LeftLovers LoopBin





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Abstract

The European Project Semester (EPS) at Instituto Superior de Engenharia do Porto (ISEP) is a challenge based learning framework where engineering students from various majors and nationalities collaborate to solve real-world problems. EPS@ISEP projects provide a context for teams to jointly acquire and apply new knowledge and skills during the design, development, and testing of a proof-of-concept prototype.

In the spring of 2025, the LeftLovers team tackled the challenge of creating an accessible, economical, ecological, and odourless kitchen food waste disposal solution for flat dwellers. LeftLovers aimed to raise awareness of the benefits of composting food waste, to educate about composting, to convert food waste into compost, and to use the compost to grow plants at home.

The proposed Loopbin concept consists of a device and an application. The device has four vertically stacked bins: a small garden for direct compost use at the top, two compost bins in the middle, and a compost storage bin at the bottom. The compost bins are equipped with handles for turning the contents and pins for opening the trap doors between bins.

A smart system monitors the composting process, controls automatic ventilation, and communicates with the app, which displays the composting status and provides instructions for producing high-quality compost. This solution stands out for its accessibility, affordability, and inclusion of a

vegetable garden.

Glossary

Abbreviation	Description
CO_2	Carbon Dioxide
EPS	European Project Semester
EMC	Electromagnetic Compatibility
EMCD	Electromagnetic Compatibility Directive
ISEP	Instituto Superior de Engenharia do Porto
LVD	Low Voltage Directive
MD	Machinery Directive
NIST	National Institute of Standards and Technology
NH_4	Ammonium
O_2	Oxygen
PWM	Pulse Width Modulation
RED	Radio Equipment Directive
RoHS	Restriction of Hazardous Substances Directive
SI	International System of Units
USB	Universal Serial Bus
UART	Universal Asynchronous Receiver/Transmitter
WBS	Work Breakdown Structure
Wi-Fi	Wireless Fidelity
MOSFET	Metal Oxide Semiconductor Field Effect Transistor
JSON	JavaScript Object Notation
HTML	HyperText Markup Language
JS	JavaScript
PVC	Polyvinyl Chloride
ABS	Acrylonitrile Butadiene Styrene
PLA	Polylactic Acid
PP	Polypropylene
HDPE	High-Density Polyethylene
API	Application Programming Interface
I2C	Inter-Integrated Circuit
RS-485	Serial Communication Standard
ESP32	Microcontroller with integrated Wi-Fi and Bluetooth

1. Introduction

1.1 Presentation

The “Leftlovers” team consists of six students from diverse nationalities and academic backgrounds who have come together at ISEP to take part in the European Project Semester. Table 1 and Figure 1 provides an overview of the team members, including their home countries and fields of study.

Table 1: LeftLovers Team

Name	Home country	Field of study
Clara Díaz Martín	Spain	Fashion, Interior and Industrial Design
Nathan Audy	France	Industrial and Mechanical Engineering
Emile Amant	Belgium	Civil Engineering
Simon Lünswilken	Germany	Mechatronic Systems Engineering
Lianne Hannah Maria Tibbe	Netherlands	Biology and Medical Laboratory Research
Qi Xuan Tan	Malaysia	Mechanical Engineering

