EchoMe: A Tangible Assistive Device for People Living with Dementia

Integrating photo recall, breathing, and memory play

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ABSTRACT

Dementia care faces growing challenges as patients often remain at home due to limited nursing home capacity, creating gaps in continuous cognitive and emotional support. This paper presents EchoMe, an interactive tangible device designed to address these needs through four integrated functions: Free Play and Memory Keys for cognitive stimulation, and Breathing Exercise and Photo Slideshow for emotional wellbeing. By combining multimodal, tactile interaction with digital feedback, EchoMe unifies prior approaches to personalization, gamification, and user-centered design into a single tool. Initial user feedback highlights the potential of memory-based games to enhance cognitive performance and of personalized visual content to provide comfort and engagement. Future refinements will focus on ergonomic hardware, adaptive functionality, and enhanced sensor integration. EchoMe demonstrates a promising, immediately applicable solution for supporting independence, engagement, and quality of life in people with early-stage dementia, contributing to the advancement of digital health interventions.

Author Keywords

Dementia care, Cognitive performance, Assistive technology, Emotional well-being, Interactive music interface, Multimodal feedback, Tangible interaction, People living with dementia, Haptic feedback

CCS Concepts

Human-centered computing → Human computer interaction (HCI) → Prototyping

1 INTRODUCTION

To this day, there is still an increasing number of elderly needs in health care, specifically for people/persons living with dementia (PLwD), which leads to a higher demand of nursing homes needed [1]. Although, nursing homes has limited capacity which are reserved for elderly PLwD with a more crucial and special care which leads to PLwD to live independently in their own homes or in sheltered homes with caregivers supervising them [1]. Due to this, there has been problems with providing these PLwD with continuous quality care and providing them with adequate healthcare services [2]. However, these challenges can be addressed by developing interactive assistive devices especially for PLwD who are in their early stages of dementia.

EchoMe is an interactive technological intervention product that aims to support PLwD who are in their early stages of dementia in terms of their cognitive performance and emotional well-being. EchoMe has multiple functions that will help with the patient's cognitive performance, such as Free Play and Memory Keys modes, which will provide PLwD with sounds and lights for visual and audio feedback. As for supporting in terms of emotional well-being, EchoMe has functions such as the Breathing Exercise and Photo Slideshow modes that were implemented to provide them comfort with visual feedback.

2 WALKTHROUGH

The intended use of the final prototype – EchoMe is illustrated in Figure 1.

Figure 1: User interaction and overall system process diagram

We have chosen to extend Leyendecker and Zagel's [5] work of the tangible object: NFC- enabled dodecahedron, by supporting more general tasks with predefined parameters and functions that address the needs of our users more generally. We aim to support cognitive performance and enhance emotional well-being.

1. **Free Play:** Functions like a keyboard. The user has the freedom to press any button, each producing a corresponding pitch and LED light. This mode helps exercise hand dexterity.

2. **Memory Keys:** Inspired by music tangible interface Kibo Games [3] and similar to game *Simon Says*, this mode challenges users to reproduce increasingly long

sequences of notes until completing *Ode to Joy*. The function process includes rewarding correct actions and signalling mistakes. Its progressively challenging, game-like format aims to stimulate working memory, pattern recognition, and sequential recall.

3. **Breathing Exercise:** The LED strip loops on fading for five seconds then brightening again for another five seconds. This pattern is similar to the box breathing technique [4], which has been shown to reduce stress and support cognitive function.

4. **Photo Slideshow:** Inspired by work of Leyendecker and Zagel [5], who used NFC tags hidden inside tangible objects to trigger different media associated with each object's unique ID. Assigning different tags to individual users enhanced their sense of identity. Similarly, this system function displays a slideshow of preselected images, which can be customized. This aims to encourage nostalgia and emotional engagement.

3 RELATED WORK

Technological solutions, such as a tangible user interface products have been ongoing research and used as a solution to tackle challenges for PLwD in terms of improving their cognitive performance and providing support for their emotional wellbeing. It is proven that a tangible user interface is a more suitable solution for elderly users accessing a more advanced digital technology due to their age-related physical or cognitive impairments [6]. Technological solutions for PLwD "must be designed with the specific needs and abilities of people living with dementia in mind to avoid confusion, frustration, and potential rejection due to complexity or unintuitive interfaces" [7] they are mostly elderlies who might not be as exposed to technological advancements.

Leyendecker and Zagel's tangible product is one of the solutions where they aim for a "person-centred care" for PLwD that are tailored closely their individual preferences [5]. This helps bridge the challenges elderly users face when using modern technology. Kibo Games [3] is also one of the many examples of tangible products that aims to allow PLwD to physically interact with an object to control the digital information. It is a musical interactive product which aims to improve the cognitive performance of PLwD by providing them with a physical board controller (Kibo's body and tangibles) to interact by pressing the keys, while digital feedback (Kibo Web Games interface) will be displayed to track the patient's progress according to the different game modes [3]. These types of tangible products will provide PLwD with physical interactions while using digitalised technologies that will support their cognitive performance improvements.

4 DESIGN

4.1 Preliminary Design and Prototyping

On the first step of our ideation process, we have illustrated a prototype idea which can be referred to in Appendix A. This ideation illustration was originally inspired from Leyendecker and Zagel's tangible product [5]. As mentioned in section 2, this approach was extended and integrated into a multimodal system within our prototype.

