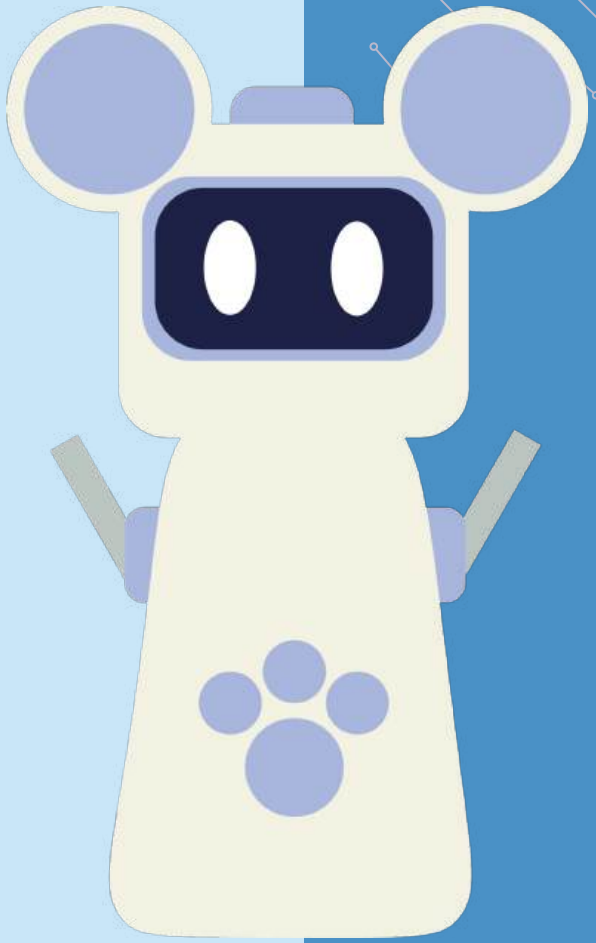
Team E6: Study Bearbot

Taylor Kynard and Kayla McFarlane



Goal:

Make studying a little less stressful and a little more fun — with BearBot!

Use-Case Requirements:

- Response Time ≤ 500 ms [1] [3]
- Scent Diffusion that lasts for ~ 1 Hour [4]
- Battery Life of 2 Hours [2]
- Easily Portable

Limitations of Bearbot & Safety

- Can't shake aggressively **X**
- Liquid is cold & harmless ✓

References

[1] Ali, Al-Sabri Akram, and Xianan Bao. "Design and Research of Infrared Remote Control Based on ESP8266." OALib, vol. 08, no. 04, Scientific Research Publishing, Jan. 2021, pp. 1–14, https://doi.org/10.4236/oalib.1107314. Accessed 3 Feb. 2025.

[2] Bart, Mary. "Students Study about 15 Hours a Week, NSSE Finds." *Faculty Focus | Higher Ed Teaching & Learning*, 17 Nov. 2011, www.facultyfocus.com/uncategorized/students-study-about-15-hours-a-week-nsse-finds/#:~:text=Findings%20released%20today%20show%20that,study%2015%20hours%20a%20week. Accessed 3 Feb. 2025.

[3] Ricard Franch Argullol, "Analysis of Raspberry Pi PLC pinout time response" Industrial Shields, 13 June 2023 https://www.industrialshields.com/blog/raspberry-pi-for-industry-26/analysis-of-raspberry-pi-plc-pinout-time-response-540

[4] Laura Garvin Gomez, "How many Drops of Essential Oil in a Diffuser" Nikura, 26 Feb, 2023 https://nikura.com/blogs/discover/how-many-drops-of-essential-oil-in-a-diffuser#:~:text=Most%20diffuser%20models%20can%20run,whole%20of%20your%20sleeping%20period.

UR == User Requirement

Design Requirements

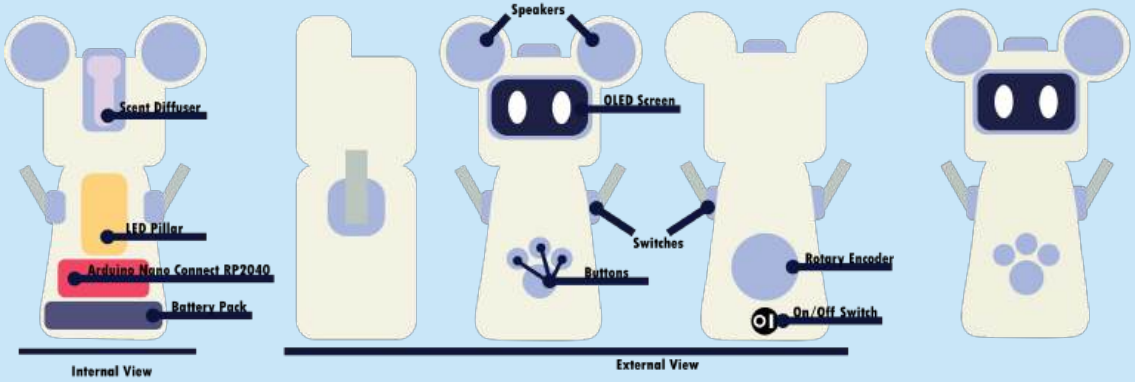
- Arduino Nano Connect RP2040 & OLED Graphic Display Module **(UR: <= 500 ms)**
  - Arduino Nano Connect RP2040 & OLED Specification (SPI)
    - **Response time of a few milliseconds**
  - SPI ranges from **10MBPs to 20 MBPs**

