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Project Development

Introduction

This chapter relates to Bloem's development process, showing how the main ideas behind the machine evolved over time to become a complete system. It begins with the ideation and conceptual stages, where initial sketches and preliminary designs are analyzed to show the transition from a creative vision to a functional solution. This is followed by a detailed design phase that includes the physical structure, smart systems and packaging.

To provide a clear view of the project, external programs, tables, and images are used to justify technical and material choices, including a fuctional analysis of the system's components. Finally, the chapter concludes with the prototyping stage and the tests performed to evaluate the final product.

Ideation

Choice of subject

The development of the project began with an initial selection phase, where we were presented with twelve potential themes covering a wide range of challenges. After an internal review, we narrowed the focus down to the three areas that best aligned with our intrests: Smartification of Everyday Objects (Smart Cities), Smart Health and Well-being (Smart Health), and Smart Marine Habitat Structures (Sustainable Environment).

Ultimately, we decided to proceed with smartification of everyday objects within the framework of Smart Cities. This choice was the result of strategic assesment of our teams's profile. As an international and interdisciplinary group, we recognized that our diverse backgrounds provided us with a unique combination of skills and technical knowledge. We concluded that the Smart Cities gave us the best opportunity to combine our knowledge and work together effectively to create a unique solution.

Brainstorming

Due to the broad nature of the Smart Cities theme, our initial brainstorming session generated a wide variety of ideas. After an initial screening, we focused our research on three specific concepts:

· A smart dehumidifier designed to collect ambient moisture and repurpose the water to automatically irrigate indoor plants.

· External facade panels aimed at improving the thermal insulation of buildings to mantain cooler temperatures more efficiently.

· A micro-break capsule specifically designed for employees to rest and recharge during work hours.

To organice our thoughts to evaluate these options, we used Miro, a collaborative digital tool that allowed us to visualize the pros and cons of each proposal. As shown in Figure 1, we mapped out the potential impact and technical feasibility of each idea.

After weighing the strenghts and weaknesses of each concept, we ultimately decided to move fordward with the micro-break capsule. We found that this area was the least explored compared to the others, meaning there was significantly less existing competition in the market. This provided us with a unique opportunity to combine our different skills into a single project that addresses a real gap in urban well-being, allowing us to create something truly original.

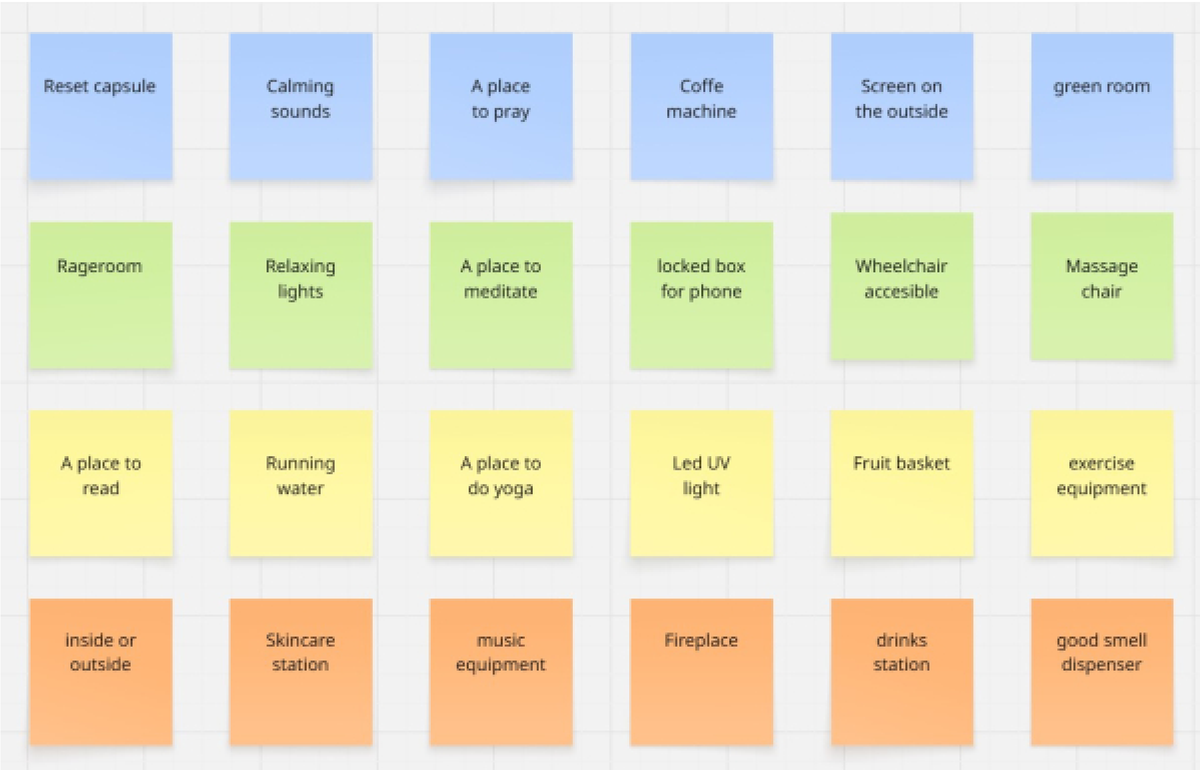

Figure 1: Brainstorming Phase

Design thinking

Once the micro-break capsule was chosen as our final concept, we moved into a Design Thinking phase to explore its phisical form. To do this, we developed five quick sketches, each representing a different approach to how the capsule could look and function. These initial ideas, shown in Figure 2, allowed us to visualize various layouts and user experiences.

· The Onion Pod: A private, fully enclosed room that prioritizes total isolation, though it requires a significant amount of floor space.

· The Wide Lounge: A large and spacious horizontal structure designed for maximum comfort, focusing on internal volume.

· The Minimalist Tipi: A practical and nature-inspired design that uses a minimalist aesthetic to create a calm, functional retreat.

· The Open Swivel: A cost-effective and compact chair system designed for very short breaks, though it lacks the privacy of a closed system.

· The Hanging Capsule: A smaller, suspended unit designed as a closed retreat, offering a sense of weightlessness while saving floor space.

As we did in the braisntorming stage, we carefully analyzed the pros and cons of each sketch. We considered factors such as user comfort, the space required in an office setting, and the tecnical feasibility of the structure.

After comparing the different designs, we ultimately chose the full-body capsule model. This design allows a person to step inside and remain standing, providing enough room to stretch, move slightly, or practice meditation in private. We decided that this spacious configuration was the most effective way to help users disconnect from workplace stress and focus on their physical and mental well-being.