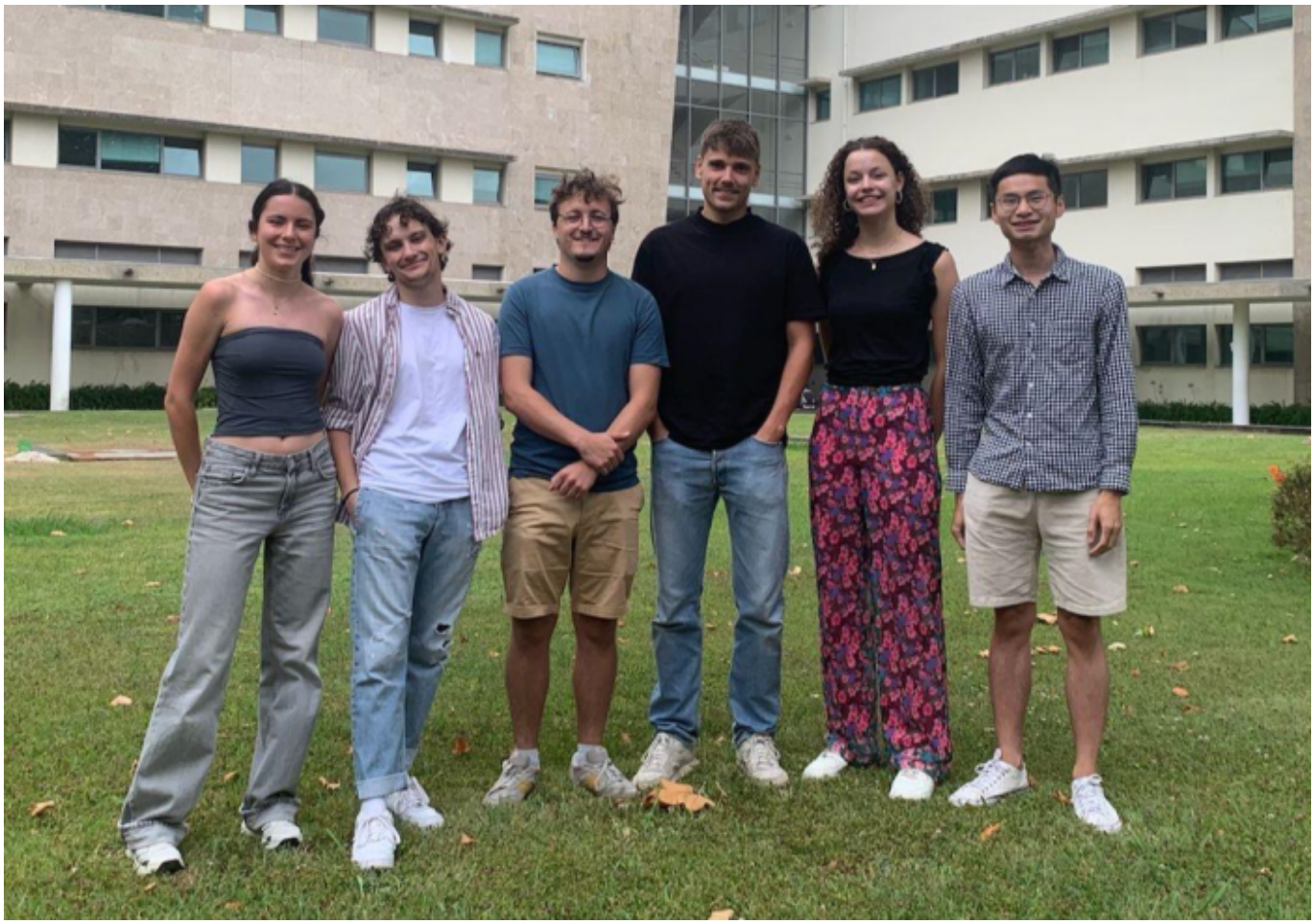


Figure 1: LeftLovers Team group picture

1.2 Motivation

As a team, we have chosen the European Project Semester because we believe this experience will enrich us both professionally and personally. Working in a multidisciplinary, international team provides us with the opportunity to collaborate with people from diverse cultures and academic backgrounds. This way we can work on our creativity and problem-solving skills while preparing ourselves for a professional work environment. We also see EPS as a way to challenge ourselves, step out of our comfort zones and improve our English skills. The fact that we get to do this in Porto makes it even more special. Besides everything we learn at school, we also have the opportunity to explore a new city and meet new people along the way.

The process of choosing a topic within our team was quite swift. We each wrote down our individual interests and topic preferences. “Smart food production in small spaces” was a common preference for the topic, while “environment” was a common interest shared by all. To combine these two areas of interest, we aimed to develop a product that would enable food production while also contributing to a more sustainable world. We decided to approach the problem from the end: food production itself was not the main issue we wanted to focus on, but rather what happens to the food afterward. We have all observed the significant amount of food waste, which we find wasteful. From this observation, the idea arose to create an organic waste bin that would allow users to repurpose food waste in a more meaningful way, while also enabling them to grow their own plants—especially for those who live in small spaces and do not have access to a garden.

1.3 Product

The project focuses on two major themes: “Smartification of everyday objects” and “Smart food production in small spaces”. These themes led to the exploration of solutions to integrate new technologies into everyday ecological practices. After careful consideration, the decision was made to develop a smart composter, an innovative device paired with a mobile app that helps users turn their food waste into compost in an efficient way.