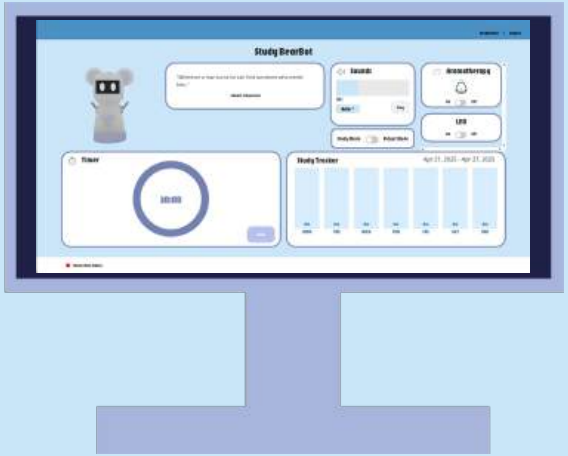
- Bearbot Diffuser Design
  (UR: 1 Hour Diffusion = 4 Oz)
  - Cylinder is 3cm long & 4 cm radius
  - $\Pi \times 4^2 \times 3$ = 150 cm^3
  - Can hold up to **5 Oz liquid → > 1 hour**

- 4 AA Battery Pack Holder, Rocker Switch, & Voltage Regulator
  (UR: 2 Hours Battery Life)
  - 1.5 V AA battery → 2000mAh
  - (2000mAh * 4 batteries * 6V) = 48Wh
  - 48Wh / (5W) = **9.6 hours**

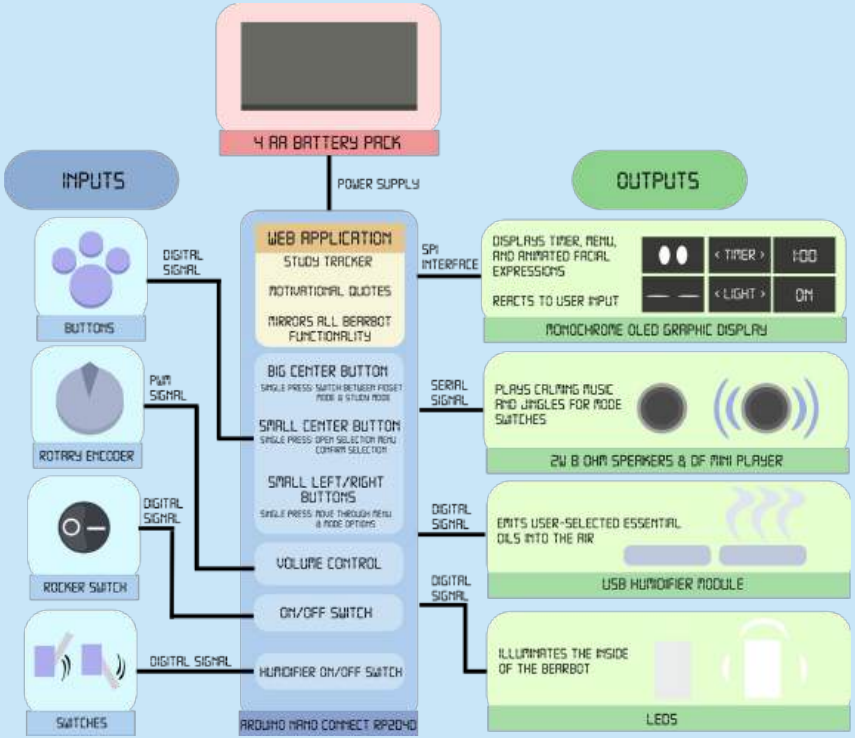
- Bearbot Diffuser Design **(UR: Safety)**
  - Hole for wires at the bottom covered by diffuser
  - Keep components safe in case of spill