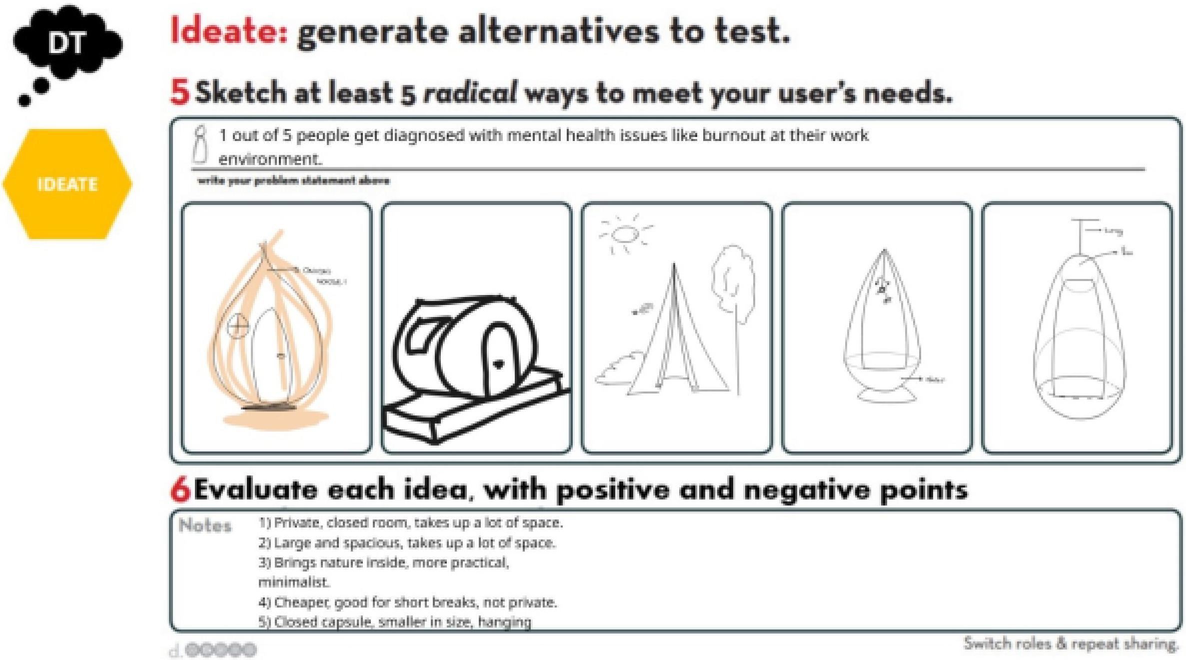

Figure 2: Design Thinking Phase

The idea

The final concept developed for this project is an egg-shaped capsule designed to integrate seamlessly into modern corporative environments, such as large halls or corridors. Our goal was to create a private sanctuary for "micro-breaks" during long working hours, a space where employees can scape the pressure of the office to perform a "power nap", meditate, strech or even release tension in total privacy.

The structure is dimensioned to be inclusive, providing enough space for a person to of average height to stand, lie down, or practice yoga confortably. A core principle of design is total isolation. The capsule is engineered to be both visually and acoustically opaque, ensuring that nothing can be seen or heard from the outside, and vice versa. This crates a true "break from the world" for the user.

Functionality is also integrated into the exterior through a smart lighting system that iluminates when the capsule is occupied, signaling to others that the space is in use. Furthermore, Bloem is designed to be part of a larger digital ecosystem; it will be liked to a user interface for reservations and can provide helpful "newsletters" or guidance on mental healh and physical well-being. This ensures the capsule is not just a physical space but a proactive tool for workplace health.

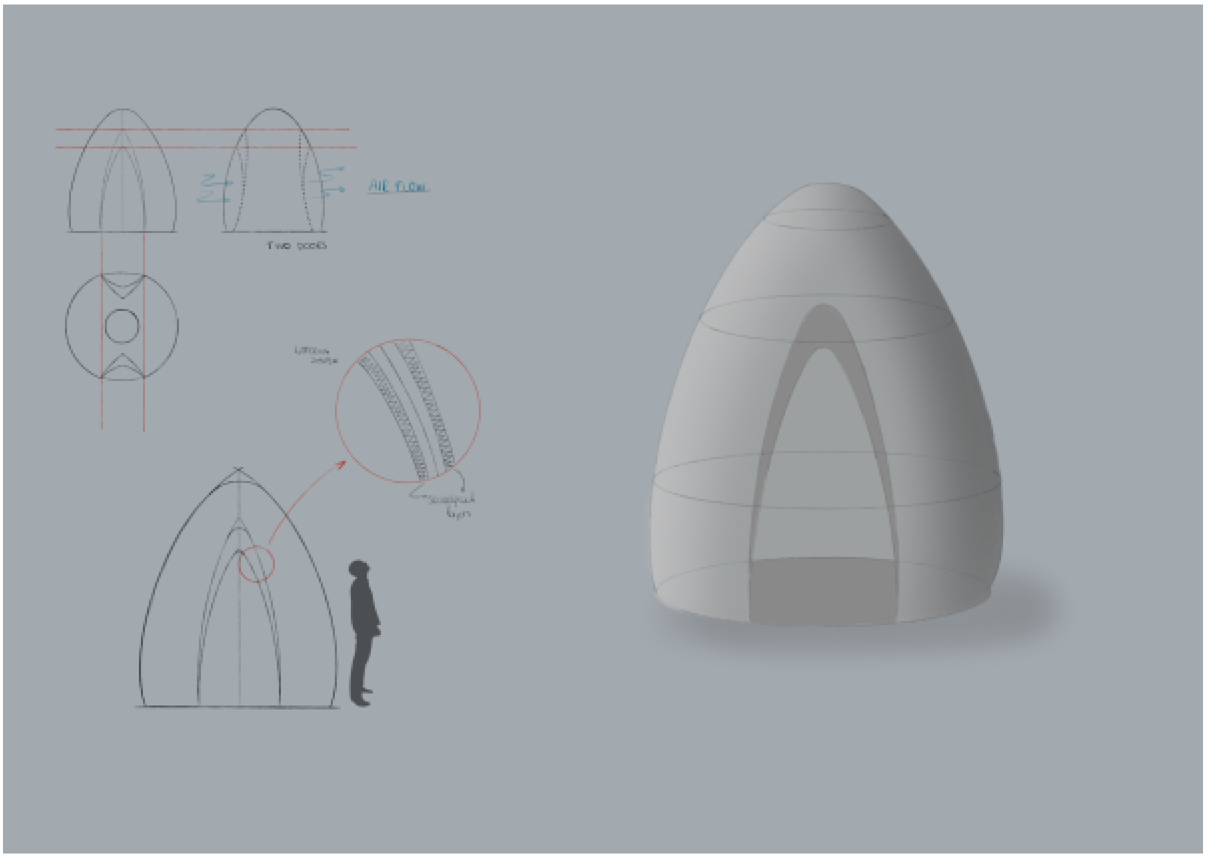

Figure 3: First Drafts

Concept

This section details the conceptual framework of Bloem, outlining how various elements converge to create a private sanctuary for workplace well-being. The process begins with the definition of the corporate identity, where the development of the logo and color palette establishes a cohesive visual language. From there, the focus shifts to the evolution of the user interface, tracing the journey from the sketches to the final prototypes.