One of the main challenges of the product is to ensure that the composting process remains odor-free, while remaining easy to use. To achieve this, the solution will incorporate an optimized compost system, making sure to maintain an optimal balance between wet/dry matter ratio to avoid any unpleasant smells. Aeration will also be an important factor: an automated system for mixing and stirring the waste will speed up the decomposition process and help keep the compost well-mixed.

By using smart sensors, the composter will be able to analyze various parameters such as humidity, temperature and gas levels in real time. This data will be sent to the mobile app, which will provide users with personalized advice on how to optimize their compost and avoid common mistakes, such as too much moisture or not enough aeration. The goal is to make composting easy for beginners, while ensuring high quality compost that can be used for urban gardening or indoor plants.

In this way, the intelligent composter is part of a circular economy approach, helping to reduce organic waste, enhance the value of bio-waste and raise awareness among city dwellers of more sustainable practices. By facilitating the adoption of composting in urban environments, the product contributes to more responsible resource management, while offering users a connected, modern and efficient solution.

1.4 Problem

The main problem identified is the complexity of accessing a food waste recycling system that is simple, reliable and inexpensive. Currently, most composting solutions require a garden or outdoor space, making them difficult to access for apartment-dwellers living in big cities. Without a solution that is adapted to their lifestyle, these people are forced to dispose their organic waste with regular household waste, which increases the amount of waste that is incinerated or landfilled.

In addition, in many urban areas, local authorities do not provide effective solutions for the recycling of organic waste. Even if collection points exist, they are often limited in number, restrictive in terms of opening hours or not well known to the public. Access to information on composting and its benefits is also limited, leaving many city dwellers with no real alternative.

The aim is therefore to provide a dual response to this problem:

1. Provide users with the knowledge they need to understand the principles of composting and integrate it easily into their daily lives.
2. To offer a product adapted to their environment, designed specifically for indoor use, without nuisances (odors, insects) and without the need for outdoor space.

A second major problem with conventional composting was also identified: time and the quality of the compost produced. Traditional composting takes several months and is often incompatible with an urban lifestyle where space and time are limited. Indeed, storing organic waste in an apartment for long periods of time can become hard to handle and unhygienic. Furthermore, without the right balance of dry and wet matter, the quality of the resulting compost can be poor, limiting its usefulness for householdplants or urban gardening.

Our approach is therefore to offer a solution for faster, more efficient composting, with a product that naturally speeds up the process while guaranteeing optimum quality of the resulting compost.

1.5 Objectives

The main aim of this project is to offer a practical, accessible and effective solution to enable city dwellers to recycle their food waste, even without access to an outdoor space. By responding to the specific constraints of urban living, the product aims to democratize apartment composting and encourage more sustainable bio-waste management.

More specifically, the objectives are:

1. Facilitate access to composting for urban residents.
   The solution must be user-friendly and suitable for indoor use. It must fit into small spaces and meet users' hygiene concerns, in particular by avoiding odors and the presence of insects. One of the challenges is to make composting as natural and instinctive as selective sorting, so that it becomes an established habit in users' daily lives.
2. Reduce composting time to better meet urban needs.
   Conventional composting can take several months, which often deters urban residents. The aim is to develop a system that speeds up the process, so that quality compost can be produced in just a few weeks. This allows for more efficient waste rotation and more regular use of the compost produced.
3. Guarantee high-quality compost.

Effective compost must be rich in nutrients and easily reusable for the care of houseplants, urban gardening or redistribution to local initiatives. The product must guarantee optimal decomposition of organic waste and produce ready to use compost.

4. Raise awareness and support users.
   In addition to offering a product, the aim is to provide educational tools that help users understand how composting works, what best practices to follow and what mistakes to avoid. A better understanding of the process will optimize the management of organic waste and increase citizen involvement in this ecological approach.
5. Contribute to waste reduction and more sustainable resource management.
   With this initiative, the goal is to stimulate the transition to a more environmentally friendly model by reducing the amount of waste that is incinerated or landfilled. The solution is therefore part of a circular economy, in which every household plays a role in recycling and preserving natural resources.