Figure 2 shows the low fidelity prototype that we have worked upon after brainstorming the first ideation process. Our design consists of two main physical components: a tangible object and a base unit. The first stage of prototyping involved paper-based prototypes, where the base unit featured a mount for the cube and buttons to control different tasks. It was made from cardboard and reinforced with superglue to create a sturdy structure. For the tangible object, we explored different shapes such as a cube, pyramid and a pentagonal prism as shown on Figure 2. Additionally, we explored other surface materials such as a soft cloth to cover the surface, and foam inside the tangible object. The fast low-fidelity prototypes made was useful in mapping out user interaction as shown by video storyboard in Appendix B and was useful in identifying exact hardware such as sensing technologies needed in order to switch between the functions seamlessly.

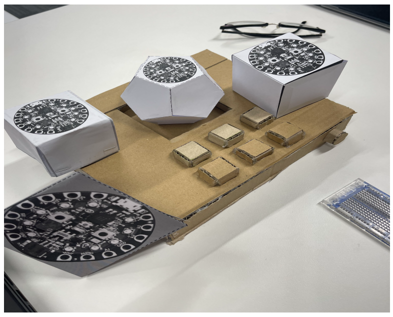

Figure 2: Low-Fidelity Prototype

Choosing the sensing detection type in order to switch between the different functions played an important role during the design process. Initially, we used the accelerometer on the circuit playground bluefruit to read the motion along the X, Y, and Z axes in the 3D space [8] and, based on thresholds, determine the board's orientation to switch functions. Since this is within the tangible object (cube), communicating the data to a separate base unit would require additional microcontroller and more complex systems, depending on the chosen communication protocol between the microcontrollers.

For the next method, we used the light sensor on the circuit playground bluefruit to measure light intensity. The measured 16-bit value is scaled down to 0-255 for the red, green, and blue channels, and a neopixel illuminates in sequence to read the corresponding intensity. From this, the dominant colour is determined. We looked for a method that would not require another microcontroller; however, this approach proved to be too sensitive to light changes in the environment.

Primary prototype is shown in Figure 3 below.

Figure 3: Primary Prototype

4.2 Final Design

4.2.1 Hardware Architecture

The hardware system is centered around a single microcontroller unit (MCU), which coordinates all sensing, actuation, and communication tasks. Figure 4 illustrates the block diagram of the system.

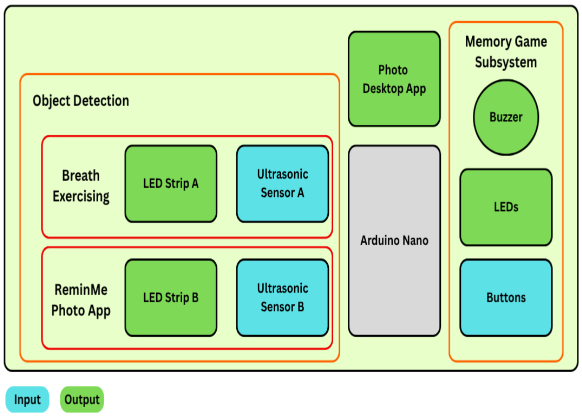

Figure 4: Hardware Diagram

4.2.1.1 *Sensor Subsystem*

Two ultrasonic sensors are used as object detection units. Each sensor corresponds to one physical placement area for a textured cube. When a cube is placed, the ultrasonic beam is blocked, signaling to the MCU that the location has been occupied. This input is used to control the behavior of the LED strips and trigger events on the connected desktop application.

4.2.1.2 *Visual Guidance (LED Strips)*

Each cube placement area is paired with an addressable LED strip. The LED strip provides a visual indicator to guide the user. When the placement area is empty, the strip illuminates with colours to indicate the target location. Once the cube is correctly placed (detected by the ultrasonic sensor), the MCU switches the strip off, providing immediate confirmation to the user.

4.2.1.3 *Game Subsystem*

The design includes an independent game module consisting of six push-buttons, each paired with an individual LED indicator. These are connected directly to the MCU via GPIO pins. The buttons are large and clearly illuminated, making them suitable for quick interaction tasks such as memory or sequence games. A buzzer is also integrated to provide auditory feedback. This subsystem is intentionally isolated from the object detection logic, allowing simultaneous use without interference.

4.2.1.4 *Communication with PC*

The MCU communicates with a PC application via a UART serial interface. Based on the sensor inputs, the MCU transmits event signals to the PC. Two example applications have been implemented:

- EchoMe photo application: triggered when Cube A is placed. The app displays familiar images to support memory recall.
- Breathing exercise application: triggered when Cube B is placed. The app provides visual prompts for guided breathing.

This division enables multimodal feedback, combining physical interaction with digital content.

4.2.1.5 *System Integration*

The integration of all modules is achieved with a compact, breadboard-based prototype shown in Figure 5. The final envisioned product relocates all components onto a single PCB for reliability and manufacturability. Power is provided over USB, ensuring simplicity and compatibility with the desktop app.

Figure 5: EchoMe Prototype

4.2.2 *Software System*

4.2.2.1 *Memory keys and free play*

The audio generation logic is used in the memory keys and free play functions. This implementation uses the standard Arduino tone function for generating square waves on the buzzer. The full firmware and PC application codebase is maintained on the project's GitHub repository (see Appendix C).