A central part of this visualization, is the integration of the capsule's physical design with its smart functionalities. Particular emphasis is placed on the occupancy signaling system and the structural aesthetics that allow Bloem to function as a seamless addition to corporate environments. By combining digital reservation tools with a specialized physical enclosure, the project is shaped into a dynamic solution for mental and physical health. Each component, from the external lighting to the internal ergonomics, contributes to the overall success and functionality of the platform.

Logo Design

The Bloem logo is designed to be simple and meaningful, combining three main ideas into one icon. A flower petal, a person meditating, and the letter “B”. By merging the human shape with the petal, the logo clearly shows our goal: helping people “bloom” and feel better at work. We used soft, rounded edges instead of sharp corners to make the brand feel safe and welcoming. This cleanlook works perfectly on everything from small phone screens to the side of the physical capsule, keeping the brand looking professional and modern.

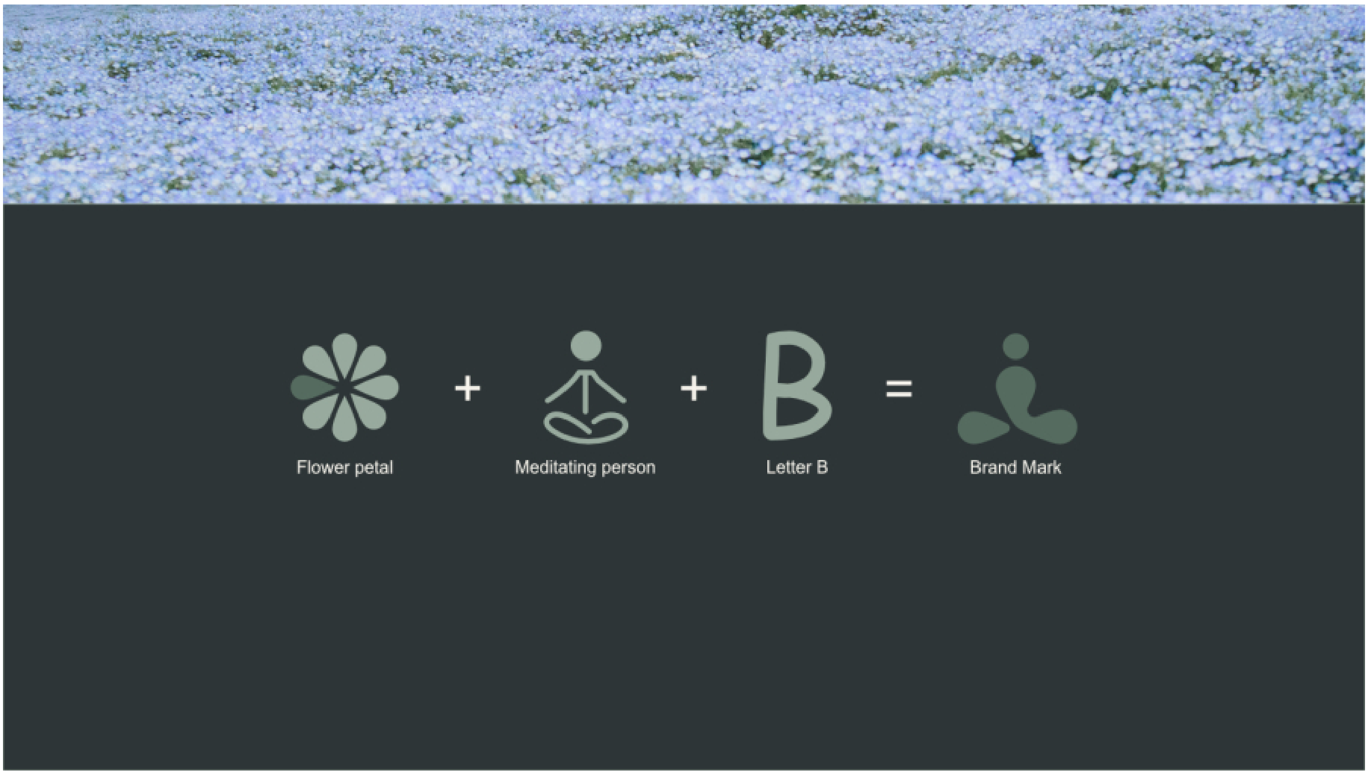

Figure 4: Final logo

Color Palette

The Bloem color palette is designed to communicate a balance between professional stability and organic tranquility. By utilizing a range of desaturated, nature-inspired tones, the brand establishes a visual language that feels both sophisticated and calming. The identity relies on a specific hierarchy of colors that ensures the brand remains versatile while consistently evoking a sense of peace.

The lighter shades, Plaster and Mist, serve as the brand's primary background tones. They provide a clean, airy feel that represents openness and clarity, allowing the brand to exist comfortably within modern corporate aesthetics without appearing aggressive. These are complemented by the core botanical tones, Moss and Eucalyptus, which ground the identity in its natural roots. These greens are strategically chosen to symbolize growth and renewal, creating a “natural refuge” within the visual identity that invites the audience to slow down and breathe.

To complete the palette, Soot is used as the foundational anchor for typography and structural brand elements. This deep charcoal provides the necessary weight and high-end contrast, ensuring that the brand is perceived as premium, reliable, and professional entity. Together, these five tones create a harmonious ecosystem that reinforces the Bloem promise “a space where human well-being and professional life can coexist in perfect balance”.

Figure 5: Color palette

Design

The design of Bloem centers on a philosophy of “Organic Minimalism”, where fluid shapes and high-performance materials work together to support the user's well-being. By stepping away from the sharp, rigid lines of traditional office furniture, we have created a form that feels naturally protective and inviting. This softer approach is more than just an aesthetic choice, it's a deliberate way to signal safety and relaxation the moment a person sees it.

