleep, focus, and calmness. By allowing users to input daily routines and stress indicators into a custom interface, the device tailors its light settings to support healthier habits. Customizable and programmable gradients of light allow users to create positive environments that encourage healthier habits. Because people can be conscious of mental wellness regardless of age, this smart lamp is for anyone looking to improve their quality of life. Combining principles from computer science, psychology, and engineering, this project demonstrates how accessible technology can be leveraged to support mental wellness in everyday environments.

Background

The relationship between lighting and human wellness has become a growing focus in both commercial and academic contexts. Numerous products have emerged to support sleep and mental well-being through lighting solutions that adjust color, temperature and intensity based on the time of day or user needs. Among these, the Philips Hue Sleep and Wake-up system stands out as a leading product designed to align lighting with natural circadian rhythms. This system eliminates blue light exposure in the evening by shifting to warmer tones and gradually increases brightness in the morning using cooler light to support wakefulness. It also features app-based customization and the ability to pair with other smart lighting devices for a more immersive experience (Philips Hue, n.d.). Another comparable product is the GE C-Sleep Smart Bulb, which offers three pre-set color temperatures designed for wakefulness, general activity, and winding down before sleep. Its functionality is built entirely into the bulb, making it a low-cost and streamlined solution for consumers (GE Lighting, n.d.). However, both commercial products either require integration with existing smart home ecosystems or are limited to the format of a bulb, which may not be ideal for all users.

The smart lamp project builds on the core concept of mood- and sleep-enhancing lighting but seeks to improve affordability and accessibility through a fully custom, 3D-printed smart lamp. Unlike bulb-based solutions that require specialized fixtures or full ecosystem buy-ins, this design emphasizes flexibility, allowing users to choose or modify the lamp's form to suit different environments. This device also supports ease of interaction through a simplified user interface, with potential for future integration of features such as a clock display. By avoiding proprietary ecosystems and costly commercial options, this smart lamp offers a more personalized and accessible alternative while utilizing the core principles of light-based behavioral support.

Deliverables

Deliverables for Capstone I:

- Framework of application interface using React Native

  For this deliverable, I developed a basic framework of the mobile application interface using React Native. The interface includes clickable buttons that represent each core function of the smart lamp: Wind Down, Focus, and Calm. Currently, each button triggers a basic alert to simulate navigation. In future iterations, these buttons will redirect users to sub-pages where they can customize lighting gradients and set schedules based on their preferences. To build this prototype, I installed several necessary VS Code extensions and configured a local development server using terminal commands.

- Utilizing 3D modeling software: Blender

  To support the physical design of the smart lamp, I began learning Blender, a 3D modeling and rendering tool. I completed several tutorials, including creating a basic animated donut scene, which helped me understand Blender's modeling and animation environment. Using these foundational skills, I began designing a preliminary concept for the lamp's shape and form. The goal is to create a model that is both functional and visually appealing, adaptable to a range of user preferences through 3D-printed customization.

- Circuit on breadboard with LEDs

  As an initial prototype for the lamp's functionality, I assembled a basic circuit on a breadboard using LEDs to simulate lighting modes. This circuit serves as a testbed for implementing color changes, brightness control, and programmable responses tied to user inputs. It also enabled me to verify that the hardware setup can be expanded upon with more complex components such as sensors or actuators in future iterations.

- Fully set-up Home Assistant OS with communicating Raspberry PIs

  I configured a full installation of Home Assistant OS on a Raspberry Pi 5 to act as the control hub of the smart lamp system. Additionally, I connected a second Raspberry Pi, designated to receive commands from the Home Assistant server and control the physical LED states based on user-selected settings. The two devices successfully communicate over the local network using MQTT. This establishes the foundation for a responsive and remotely manageable smart lamp system.

Deliverables for Capstone II:

- Complete React Native App with Home Assistant Integration

  The mobile application developed in Capstone I will be expanded into a fully functional interface that communicates directly with Home Assistant. This integration will allow users to customize lighting settings, switch between lamp modes (e.g., Wind Down, Focus, Calm), and schedule lighting behaviors via MQTT or other supported protocols. The app will move beyond its prototype stage to include proper routing, state management, and responsive design for real-time interaction with the smart lamp system.

- Finalized 3D Model with Iterative Testing and Functional Printing

  The preliminary 3D model created in Capstone I will be refined into a finalized version suitable for physical prototyping. Several test prints will be completed to ensure the design is both structurally sound and visually appealing. Special attention will be given to the dimensions and fit of the bulb socket, which must hold securely during use. The iterative design process will address issues related to alignment, material tolerances, and aesthetic appeal, resulting in a practical, durable housing for the smart lamp.