Six push-buttons, configured as mentioned in section 4.2.1.3 are mapped to a set of musical frequencies, representing the notes C (262 Hz), D (294 Hz), E (330 Hz), F (349 Hz), G (392 Hz), and A (440 Hz). The tone function is called with the corresponding frequency and fixed duration when a button is pressed. This method is the main driver to the free play function. Extending this, the memory key function operates on a finite state machine, where the user's goal is to replicate an increasingly long sequence.

The game progresses through two core states. First, in the sequence demonstration state, the system plays back the current turn length, using the timed LED and musical frequency cue. Second, it transitions into recording what buttons the user presses. Each input is checked in real-time against the expected note in the sequence; where if the sequence is correctly echoed, the turn increments, and the cycle repeats with a longer sequence. An incorrect input immediately triggers a failure state.

4.2.2.2 *Breathing exercise*

This function uses an algorithm designed to mimic the natural rhythm of breathing, instead of a robotic linear fade. The core logic is contained in a function that is called periodically based on a timer to maintain consistent animation speed.

The brightness is calculated using an exponential function on a sine wave to stretch the peaks and compress the troughs of the waveform. This creates an organic breathing profile where the brightness intensity decelerates as it approaches maximum brightness, holds towards the peak, then descent gradually before accelerating. Simultaneously, the colours are in sync with the brightness and the hue and saturation values are continuously interpolated between a defined start and end colour based on the current brightness. This results into a seamless coupling where the brightness "breathes" through a spectrum of colours evolving in shade, with each pulse. Then the calculated hue, saturation, value (brightness) are mapped to colour channels red, green and blue, producing the intensities required to reach the target colour.

4.2.2.3 Photo Desktop Application

The desktop application, developed in C# using Windows Forms, provides the graphical interface for the photo recall feature of EchoMe. It communicates with the Arduino-based base unit via serial connection, interpreting real-time distance data from the ultrasonic sensor to automatically trigger the slideshow when the cube is placed on the base. Figure 6 below shows the EchoMe photo desktop application interface.

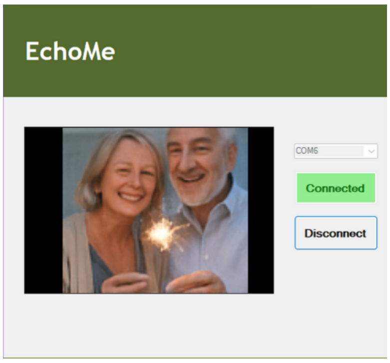

Figure 6: EchoMe Photo Desktop Application Interface

The program loads images from a predefined local directory and cycles through them every five seconds. A hysteresis and debounce algorithm ensure stable activation, preventing flicker caused by sensor noise. Moving average smoothing further filters raw distance readings for reliable cube detection. The interface supports automatic COM port detection, connection management, and graceful shutdown on exit.

The user interface was designed for clarity and accessibility; a single large image frame, minimal text, and simple controls (Connect/Disconnect). The system's responsive feedback and low visual complexity make it dementia-friendly, aligning with course themes of tangible interaction, usability, and inclusive design.

4.2.3 Mechanical Design

The mechanical design of EchoMe focuses on creating a robust, ergonomic, and precise housing for the hardware components, ensuring correct alignment for sensors, LEDs, buttons, and the tangible cube. The mechanical structure was developed using a combination of laser cutting, 3D printing, and resin printing, allowing for rapid prototyping and iteration while maintaining accuracy for component placement. Figure 7 shows the key mechanical features (more details on the key features of final prototype can be referred in Appendix D).

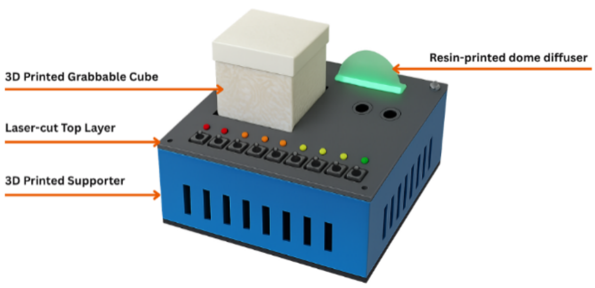

Figure 7. Key Mechanical Features

4.2.3.1 Laser-Cut Top Layer

The base unit of EchoMe was fabricated using a laser cutter, designed to accommodate all sensors, LED strips, and cube placement areas precisely. The design included:

1. Slots for ultrasonic sensors to detect cube placement accurately.
2. LED strip channels to guide users visually and provide immediate feedback.

The cube placement slots include precise tolerances, to ensure each cube sits securely and allow a seamless interaction. Laser cutting enabled fast generation of the base unit structure while maintaining clean edges and structural rigidity, critical for repeated user interactions. The design of the laser-cut top layer is shown in Appendix E.

4.2.3.2 3D-Printing Design

3D-Printed Graspable Cube:

The prototype includes a single 3D-printed cube, designed for ergonomic handling and enhanced multisensory interaction. The cube features decorative patterns and textured surfaces (refer to Appendix F) that provide haptic feedback, improving tactile engagement and making it more enjoyable for elderly users to hold and manipulate. Additionally, simple elements inside the cube generate sound effects when interacted with, further enhancing the multisensory experience during Free Play and Memory Keys activities. 3D printing enabled precise control over the cube's size, shape, texture, and decorative features, ensuring both comfort and effective interaction.