The effectiveness of the design relies heavily on its materiality. Every surface and texture is chosen to create a true sensory escape, using advanced acoustic shielding to block out the noise and sustainable, tactile finishes to provide physical confort.

Structure

The skeletal framework of Bloem draws deep inspiration from traditional Japanese joinery, a craftsmanship philosophy that prioritizes the assembly of wooden structures without the use of nails, screws, or industrial adhesives. By relying on interlocking joints, the structure benefits from a superior level of durability and flexibility. Unlike rigid mechanical fasteners that can weaken wood over time, these traditional techniques allow the material to expand and contract naturally, ensuring a long-lasting structural integrity. As seen in Figure 6 the structural drawings, the capsule is built around a series of vertical wooden ribs that converge at a central ring. This “puzzle like” assembly that is both an engineering feat and a warm, organic alternative to industrial frames.

This structural choice is also fundamental commitment to sustainability and circular design. By eliminating metal fasteners and chemical adhesives, the capsule becomes a mono-material system that is significantly easier to disassemble and recycle at the end of its life cycle. This design ensures that each wooden component can be individually repaired or repurposed without damaging the rest of the frame, drastically reducing the project's carbon footprint. Ultimately, by merging ancestral assembly techniques with modern professional needs, the structure of Bloem stands as a durable, low-impact solution that respects both natural resources and high-quality craftmanship.

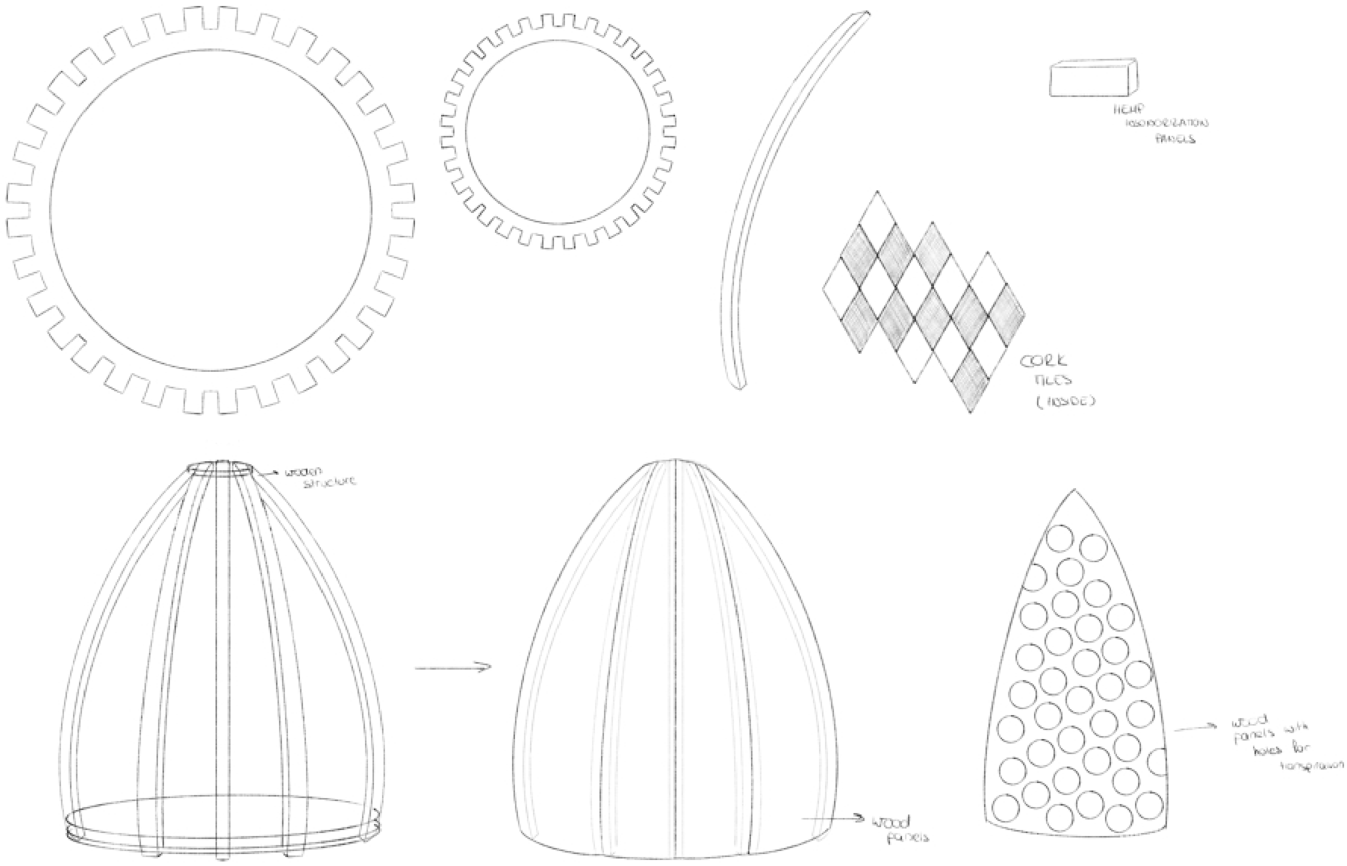

Figure 6: Structural drawings

Materials

The choice of materials for Bloem is a tribute to Portuguese industruial heritage, prioritizing “kilometer 0” sourcing and high-performance sustanaibility. By utilizing local resources like cork and hemp, the project not only supports regional craftmanship but also achieves superior acoustic insulation through natural, breathable materials.

Theinterior is lined with cork tiles. Beyond the warm and organic aesthetic , these tiles provide excellent sound absorption, creating a soft, quiet atmosphere that is essential for meditation and rest. Following the layering system shown in the technical sketches, the exterior of the wooden frame is reinforced with hemp blocks. Known for their exceptional thermal and sound-proofing properties, these blocks act as a dense acoustic barrier, shielding the user from the high-frecuency noise of a busy office.

While the hemp blocks provide soundproofing, their raw appearance is elegantly concealed by an outer skin that defines the capsule's botanical silhouette. We are currently exploring sustainable fabrics and natural fibers for this decorative layer, seeking a material that is both durable and tactile. This outer shell will mimic the soft, overlapping curves of flower petals, ensuring that the capsule remains a beatufil piece of biophilic design while hiding the complex technical layers of insulation underneath. This combination of traditional materials and smart layering ensures that Bloem is as effective as it is respectful of the environment.

Structure

The structural drawings of Bloem illustrate a highly engineered system designed to balance formal elegance with technical performance. The assembly is built around a primary wooden skeleton, as detailed in Figure 6, wich utilizes a central compression ring to secure the vertical ribs. This radial configuration allows for a self-supporting dome structure that maximizes internal volume while maintaining a compact footprint within the office environment. By relying on traditional joinery as shown in the components of Figure 6, the frame remains flexible yet stable without the need for mechanical fasteners.