1.6 Requirements

The project has established the following requirements to guide the development of the compost bin:

1. Budget Constraints: The total cost of the prototype must not exceed 100 €. Priority should be given to low-cost hardware solutions, including reused or recycled components where possible.
2. Software & Standards: The system should use open-source software to encourage community contributions, continuous improvement and transparency. All measurements and documentation should conform to the International System of Units (SI), as per the NIST International Guide for SI Units.
3. Regulatory Compliance: The product should comply with relevant EU directives, including:
   - Electromagnetic Compatibility Directive (EMCD)
   - Low Voltage Directive (LVD)
   - Machinery Directive (MD)
   - Radio Equipment Directive (RED)
   - Restriction of Hazardous Substances Directive (RoHS)
4. Functional Requirements: The compost bin should efficiently process food waste by shredding it into smaller pieces and actively mixing it to accelerate the composting process and provide fresh fertilizer every 4-6 weeks. The resulting compost should be suitable for plant growth and usable as high-quality fertilizer. The design should focus on optimizing and accelerating the natural composting process using all available means. In addition, users should be able to add food waste at any time without interrupting the process. An integrated garden should allow users to directly apply the produced fertilizer to grow herbs or vegetables, making it ideal for small living spaces or balconies.
5. Usability & Ergonomics: The design should be user friendly, with intuitive controls and ergonomic considerations for ease of use. Maintenance and cleaning should be easy.
6. Sustainability: The materials used in construction should be environmentally sustainable, with priority given to recycled, biodegradable or eco-friendly options. The product life cycle (production, use, disposal) should minimize damage to the environment.
7. Smart Monitoring & Application: A mobile application should allow users to monitor important composting parameters (like temperature, moisture and carbon dioxide level) and receive real-time instructions for optimal compost maintenance.

1.7 Tests

Before LoopBin can be marketed, it is important to make sure that it works properly. This involves conducting tests at each stage of a cycle, mainly to check the elements that have been designed, as well as some complex connections.

- Test connecting the Arduino to the application. The board is equipped with an ESP32 chip that enables it to connect to the Internet. We need to check that this connection works without a hitch, to ensure error-free operation of the prototype.
- Efficiency of the cutting system. Reducing the size of food waste is a crucial step in LoopBin's operation, as it enables a faster response. The efficiency of the devised system needs to be verified.
- How the mix system works. Waste mixing is crucial to an odor-free composting process. Its system is associated with the cutting system, but needs to be tested in a different way, which is why a different test must be set up.
- Testing the system for transferring waste to a lower level. The triangular opening for transferring waste from one floor to another is also a component of the system. The operation needs to be tested, mainly the complete opening of the mobile part, as well as a closure that correctly retains the waste on one floor.
- Test fan control via the application / sensor operation. Once the connection between the prototype and the application has been established, it's time to check that requests can be sent without malfunctioning, such as requesting information from a sensor, or turning the fan on/off. This is also the way to check that connections have been made correctly, especially humidity sensors, which require the use of the MAX3485 transceiver, and a parallel connection.
- Test battery discharge time. After checking each stage of the prototype's operation, it is important to ensure that it remains functional over time, i.e. that the battery is fulfilling its role correctly.

1.8 Report Structure

Chapter	Description
1. Introduction	Introduction of the team, the topic, the problem and the objectives within the project
2. Background and Related Work	Background information on the topic and research on existing solutions
3. Project management	Overview of the methods used within the team for project management
4. Marketing plan	Market analysis, identification of the target audience and competitors, and market strategy
5. Eco-efficiency Measures for Sustainability	Measures to minimize the ecological footprint of the project and an overview of the most important aspects of sustainable development and eco-efficiency
6. Ethical and Deontological Concerns	Analysis of ethical considerations to be taken into account
7. Project Development	Development of the product from concept to prototype
8. Conclusions	Discussion of everything that has been achieved with the project, what is still missing and future developments
9. Bibliography	List of all sources used in the project

2. Background and Related Work

2.1 Introduction

Compost bins have significantly evolved in the last years. They are not just for storing food scraps, they have become an essential part of eco-friendly living. Modern compost bins are designed with advanced materials, innovative aeration systems and user-friendly features to optimize the breakdown of organic waste while minimizing odors and pests. They come in all shapes and sizes, from small kitchen bins to larger backyard bins. As global interest in sustainability increases, these bins are playing an increasingly important role in promoting environmentally friendly practices and reducing environmental impact.

This chapter examines the theoretical background of the composting process, including all the factors that influence the best compost conditions. It also discusses the latest technologies used in modern compost bins available on the market. Understanding the functionality and design of these systems is crucial to the design process of the compost bin. The following sections present findings and insights into the latest advancements in composting technology.

2.2 Concepts

Composting is a natural process where microorganisms break down organic waste into nutrient-rich humus. This happens under aerobic conditions, meaning the presence of oxygen. Several factors affect composting, but they can be controlled by adjusting the material mix, ensuring good airflow, and turning the compost regularly.