Resin-Printed Dome Diffuser:

To enhance visual feedback and create a soft, diffuse light for the LED strips, resin-printed dome (refer to Appendix G and H) diffusers were used. The resin material provides a smooth, translucent surface that evenly spreads light, reducing glare and creating a more pleasant, dementia-friendly visual cue. The domes are precisely dimensioned to fit over the LED strips, combining aesthetics with functional guidance for users. This approach allows customization of colour diffusion and improves the overall tactile and visual quality of the prototype.

3D-printed Supporter (Base Enclosure):

The enclosure was designed in Fusion360. The 3D-printed base enclosure (refer to Appendix I) houses all internal electronics including the MCU, sensors, and wiring. It features ventilation slots to improve airflow and enable soft sound diffusion from the internal buzzer. The rectangular geometry enhances stability, portability, and ease of placement, particularly for users with limited dexterity. Smooth corners and matte finishing improve safety and tactile appeal.

5 USABILITY EVALUATION

A task-centred walkthrough and follow-up interview questions were conducted on a participant to evaluate the four functions.

To evaluate the functions, we asked them four simple questions:

1. Was it difficult to navigate, understand, or operate the function?
2. Did the experience help you feel relaxed?
3. Did it capture your attention, or keep you stimulated?
4. Did it evoke positive feelings or feel enjoyable overall?

The participant answered these on a scale of 0-5 with 0 being no and 5 being yes. The results are shown on Figure 8.

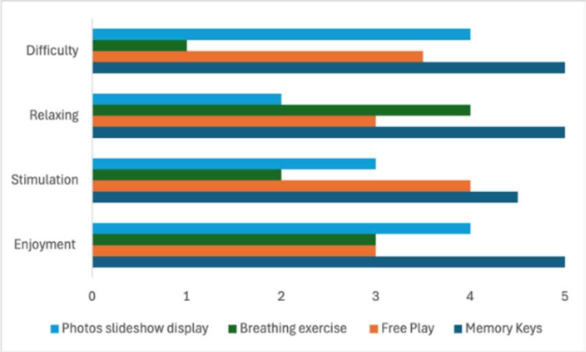

Figure 8: Participant ratings on four functions (0=no, 5=yes)

They felt that the push-buttons on the base unit successfully mimicked an instrument, however it was initially hard to recognize it as the order of piano pitches. Therefore, the participant commented that they would've liked other visual feedback or more tactile buttons to make it more enjoyable. They were entertained and challenged by the game-like format on the memory game. In terms of recommending this to PLwD, they believed the memory game especially, is a good aid in memory recall, and the hand movements required as particularly valuable.

The participant had a neutral perspective on the breathing exercise. They mentioned in their own experience in meditation, that they prefer not to focus intensely on anything. They also found the visual feedback difficult to follow without prior instruction.

The participant's perspective on the photo slideshow was personally neutral. It reminded them of existing modern tech, such as the photo cube, and they felt it would function best as a background feature. However, they believed elderly users would enjoy it more, suggesting they would appreciate it as a tool for recalling fond memories.

6 CONTRIBUTION

This work shows that a single tangible appliance can deliver three complementary supports for people living with dementia—photo recall, guided breathing, and a simple memory game—using one-gesture interactions and privacy-preserving, offline operation. In doing so, it reframes tangible interfaces from one-off activities into a daily, calming routine that is realistic for care homes and family settings.

6.1 Novelty and Creativity

Based on our knowledge from doing prior research in existing tangible products catered towards PLwD, EchoMe is the first prototype that unifies recall, relaxation, and cognitive play within a tangible device that uses a consistent physical grammar: *place the cube, press a button*. Most existing tangible products focus on a single type of function, whereas EchoMe combines multiple functions, highlighting its novelty. Additionally, the multimodal prototype proposed screen-based navigation and short-term memory demands with direct manipulation and immediate feedback, lowering barriers to connection for users who struggle with conventional apps.

6.2 Design Contribution

We distil a set of dementia-friendly TUI patterns that others can reuse: a sensory triad (textured surface for secure grip; resin-diffused soft light for non-intrusive cues; gentle audio—buzzer plus subtle metallic click—for reassurance), a presence LED to confirm cube detection at a glance, and single-action flows that minimises cognitive load. Together, these elements provide clear, calm, and consistent feedback, aligning interaction, affect, and accessibility.

6.3 Technical Contribution

The system demonstrates a low-cost, modular, offline-first architecture—Arduino-controlled sensing and actuation that triggers desktop applications—chosen for reproducibility and ease of deployment. The design intentionally leaves a clear pathway to BLE connectivity and battery power management, enabling a future standalone appliance without tethering.

6.4 User-Centered Insights

Pilot feedback indicates that the memory game is engaging and learnable, while button labelling and larger spacing improve recognisability and motor comfort. Participants also surfaced the need for clearer breathing cues, which directly informed our diffuser and LED timing decisions. These insights evidence iteration grounded in user needs rather than purely technical optimisation.