A key focus of the technical development is the multi-layered wall system shown in the details of Figure 7. The capsule's shell is composed of several functional layers designed for total acoustic isolation:

- Interior Skin: Aesthetic cork tiles for immediate sound absorption and tactile warmth.
- Insulation Layer: High-density hemp blocks that serve as a dense acoustic barrier.
- Outer Finish: A flexible decorative skin, currently in development, which gives the capsule its distinctive petal-like texture.

Furthermore, Figure 7 specifies a dual-door system and integrated “transpiration holes” in the wood panels to facilitate natural Air Flow. By placing openings on opposite sides, the design promotes passive ventilation, ensuring a constant supply of fresh air without compromising the soundproof integrity of the space. The synergy of these technical details demonstrates a design that is as functional as it is visually inspiring.

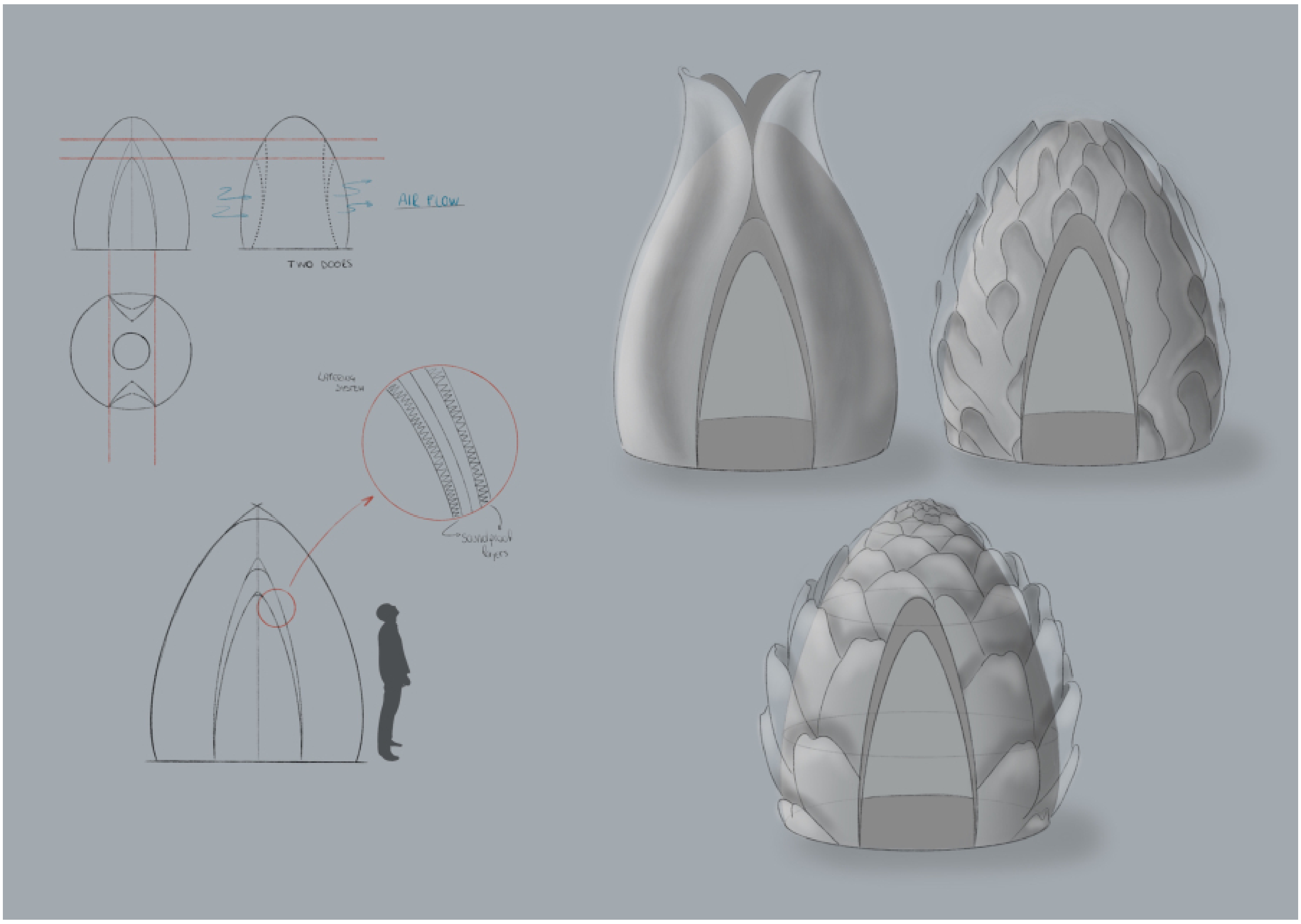

Figure 7: Structural drawings

3D model with load and stress analysis

The 3D modeling and structural stress analysis are scheduled for the next phase of the project's technical development. This stage will involve a digital simulation to verify how the interlocking wooden structure (Figure 6) supports the weight of the hemp and cork insulation layers. By postponing the deep stress testing until the final geometry and materials are fully defined, the analysis can provide more accurate data on the capsule's durability and safety. This future step will ensure that the organic form is structurally sound and ready for professional manufacturing.

Color palette

The color identity of Bloem has been meticulously curated to foster a state of physiological and mental calm. The palette is composed of desaturated, nature-inspired tones that balance professional elegance with organic tranquility as shoun in the Figure 5.

The strategic application of the palette is divided into three functional areas:

- Exterior Surfaces: The shades Plaster (off-white) and Mist (pale blue) are used for the capsule's outer shell. These tones allow the large structure to remain visually light and blend seamlessly into modern office environments without becoming a distraction.
- Interior Environment: The interior utilizes Moss and Eucalyptus greens. These shades are scientifically associated with stress reduction and focus. By surrounding the user with these deeper botanical tones, the capsule creates a “cocoon” effect that psychologically distances the user from the bright, high-pressure office atmosphere.
- Contrast and Accents: The shade Soot (deep charcoal) is used for structural details, hardware, and typography. This tone provides the necessary professional weight and high-end finish, ensuring that Bloem is perceived as a sophisticated tool for corporate wellness.

The synergy of this palette ensures that every touchpoint reinforces the brand's promise: providing a quiet, restorative space where users can truly “bloom.”