The composting process occurs in several stages. It starts with the mesophilic phase (0 – 40 °C), where microorganisms start to break down easily degradable materials such as sugars and proteins. As the temperature rises, the thermophilic phase (40 – 70 °C) begins. In this stage, heat-resistant microorganisms take over and help kill pathogens and weed seeds. After this, the cooling phase starts, where the temperature drops, and microorganisms continue breaking down complex materials like cellulose and lignin. Finally, in the maturation phase, the compost stabilizes, and the result is a nutrient-rich final product **[Florian Amlinger, 2025]**, **[Benjamin Lammert, et al., 2002]**.

Several key factors influence composting. Temperature is important, with an ideal temperature between 50 °C and 60 °C for efficient decomposition. Moisture also plays a role, as microorganisms need water to survive. The optimum moisture is between 55 and 65 %. Another crucial factor is the gas composition. Composting requires oxygen (O_2) to support aerobic microorganisms. The oxygen level should not fall below 5 %, with ideal values between 7 % – 12 %. If oxygen levels drop too low, anaerobic microorganisms start to grow, producing methane (CH_4) and hydrogen sulfide (H_2 S), which cause bad smells. Additionally, carbon dioxide (CO_2) levels should stay below 10 – 12 %, and methane levels should not exceed 1 % **[Florian Amlinger, 2025]**, **[Benjamin Lammert, et al., 2002]**, **[Muaid S. Ali, 2017]**, **[K. J. Park, M. H. Choi, J. H. Hong, 2002]**, **[Nisha N. Gurusamy, et al., 2021]**.

For a successful composting process, it is essential to maintain good air circulation, turn the compost regularly, and create a balanced mix of materials. This helps microorganisms to effeciently break down the waste, prevents unpleasant odors and produces high-quality compost. Studies show that the frequency of turning the compost directly affects the duration of the composting process. Turning it twice a week is already sufficient. Adding fully composted humus can also help speed up the process **[Florian Amlinger, 2025]**, **[Muaid S. Ali, 2017]**.

The size of organic particles also affects composting speed. Smaller pieces have a larger surface area,

making it easier for microorganisms to break them down. The best particle size is between 0.5 and 5 cm. If pieces are too large, decomposition is slow. If they are too small, the compost becomes too dense, reducing oxygen flow and increasing the risk of anaerobic processes **[Patrizia Messmer, 2022]**, **[GrowVeg, 2025]**.

Another important factor is the Carbon-to-Nitrogen (C/N) ratio, which should be 25–35:1. A good balance of “green” and “brown” waste is necessary:

- Green waste (high in nitrogen, moist, and easy to break down): Includes food scraps (fruit and vegetable peels, coffee grounds, tea bags) and fresh garden waste (grass clippings). These materials increase microbial activity and speed up decomposition.
- Brown waste (high in carbon, dry, and provides structure): Includes leaves, branches, sawdust, cardboard, and paper. These materials improve airflow, absorb excess moisture and prevent anaerobic conditions.

Too much green waste leads to excess nitrogen, causing ammonia smells. Too much brown waste slows down composting because microorganisms need nitrogen to work efficiently. A balanced mix ensures stable decomposition and high-quality compost. There are different recommendations in the literature on how to balance the carbon-to-nitrogen (C/N) ratio in terms of amounts of green and brown food waste. A common rule of thumb is to mix equal amounts of both. However, some sources suggest using two parts brown food waste to one part green food waste **[Florian Amlinger, 2025]**, **[Benjamin Lammert, et al., 2002]**, **[GrowVeg, 2025]**.

To control the composting process, it is important to adjust the material composition, maintain good airflow, and turn the compost regularly. These steps create ideal conditions for microorganisms, speed up decomposition, and prevent bad odors.

To create optimal composting conditions, several concepts can be found in current technology that help establish these environments. For example, some composting solutions include shredders, as seen in Figure 2 from the Greezy composting solution **[Greenzy, 2025]**.



Figure 2: Greenzy Grinder **[Greenzy, 2025]**.

Many modern compost bins also use IoT (Internet of Things) technology. They have smart sensors.

These sensors check temperature, moisture, and the gas consumption. The sensors keep the composting process at its best. Some bins connect to mobile apps, as shown in Figure 3. Users can track progress and get alerts through these apps. The apps also give tips for better composting. This makes the process simpler, especially for beginners **[AMAZON, 2025]**.