Solution Approach





Solution Approach



Complete Solution

Physical Study Bearbot

- **Hardware Electronic Components**
  - Speakers → Music
  - Diffuser → Aromatherapy
  - Rotary Encoder → Volume & Fidget
  - Buttons → Navigation & Fidget
  - Motors & Arms → Personality/Companionship
  - OLED Screen → Navigation & Personality/Companionship
  - Power Rocker Switch & Battery Pack → Transportability

- **Hardware Exterior**
  - Transparent Plastic
  - Silicone Skin

Study Bearbot Web Application

- **User Authentication System**
  - Login/Signup Functionality
  - User Data Storage - Study session history

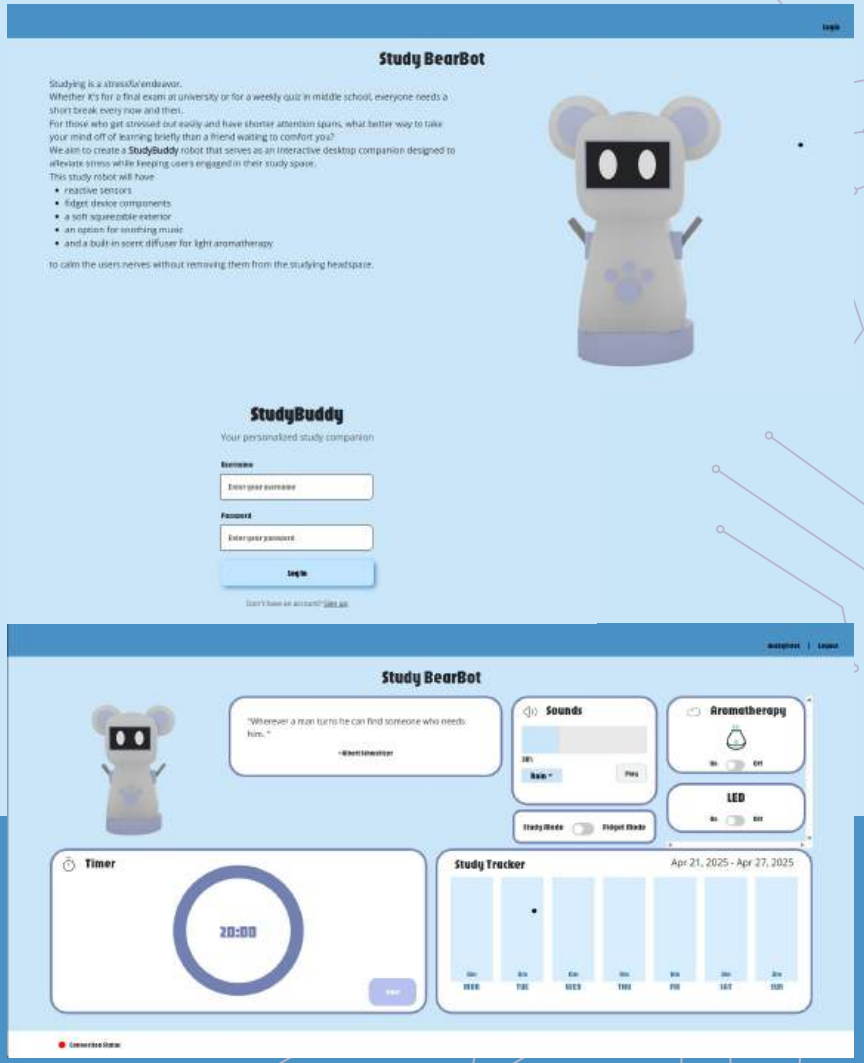
- **Interactive Controls**
  - **Timer Function** - Pomodoro-style study timer with start/pause/stop capabilities
  - **Study Mode Toggle** - Switch between study and fidget modes
  - **Sound Control** - Selection of ambient sound tracks and volume adjustment
  - **LED Light Control**

- **Study Analytics**
  - Weekly Study Tracker - Visual representation of study hours per day
  - Session History - Record of completed study sessions

- **Connectivity Features**
  - Real-time Sync - Bidirectional communication with physical Bearbot
  - Connection Status Indicator

- **User Experience**
  - Motivational Quotes - Encouraging messages to maintain study motivation
  - Intuitive Interface - Clean, minimal design for distraction-free studying