6.5 Impacts Towards Users

By replacing cognitively heavy menus with tangible, one-step interactions, EchoMe makes connection and calm immediately accessible, supports dignity and autonomy for people with dementia, and can reduce caregiver burden through simpler, more reliable routines. The combination of unified functionality, reusable design patterns, and deployable architecture positions this work as a concrete, scalable contribution to HCI and digital health.

7 FUTURE ENHANCEMENT

While the current prototype demonstrates effective multimodal interaction between tangible objects and digital content, several enhancements could significantly expand its functionality, usability, and emotional impact.

7.1 Hardware and Interaction Improvements

7.1.1 Unified Cube Design

Future iterations could consolidate multiple placement areas into a single slot, enabling the device to detect which side of a cube, pentagon, or hexagon is placed. Each side could be differentiated by colours, icons, or actions to support richer and more intuitive interactions.

7.1.2 Orientation and Gesture Recognition

Cube orientation could be detected using Adafruit motion/orientation sensors, enabling orientation-based mode switching. Additionally, touch-sensitive surfaces could allow gesture-based inputs for more versatile interaction.

7.1.3 Object Detection

Adafruit distance sensors would be used to detect cube placement and object proximity, ensuring accurate input recognition.

7.1.4 Haptic Feedback and Fidget Functionality

Integrating haptic elements would provide tactile cues, while fidget-friendly design could support stress relief, engagement, and accessibility.

7.1.5 Visual Feedback

Adafruit LED modules could be integrated to provide real-time light-based feedback, enhancing usability and accessibility.

7.1.6 Biomedical Sensing

Incorporating Adafruit heart-rate and temperature sensors would allow the device to monitor user wellbeing in real time. This data could be used to adapt interaction modes, detect stress, or provide personalized support.

7.2 Audio, Memory, and Social Features

7.2.1 Personalized Memory Playback

Recording and playback functions could store voices, messages, and memories from loved ones, while music and video integration would enhance engagement.

7.2.2 Emergency Support

An integrated switch could provide immediate contact with caregivers or family members.

7.2.3 Social Connectivity

Future systems could allow memory sharing, collaborative play, and connection with friends using similar devices.

7.3 System Integration and Independence

7.3.1 Standalone Power and Wireless Communication

Rechargeable batteries, Bluetooth Low Energy (BLE), and efficient power management would support untethered use.

7.3.2 Single Device Integration

Combining projection, audio, sensors, and haptics into a unified standalone device would eliminate reliance on an external computer.

7.3.3 Interface Clarity and Usability

Larger, labelled buttons and ergonomic layouts would improve accessibility and reduce user effort.

7.4 Advanced Enhancements

7.4.1 Gamified Cognitive Support

Adaptive memory and attention exercises could provide personalized training for users.

7.4.2 AI-Driven Personalization

Machine learning algorithms could tailor content delivery to individual preferences, behaviours, and emotional states.

7.4.3 Wearable Sensor Integration

Linking with biometric sensors (e.g., heart rate, stress detection) could enable responsive adjustments to content or feedback.

7.4.4 Augmented Reality (AR) Projection

AR-based features could create immersive, interactive environments that blend digital and physical play.

7.4.5 Aesthetic and Ergonomic Refinement

Future designs should prioritize user comfort, portability, and visual appeal, with accessibility as a guiding principle.

7.5 Prototype Outlook

These enhancements would transform the system into a more engaging, adaptive, and emotionally supportive platform. EchoMe version 2.0, shown in Figure 9 below, represents a conceptual prototype integrating these future developments.

Figure 9: EchoMe version 2.0

8 CONCLUSION

This paper presents EchoMe, an assistive tangible device that integrates cognitive and emotional support through Free Play, Memory Keys, Breathing Exercise, and Photo Slideshow functions. By unifying elements from previous tangible interface research, EchoMe moves beyond isolated interventions, offering a multimodal, user-centered tool for people with early-stage dementia. Initial user feedback highlights the effectiveness of gamified memory exercises for cognitive stimulation and the value of personalized visual content for emotional wellbeing. While the current prototype validates key user needs, future refinements will focus on improving physical ergonomics, enhancing hardware interaction, and incorporating additional sensors for adaptive functionality. Overall, EchoMe demonstrates the potential of tactile, interactive technology to support independence, engagement, and quality of life, representing a meaningful contribution to digital health and dementia care environments.

AI ACKNOWLEDGEMENT

Generative AI (ChatGPT) was used solely to refine grammar and generate the “Future Enhancement” figure for visual clarity. All ideas, analyses, and written content were developed independently by the authors. See Appendix J for lists of the input queries.