Figure 3: GoveeLife Composter allows user to create a composter schedule and monitor the status via the app from everywhere **[AMAZON, 2025]**.

To control odors, many compost bins use activated carbon filters. These filters trap odor-causing molecules as air passes through. Activated carbon is characterized by its highly porous structure, which provides a large surface area for absorbing odors. This property makes it an ideal solution for maintaining odor-free compost bins, especially in indoor or confined spaces. Many compost bins today are equipped with replaceable carbon filters, which allows for easy maintenance and long-term use **[Breathe Naturally, 2025]**.

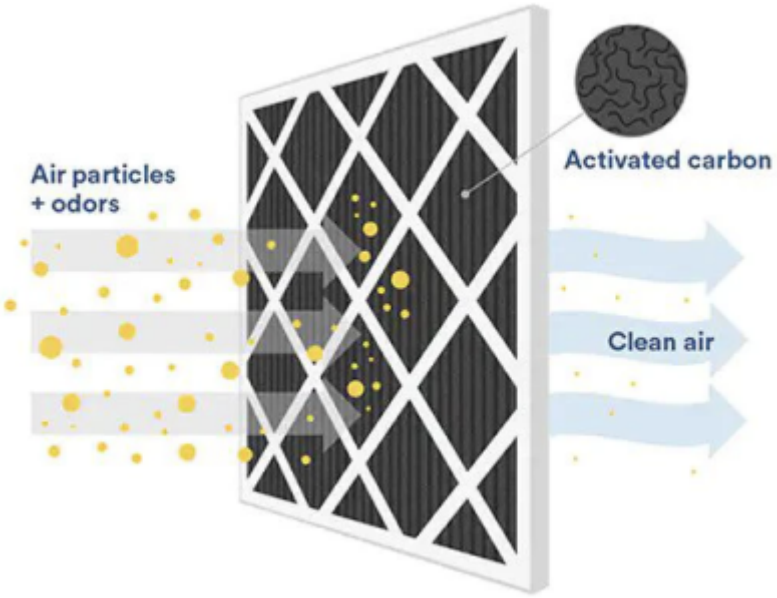


Figure 4: Activated carbon filter **[Breathe Naturally, 2025]**.

Modern compost bins are also designed to work quietly. They use low-noise grinding mechanisms and quiet aeration systems. This makes them suitable for homes, offices, and urban spaces. Quiet operation ensures the composting process does not disturb daily activities.

2.3 Product

As there is already different products on the market, it will be helpful to analyze these and try to find their differences and components that may be useful in the design. The different existing products are analyzed in this chapter. The most notable features per product are discussed, at the end of the chapter a summarizing table is provided with extra general information of the products.

1. Reencle Home Composter The Reencle Home Composter **[reencle, 2025]** is a food waste bin which breaks down the food waste in 24 hours by mirroring the aerobic composting process. It creates and optimizes the environment to speed up the microbial decomposition of food scraps. It uses a mesh filter, carbon filter and an organic additive to avoid bad smell. The company claims that they make real compost and not just dehydrates food. Important to mention is that the optimum compost amount per day is 0.68 kg with a maximum of 2.2 lbs or 1 kg, this shows the high capacity and flexibility for the customer in their personal use. With the starter package and the organic additive, Reencle includes the customer in the composting process.

2. Foodcycler - Eco3 The FoodCycler Eco 3 **[FoodCycler, 2025]** is a food recycler which breaks down the food in 4 to 9 hours. Due to the drying process, no real compost is produced, but a by-product that can be added to the soil of the plants or backyard compost. Different ratios of byproduct to soil are recommended depending on the composition of the food waste. The product is provided of an application which helps the customer to monitor and schedule the composting process. As it is self-cleaning, the product is user friendly.

3. GoveeLife GoveeLife **[AMAZON, 2025]** is a composting bin that uses a drying process to break down food scraps into a mixture that can be mixed into the garden soil for fertilization. The product makes it easy to add food waste when it is in composting mode, within 15 minutes the extra food waste can be added. The company claims that the bucket is easy to clean due to the non-stick coating of the inner bucket.

4. InnovaGoods The Electrical Kitchen Composter Ewooster by Innovagoods **[InnovaGoods, 2024]** is another composting bin which uses 3 different stages to break down foodwaste: drying, chopping and cooling. The resulting product is a fertilizer that can be used for the lawn, garden, plants and other uses. It is provided with 3 carbon filters to avoid odors and has a self-cleaning function that takes 1 hour to fulfill. A downside of the product is that the temperature goes up to 115 °C to complete the composting process.