Complete Solution



Testing, Verification and Validation

- **Conduct Trial Runs with Bearbot for 20 Minutes (10 Participants)**
  - **Goal: Measure stress relief, ability to focus, & interactivity**
  - Pre and Post Study Survey
  - Screen Record Web Application
  - Avg Response > 5 → **Pass**
  - If user receives a positive experience from Bearbot (i.e 7-10 on survey scales) → **Pass**
- **Conduct Trials on Battery Life (5 Trials)**
  - **Goal: Measure the lifetime for the Battery**
  - For 1 trial, if battery life >= 2 Hours → **Pass**
- **Conduct Trials on Diffusion Time (5 Trials)**
  - **Goal: Measure the lifetime for the Diffuser**
  - For 1 trial, if diffuser life >= 1 Hour → **Pass**

Testing, Verification and Validation

Battery Tests

Trial	Hour
1	5
2	9
3	10
4	7
5	8

Average Hours: 7.8
Standard Deviation: 1.9
Passed Use Case Requirement

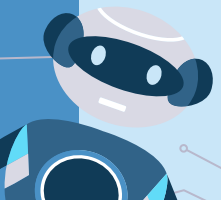
Notes: First two trials were with rechargeable Amazon Batteries - last three trials were with Duracell Batteries.

Diffuser Tests

Trial	Time
1	42:25:00
2	44:25:00
3	56:40:00
4	47:28:00
5	43:40:00

Average Minutes: 46:55:36
Standard Deviation: 5:45
Refill Rate / 2 Hours: ~2.5
Failed Use Case Requirement

Notes: An additional part was needed for the diffuser that took up some of the area of the hole: another fabrication pass with the CAD



Testing, Verification and Validation

User Study Tests

- **Participants:** CMU students from diverse majors (ECE, MechE, CS, etc.)
- **Context:** Users studied with Bearbot for ~20 minutes in a private study setting.
- **Data Collected:** Pre/post-study surveys + recorded interactions.

Key Metrics	Before	After
Stress (1=relaxed, 7=stressed)	4.5	3
Focus (1=unfocused, 7=focused)	4.5	5.5
User Comfort	–	~6.33
Would Use Again	–	~6.17

**Note: We plan to test with 4 more participants, but based on current data:*

Passed Use Case Requirement

Design Tradeoffs

Diffuser Activated with Switch

- More Powerful with Constant 5V vs Digital Write
- Removed Aroma Option from OLED Screen
  - Fabricated New Part to Cover Diffuser

Removing Rotating Base

- Made Bearbot Less Clunky & Easier to Hold
  - Moved Away from Voice Recognition
- Lost Some Interactivity

Project Management - Schedule

WBS NUMBER	TASK TITLE	TASK OWNER	DUE DATE	PCT OF TASK COMPLETE
1	**Deliverables**			
1.1	Project Abstract	All	1/22/25	100
1.2	Website Initial Setup	All	2/1/25	100
1.3	Project Proposal Presentation	All	2/3/25	100
1.4	Design Review Presentation	All	2/15/25	100
1.5	Design Review Report	All	2/28/25	0
1.6	Ethics Assignment	All	3/12/25	0
1.7	Interim Demo	All	TBD	0
1.8	Final Presentation	All	TBD	0
1.9	Final Report	All	TBD	0
2	**Web App Interface**			
2.1	Define technology stack	Kayla	2/12/25	100
2.2	Refine web-app wireframes	Kayla	2/16/25	100
2.3	Develop web-app backend/frontend	Kayla	3/22/25	0
2.4	Set up basic API endpoint to connect the web app with the robot	Kayla	3/8/25	0
2.5	Implement motivational quotes display	Kayla	2/28/25	0
2.6	Implement study tracker functionality	Kayla	2/28/25	0
2.7	Implement timer functionality	Kayla	2/28/25	0
3	**Firmware**			
3.1	Configure OLED display (eye/facial expressions, clock, timer)	Kayla	3/15/25	0
3.2	Configure dial for volume control	Kayla	3/15/25	0
3.3	Implement button controls (modes, timer, scent diffusion)	Kayla	3/15/25	0
4	**Hardware**			
4.1	Create CAD design	Taylor	2/16/25	100
4.2	Create a 3D print skeleton prototype	Taylor	2/23/25	50
4.3	Wire components together	Taylor	3/12/25	0
4.4	Assemble the robot	Taylor	3/15/25	0
4.5	Work on silicone exterior	Taylor	2/28/25	10
4.6	Perform material testing	Taylor	2/28/25	0
4.7	Iterate and reprint if necessary	Taylor	2/28/25	0
5	**Integration**			
5.1	Work on system diagram	All	2/22/25	85
5.2	Integrate hardware components	All	3/29/25	0
6	**User Testing**			
6.1	Find users for testing	All	3/10/25	0
6.2	Small-scale user study (~10 students)	All	4/5/25	0
6.3	Survey to evaluate effectiveness	All	4/5/25	0