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APPENDIX A: Early Ideation Sketches

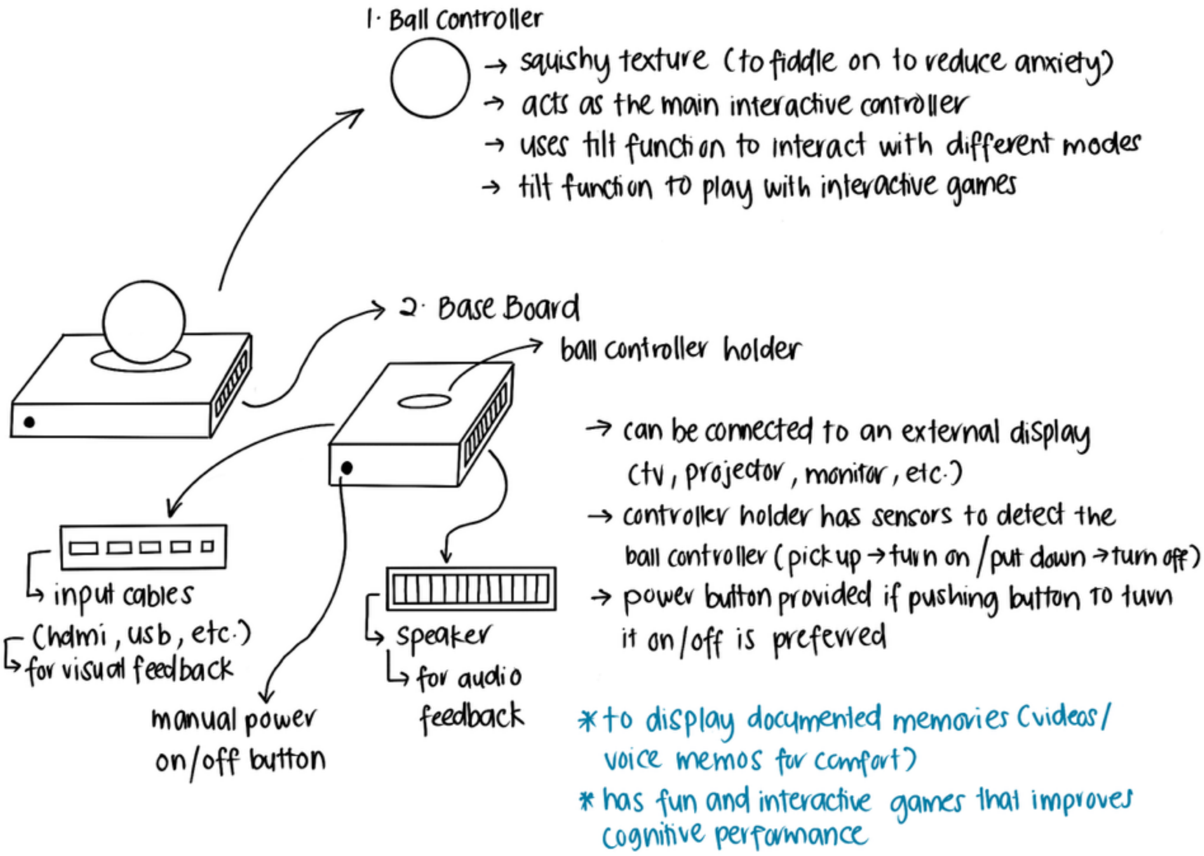

Figure 10: Early Ideation Sketches

APPENDIX B: Video Storyboarding of Initial Base Unit

Click following to view the video prototype: Video_storyboard.mp4

Figure 11: Snapshot of Video Storyboard

APPENDIX C: Sourced Code

Source code and documentation are available on GitHub:

https://github.com/claire0360/COSC439-Group-Project

APPENDIX D: Key Features of the Final Prototype

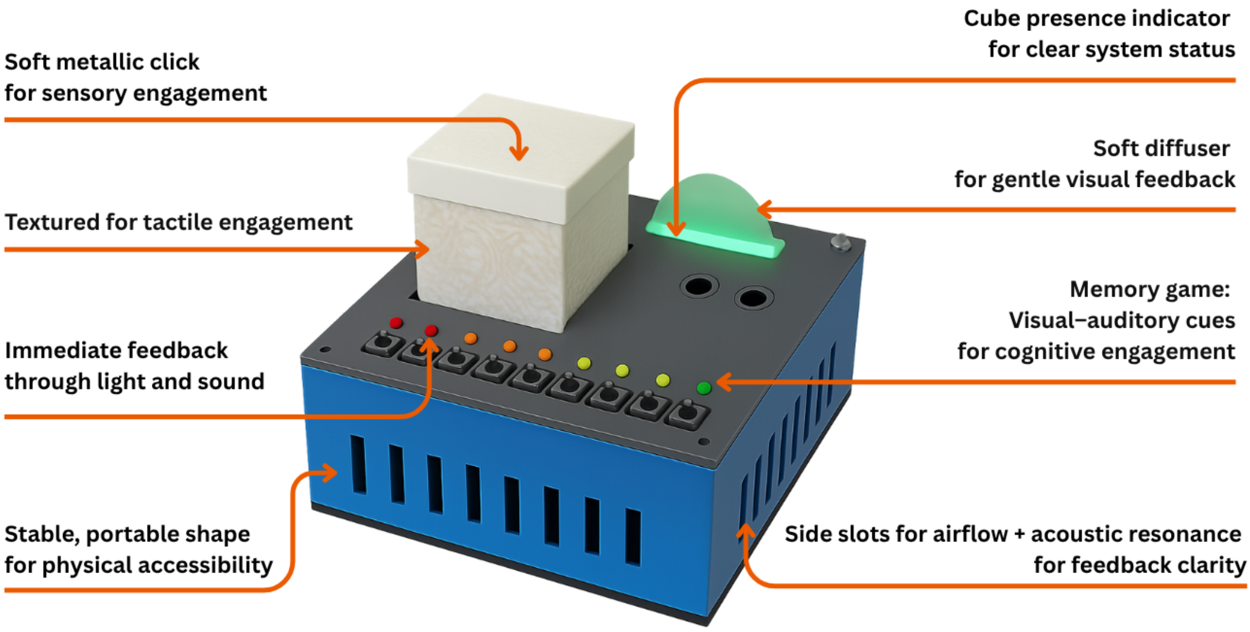

Figure 12: Key Features of the Final Prototype

APPENDIX E: Laser-Cut Top Layer Design

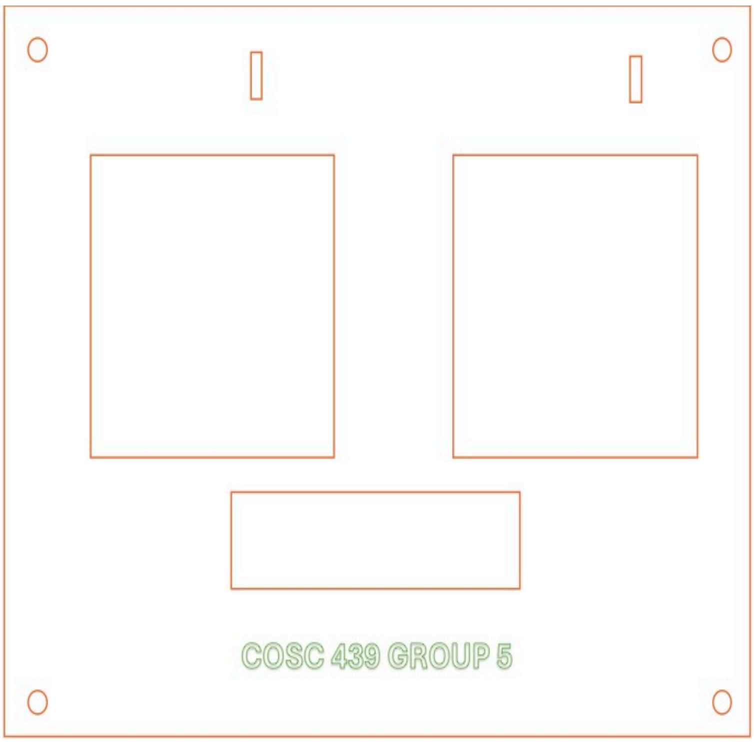

Figure 13: Laser-Cut Top Layer Design

APPENDIX F: 3D Cube Design

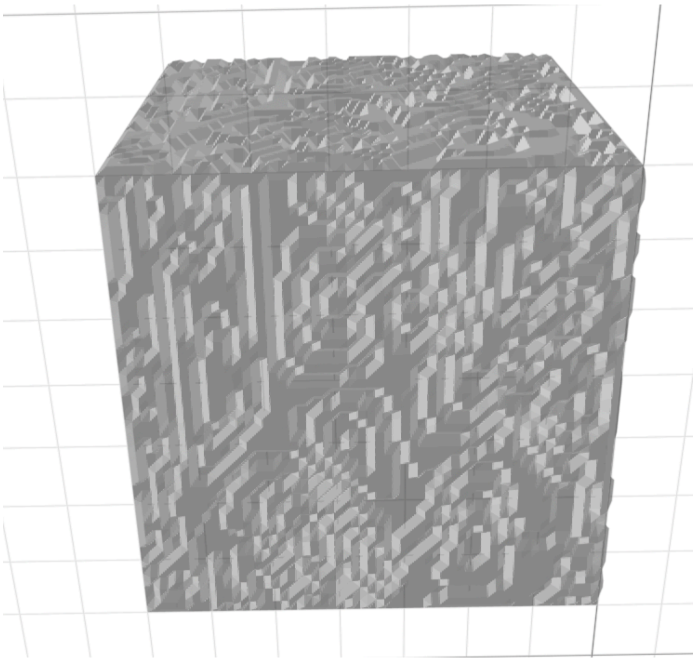

Figure 14: 3D Cube Design

APPENDIX G: Resin Dome Design –1

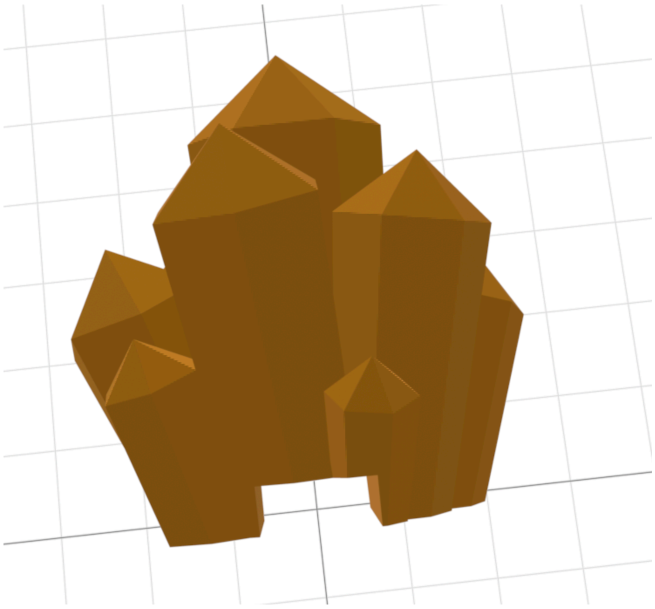

Figure 15: Resin Dome Design 1

APPENDIX H: Resin Dome Design –2

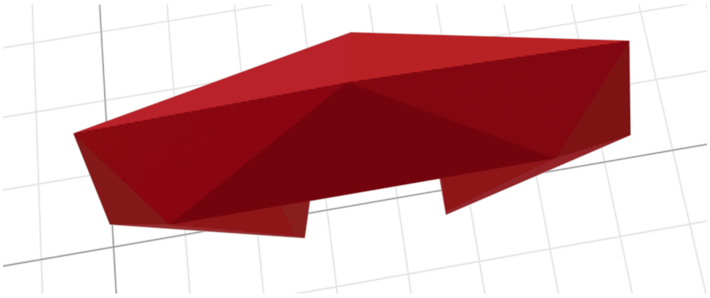

Figure 16: Resin Dome Design 2

APPENDIX I: 3D Base Design

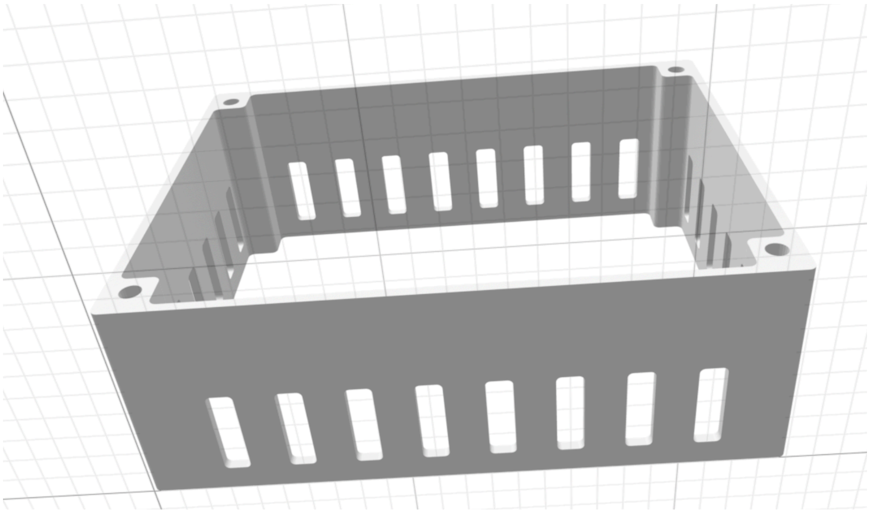

Figure 17: 3D Base Design

APPENDIX J: AI Input Queries and Outputs

Table 1: AI Input queries and outputs

Input queries	Corresponding outputs
Create a realistic concept image illustrating the **future version** of our project device. The design should show a single cube that integrates a microcontroller and orientation sensor, placed on a base box. The cube and base box communicate via Bluetooth, enabling different functions depending on cube orientation such as a breathing exercise mode or photo display mode. The image should have a clean background and visually communicate the technological concept for presentation clarity.	Please refer to Figure 9.
Enhance the clarity of our final prototype image by digitally cleaning it for presentation purposes. The goal is to improve visual quality while **keeping all design features exactly as in the real prototype**. **Remove only the external wires and background noise** to produce a clearer, more professional representation of the existing design.	Please refer to Appendix D for the cleaned image of the final prototype, which was enhanced using AI solely for visual clarity. All feature explanations in Appendix D were written entirely by the team and not generated by AI. Figure 5 presents the real, non-AI-generated prototype.

APPENDIX K: Contributions of each team member