Smart System

Hardware

Figure 8 shows the block diagram of the capsule system. At its core is a microcontroller, which is connected to a RGB LED strip and light sensor. All components are powered by an external power supply. The microcontroller communicates wirelessly with an application via Bluetooth/Wi-Fi. The application acts as the central control hub, managing communication with the ESP32 and thereby controlling the lighting system. In addition, the app connects to a Bluetooth speaker to provide audio within the capsule.

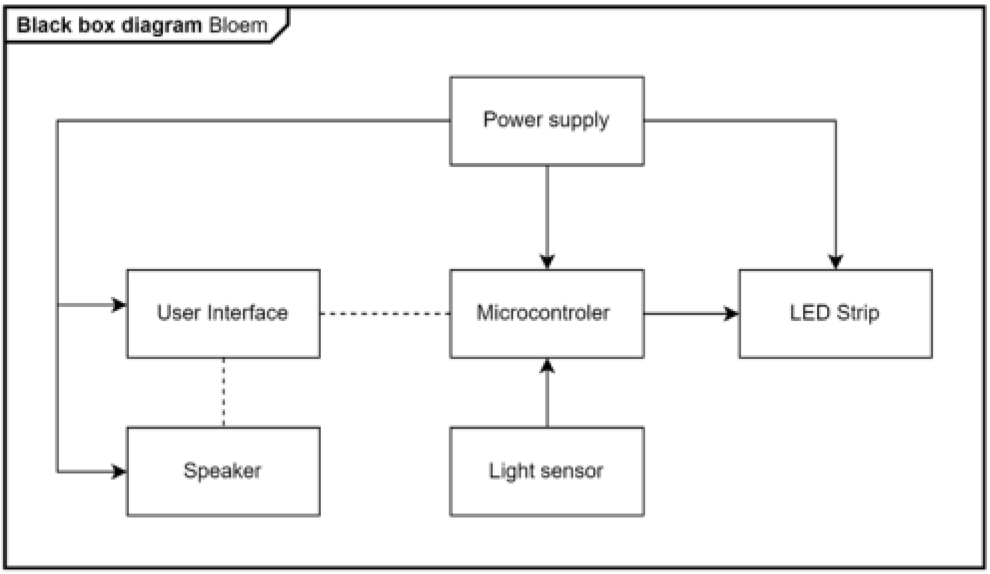

Figure 8: Black Box Diagram

To determine the most suitable components for the system, a comparative analysis was conducted. Multiple components were evaluated based on key parameters such as performance, functionality, and size. The following presents a comparison of microcontrollers (Table 1) and LED strips (Table 2). This comparison forms the basis for the final selection of components used in the project.

Table 1: Comparison of microcontrollers. We have chosen to work with the ESP32 because of its compact size, high performance, and built-in Wi-Fi/Bluetooth connectivity.

Microprocessor	**Arduino UNO R4 [1]**	**ESP32 Dev Module [2]**	**Raspberry Pi 4 [3]**
Processor	48 MHz	Up to 240 MHz	1.8 GHz
Wi-Fi	IEEE 802.11 b/g/n (Wi-Fi 4)	IEEE 802.11 b/g/n (Wi-Fi 4)	IEEE 802.11ac (Wi-Fi 5)
Bluetooth	Bluetooth 5	Bluetooth 4.2 / BLE	Bluetooth 5
Power	5 V DC via USB	3.3 V DC via USB	5 V DC via USB
Form factor	68.6 × 53.3 mm	51 × 28 mm	85.6 × 56.5 mm

Table 2: Comparison of LED Strips. We have chosen RGB LED strips because they offer full color control and flexibility for creating immersive lighting effects.

Feature	**RGB LED Strip [4]**	**Single Color LED Strip [5]**	**Tunable White LED Strip [6]**
Color Options	Color changing	Fixed	Adjustable white
Control	App / Microcontroller	On-off / Direct power	App / Microcontroller
Voltage	5–12 V DC	5–12 V DC	5–12 V DC
Connections	4 (R/G/B + V/GND)	2 (+V / GND)	3 (Warm / Cool + V/GND)
Notes	Can produce millions of colors	Simple and low cost	Mood adjustment with white tones

Based on this analysis, we have chosen the ESP32 Dev Module. It offers a high processor speed and provides excellent flexibility for connecting sensors while still being compatible with the Arduino platform. Likewise, we want to give ourselves the option to use multiple colors of lighting in the capsule, which is why we have selected RGB LED strips. Below, we present a summary of all the electrical hardware components that will be part of the capsule.

Electrical Components Overview:

1. 12V Power Supply: Supplies power to the system and LED strip.
2. Buck Converter: Steps down voltage for low-power components.
3. RGB LED Strip: Enables flexible and dynamic lighting.
4. Light Sensor: Adjusts lighting based on ambient conditions.
5. ESP32 Dev Module: Provides control and wireless communication.
6. 3× Resistors (1 kΩ): Protects components and limits current.
7. 3× Transistors (IRLZ44N): Controls higher current to the LED strip.
8. Speaker (Bluetooth): Provides audio output.
9. Tablet: Acts as the user interface.

This section describes the schematic design of the system shown in 9. The diagram illustrates the integration of the main components and their interactions. The ESP32 functions as the central controller and is responsible for controlling the lighting of the capsule. A light sensor is included to detect ambient light levels and determine when a session should begin. The capsule uses a 12V RGB LED strip with four connections: a 12V supply line and three control lines for red, green, and blue. The color and brightness are controlled using pulse-width modulation (PWM). Each control signal is generated by a digital output pin on the ESP32 and passes through a resistor and a logic-level N-channel MOSFET. This setup allows the low-voltage ESP32 to safely control the higher voltage and current required by the LED strip. Power is provided by a 12V power supply. Since the ESP32 and sensor require a stable 3.3V supply, a buck converter is used to step down the voltage accordingly. Additionally, the ESP32 communicates with a mobile application via Bluetooth Low Energy (BLE), enabling configuration and control of the system. It is important to note that this design represents an initial draft, developed to explore component selection and overall system integration.