- Hardware Integration and Thermal Design Considerations

  The finalized hardware components: including LEDs and Raspberry Pi—will be embedded into the printed lamp housing. Throughout this integration process, ventilation and heat dissipation will be evaluated to determine whether internal fans or passive cooling solutions are necessary. Iterations of the lamp shell will be adjusted accordingly to accommodate airflow or venting.

Methodology

Task	Timeframe	Expected Hours	Details
Set up basic app UI with React Native	June 1 – June 15	10 hrs	Create screens for each lighting mode (Wind Down, Focus, Calm).
Connect React app to Home Assistant	June 15 – July 1	12 hrs	Use MQTT or HTTP APIs for interaction with backend services.
Iterate on React app interface and state	July 1 – August 1	15 hrs	Add customization, schedule inputs, refine user flow.
Learn Blender & design initial lamp model	June 5 – June 20	8 hrs	Complete tutorials and create first prototype of lamp design.
Iteratively 3D print and test housing	June 20 – August 5	20 hrs	Refine model through 2–3 prints to ensure bulb socket fit and ventilation.
Build and test LED breadboard circuit	July 1 – July 15	5 hrs	Assemble RGB LED circuit for visual testing of light modes.

Task	Timeframe	Expected Hours	Details
Integrate hardware into printed housing	August 1 – August 10	6 hrs	Combine 3D print with electronics; test physical alignment and wire routing.
Evaluate airflow / add vents or fans	August 10 – August 20	4 hrs	Adjust model to support safe heat dissipation.
Begin testing full prototype	August 20 – September 10	8 hrs	Test light behavior, app responsiveness, and connection stability.
Final bug fixes & polishing (UI and case)	September 10 – November 1	6 hrs	Refine lighting gradients, input handling, and final 3D enclosure touches.
Prepare final presentation & documentation	November 1 – December 1	8 hrs	Final user guide, demo, and summary of testing data.

Software: Visual Studio, React Native, Home Assistant OS, Blender
Hardware: Raspberry Pi 4, 5, 3D printer, Smart Led, breadboard

Indication of Competency

This project showcases a multifaceted application of computer science and engineering concepts acquired through upper-level coursework, particularly in software development, system integration, and networking. The development of a cross-platform mobile application using React Native draws directly from material covered in Advanced Webtech and Software Engineering. This includes user interface design, modular development, and version control.

In addition to front-end development, this project also incorporates back-end communication protocols, aligning with topics covered in Cybersecurity and Systems. Specifically, the smart lamp system utilizes MQTT over a shared local network, requiring secure, consistent communication between devices. This reflects knowledge of networking principles, message brokering, and socket-based communication.

On the hardware side, Python programming, Linux command-line operations, and file system management are all essential to configuring and controlling the Raspberry Pi devices. The integration of Home Assistant OS further demonstrates the ability to adapt and deploy open-source platforms in a real-world setting.

By combining multiple programming languages (JavaScript, Python, shell scripting) and cross-domain knowledge from both software and hardware perspectives. This project exemplifies the interdisciplinary problem-solving, technical communication, and system design skills expected of a graduating computer science student.

References

Blender Guru. (2019, May 16). *Blender beginner tutorial - Part 1* [Video]. YouTube. https://www.youtube.com/watch?v=4haAdmHqGOw

Eli the Computer Guy. (2020, August 3). *Home Assistant MQTT* [Video]. YouTube. https://www.youtube.com/watch?v=xTIBG_KD8Bk

GE Lighting. (n.d.). *GE C-Sleep smart bulb*. https://www.gelighting.com/led-lights/bulbs/medium-base/ge-c-sleep-smart-bulb-bedroom-3-color-settings-works-google-assistant

Harvard Summer School. (2023, October 2). *Why you should make a good night's sleep a priority*. https://summer.harvard.edu/blog/why-you-should-make-a-good-nights-sleep-a-priority/

Home Assistant. (n.d.). *Installation on a Raspberry Pi*. https://www.home-assistant.io/installation/raspberrypi

Philips Hue. (n.d.). *Sleep and wake-up lighting*. https://www.philips-hue.com/en-us/explore-hue/propositions/wellbeing/wake-up

Programming with Mosh. (2020, April 9). *React tutorial for beginners* [Video]. YouTube. https://www.youtube.com/watch?v=0-S5a0eXPoc

Sleep Foundation. (n.d.). *Final exams and sleep*. https://www.sleepfoundation.org/school-and-sleep/final-exams-and-sleep