Table 2: Contributions of each team member

Team member	Allocated Tasks
Alyaa Batrisyia Binti Omar Bakhtiar	• Contribution to group discussions and meetings. • In depth research on dementia patients, existing tangible user interface products catered for dementia patients or elderly, and technologies that support dementia patients. • Illustrate initial ideation prototype design and functions. • Contribute to prototype function ideas and brainstorming. • Detailed usability evaluation questionnaire. • Report writing – Introduction, Related Works. • Report formatting. • Proofread and refined the final report and formatting.
Joan Claire Inacay Teves	• Contribution to group discussions, meetings and recording down tasks for group members. • Conclusion, Walkthrough. • Code and report section for final memory game, free play, and breathing LED strip effect in the report. • Code and report section for sensors: orientation, light. • Usability evaluation testing on participant using Alyaa's questionnaire and write up for the report. • Cube prototyping. • Creating or edited user section in slide presentation. • Proofread and refined the final report.
Claire Kim	• Contribution to group discussions and meetings. • Create the initial prototype using cardboard. • Designed and 3d-printed the base enclosure in Fusion 360. • Built and wired the electronic system on breadboard and Vero board. • Developed firmware for ultrasonic object detection. • Programmed the C# desktop photo application using Windows Forms. • Report writing: Design (Hardware architecture and mechanical design), and Contribution. • Created system block diagrams and presentation slides. • Proofread and refined the final report.
Divya Amin	• Contribution to group discussions and meetings. • Developed all mechanical and interaction designs, including the laser-cut base, 3D-printed haptic cube, and resin-printed dome diffuser. • Authored key sections of the report, including the Abstract, Future Work, Conclusion, and Mechanical Design. • Report Formatting and general editing.