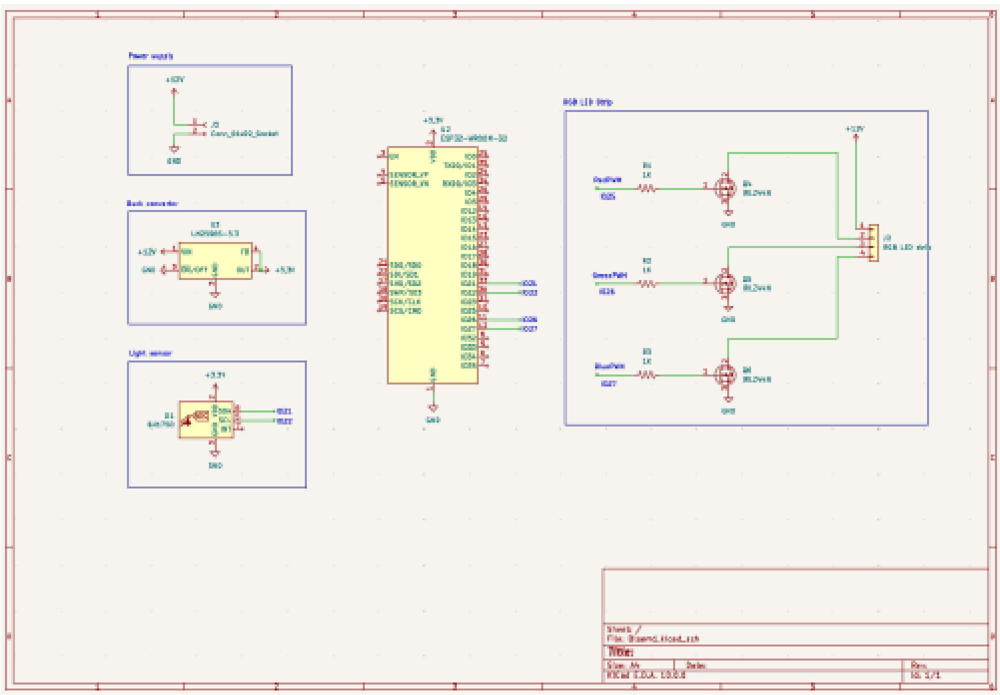

Figure 9: Schematic drawing **[7]**

To ensure the system operates reliably, a power budget was established for all electronic components. Table 3 below outlines the voltage, maximum current draw, and resulting power consumption for each component. The data is based on the datasheets of each component.

Table 3: Total Power Budget for the System.

Component	Rail	Max Current	Power (W)	Note
ESP32-WROOM-32	3.3 V	500 mA	1.65 W	During Wi-Fi activity
BH1750 Sensor	3.3 V	< 1 mA	~0.01 W	I2C communication
LM2596 Loss	12 V	~50 mA	~0.6 W	Based on ~80% efficiency
RGB LED Strip (3 m)	12 V	3.6 A	43.2 W	Full white brightness
Total System	12 V	~3.8 A	~45 W	Input requirement for J3

The power budget analysis shows that the system has an estimated total power consumption of approximately 45 W, where the RGB LED strip constitutes the primary load. In comparison, the ESP32 and connected sensors contribute only a minor portion of the overall consumption, while losses in the voltage regulation stage are relatively small but included in the calculation. Based on this analysis, the system requires a 12 V power supply capable of delivering at least 3.8 A. To ensure stable operation under varying load conditions, a safety margin should be applied. Therefore, a power supply in the range of 5–6 A (60–72 W) is recommended. Overall, the power budget confirms that the system design is r well-justified in terms of power requirements.

Software

The software component of the Bloem project is responsible for enabling the interaction between the user and the capsule environment. It consists of a mobile application installed on a tablet and an embedded control system running on a microcontroller. Together, these elements allow the user to book sessions, control environmental settings, and experience a guided relaxation process.

The tablet application acts as the main interface between the user and the system. It is designed with a calm and minimal user interface, using simple navigation, large touch elements, and soft visual feedback to align with the relaxing purpose of the capsule. The application allows users to quickly book a session, select a time slot, and adjust lighting and sound settings without unnecessary complexity.

The embedded system, implemented using a microcontroller (ESP32), is responsible for executing commands received from the tablet application. It controls the lighting system, manages audio triggers, and processes sensor data when necessary. This separation between interface and control ensures modularity and simplifies both development and maintenance.

Use Cases and User Stories

The Bloem system supports a set of focused interactions that define the user experience.

Table 4: Main Use Cases of the Bloem System

Use Case	Description	Main Actor
Book a session	The user selects a session duration and an available time slot	User
Start session	The user initiates the relaxation session	User
Adjust lighting	The user changes brightness or selects a predefined lighting mode	User
Adjust sound	The user selects a sound environment or silence	User

Use Case	Description	Main Actor
Run session	The system maintains the selected environment during the session	System
End session	The session ends automatically or is stopped manually	User / System

Table 5: User Stories

ID	User Story
US1	As a user, I want to quickly book a session so that I can relax without waiting
US2	As a user, I want to choose a time slot so that I know when the capsule is available
US3	As a user, I want to control lighting so that I can create a comfortable environment
US4	As a user, I want to select sounds or silence so that I can personalize the experience
US5	As a user, I want a simple interface so that I can use the system without confusion
US6	As a system, I want to automatically end sessions so that the capsule is available for the next user

Selection of Development Platforms and Software Components

The Bloem system requires both a front-end application and an embedded control system. Different options were considered for the tablet application.

Table 6: Comparison of Tablet Application Development Options

Option	Advantages	Disadvantages	Suitability
Native Android application	Full access to device features, high performance, stable user experience	Platform-specific development	High
Cross-platform mobile framework	Faster development and shared codebase	Additional abstraction layer, possible performance trade-offs	Medium
Hybrid application	Easier UI development, flexible design	Limited hardware integration, less optimized	Medium

For Bloem, a **native Android application** is considered the most suitable option. It allows direct integration with the tablet hardware, ensures smooth performance, and provides better control over the user interface and device communication.

The selected software components are summarized below.

Table 7: Selected Software Components

Component	Technology	Purpose
Tablet application	Native Android app	User interaction and session control
UI design	Custom interface (Bloem design system)	Calm and intuitive experience

Component	**Technology**	**Purpose**
Embedded firmware	ESP32 (Arduino framework)	Hardware control and system logic
Communication	Wi-Fi and Bluetooth local communication	Data exchange between tablet and ESP32
Session management	Internal app logic	Controls timing and session flow

Software Architecture

The software architecture is divided into two main layers: the user interface layer and the hardware control layer.

The tablet application manages all user interactions, including session booking, environment configuration, and session control. Once the user selects a session and its parameters, the application sends commands to the embedded system.

The ESP32 receives these commands and applies them to the physical lightning component. During the session, the system maintains the selected environment and ensures that the session duration is respected through a timer mechanism.

This architecture ensures a clear separation between user interaction and hardware control, making the system easier to develop, test, and extend.

Interaction Diagram

The following diagram illustrates the interaction between the user, the tablet application, and the hardware components of the Bloem system.

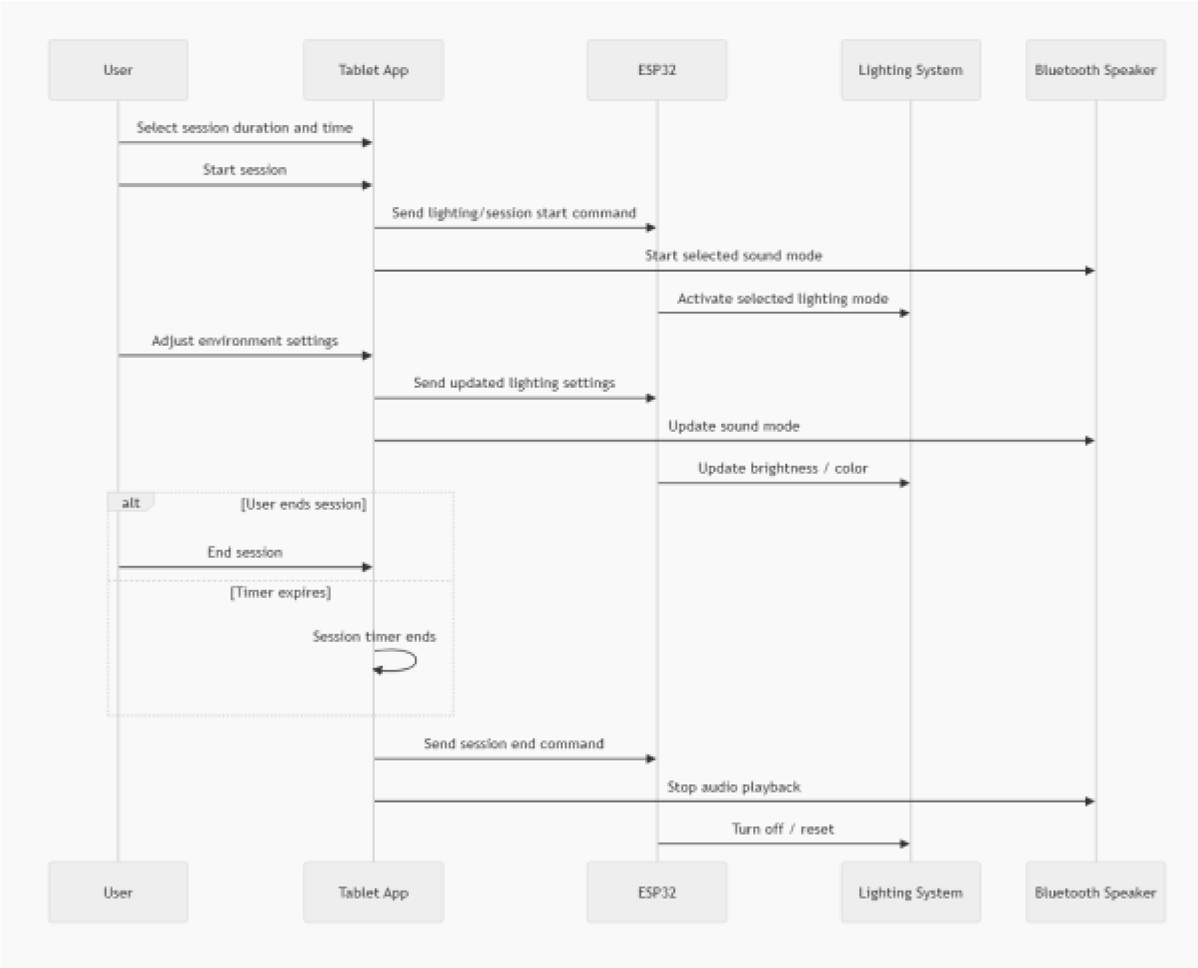

Figure 10: Interaction flow between user, tablet application, and capsule control system

Packaging

Given the significant scale of Bloem and its commitment to sustainable logistics, the packaging is designed as a high-end, industrial Flat-Pack System. Instead of shipping a voluminous, pre-assembled structure, the capsule is divided into modular components that optimize transport space and significantly reduce the carbon footprint of delivery. This system is specifically engineered for professional B2B handling, ensuring that all large-scale vertical ribs and delicate acoustic layers are protected during transit to corporate environments. The packaging utilizes heavy-duty, reinforced recycled kraft liners with a structural internal framework that mimics the protection of traditional wooden crates used for fine furniture, yet remains entirely plastic-free and recyclable.

Each component is nested within custom-molded pulp inserts that secure the cork tiles and hemp blocks, while the exterior of the crate serves as both a technical manual and a brand statement. Using monochromatic, eco-friendly inks, the surface displays the assembly hierarchy and the structural logic of the project, providing immediate visual guidance for the professional installation team. Centered prominently on the main face of the packaging is the brand’s core promise: “Space to breathe, room to bloom.” This serves as the final touchpoint of the delivery process, signaling that once the industrial protection is removed, what remains is a sanctuary designed for professional clarity and personal growth.

Prototype

Refer main changes in relation to the designed solution.

Structure

Detail and explain any changes made in relation to the designed solution, including structural downscaling, different materials, parts, etc.

Hardware

Detail and explain any change made in relation to the designed solution. In case there are changes regarding the hardware, present the detailed schematics of the prototype.

Software

Detail and explain any changes made in relation to the designed solution, including different software components, tools, platforms, etc.

The code developed for the prototype (smart device and apps) is described here using code flowcharts.

Tests & Results

Hardware tests

Perform the hardware tests specified in Tests. These results are usually presented in the form of tables with two columns: Functionality and Test Result (Pass/Fail).

Software tests

Software tests comprise: (i) functional tests regarding the identified use cases / user stories; (ii) performance tests regarding exchanged data volume, load and runtime (these tests are usually repeated 10 times to determine the average and standard deviation results); (iii) usability tests according to the System Usability Scale.

Summary

Provide here the conclusions of this chapter and make the bridge to the next chapter.

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[1] Arduino, 2025. *Arduino UNO R4 WiFi Datasheet (ABX00087).*
[2] Espressif Systems, 2024. *ESP32 Series Datasheet.*
[3] Raspberry Pi (Trading) Ltd., 2024. *Raspberry Pi 4 Model B Datasheet.*

[4] Worten / LEDKIA LIGHTING, n.d.. *Fita LED RGB 12V DC SMD5050 60 LED/m 5m IP20, Width 10 mm, Cut every 5 cm – LEDKIA.*
[5] Amazon.es / Seller, n.d.. *LED Strip Lights Kit – RGB LED Tape (12 V, with Remote / Controller).*
[6] Amazon.es / Seller, n.d.. *LED Strip Lights – Multicolor RGB LED Tape (12 V, with Remote / Controller).*
[7]

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