5. Greenzy The Geenzy food waste bin **[Greenzy, 2025]** uses a composting process that includes microorganisms. The whole process of composting takes 2 months to complete while u can keep adding food waste to the bin. It has a fly trap on the surface to prevent the disturbance of flies.

6. Geme The Geme compost bin **[GEME Composter, 2025]** is one of the more expensive products on the market. It uses an aerobic composting system that breaks down the food in 6 to 8 hours. The bin has to be emptied partly every 3 months. The resulting compost is a high nutritious soil. The bin uses catalytic oxidation to prevent odors. This makes it low in maintenance.

7. CEERCLE The compost towers of CEERCLE **[Ceercle, 2025]** use worms in the composting process. This way the process is sped up by four times compared to traditional composting. This product combines gardening with composting in the compost tower.

8. Hotbin Composting The Hotbin Composting **[HOTBIN Nederland en Belgie, 2025]** is a bin for outside use which is provided with insulated walls that keep the warmth of the natural composting

process (microorganisms) inside. This speeds up the process without causing odors. Almost all organic waste can be added to the bin.

9. Lomi Bloom The Lomi Bloom compost bin **[Lomi, 2025]** uses 3 different stages to break down food waste from 3 to 20 hours. With the heating, grinding and cooling stages, it mimics the natural composting process. The bin comes with an application that tracks down the waste footprint of the user with real-time data.

10. Bokashi Bucket The Bokashi Bucket **[Mdr.de, 2023]** uses food waste to create liquid fertilizer and pre-compost soil. This is possible through a fermenting process. Every time the user adds food waste to the bin, it must be sprayed with a liquid mixture called “Effective Microorganisms” that contains bacteria and fungi that help the fermenting process. The effluent must be drained every two to three days. The liquid fertilizer can be added to water for watering plants.

11. Soilkind The Soilkind compost bin **[Soilkind, 2025]** is divided into two chambers. In the first one, the foodwaste is dried and chopped into smaller pieces. The second chamber is for decomposting the foodwaste with the help of microorganisms. The whole process takes 48 hours. Also, the water from the waste gets collected and can be used for watering plants. The bin also is provided with a heat exchanger so the heat from the composting process can be used for drying the food waste in the first chamber.

Table 2 summarizes the main features of the researched products.

Table 2: Comparison of the researched products.

Product	Price (€)	Process	Process Time	Filters against bad odors	Loudness	Socket Needed?	Daily Food Waste Capacity (kg)	Frequency of Emptying	Extra Feature
Reencle	458	Mirroring of Aerobic Composting	24 h	mesh filter, carbon filter, organic additive	< 28 dB	yes	≈1	1-3 months	filter cost: 25 €/year, compost starter pack included
Foodcycler - Eco 3	412	Drying, grinding, cooling	4-9 h	Carbon filter (refillable)	“quiet”	yes	≈1.5	every 2 days	0 methane gas emitted, patented grinding system
Goveelife	227	Drying	4-8 h	2 changeable carbon filters	“superquiet”	yes	≈1.5	every 2 days	for animal and vegetable food, app for monitoring, self cleaning
Innovagoods	298	3 stages: drying, chopping, cooling	6-10 h	3 carbon filters	< 45 dB	yes	≈1.5	daily	self cleaning function
Greenzy	899	Microorganisms	2 months	carbon filter	< 42 dB	yes	≈2	2 months	sensors/humidity, temperature, air quality, process via the app, filter change every 3 months (45 €)

Product	Price (€)	Process	Process Time	Filters against bad odors	Loudness	Socket Needed?	Daily Food Waste Capacity (kg)	Frequency of Emptying	Extra Feature
GEME	1000	Aerobic composting	6-8 h	metal ions as catalyst, carbon	35-45 dB	yes	up to 5	2 months	no filter change
CEERCLE	179	Worm composting	2-6 weeks	no filter system	no noise	no	≈1.5	not mentioned	combines composting and gardening, hand-made pottery
Hotbin Composting	655-805	Microorganisms	30-90 days	no filter	no noise	no	≈0.6	30-90 days	all sorts of food waste can be added
Lomi Bloom	479	Heating, grinding, cooling	3-20 h	carbon filter	< 60 dB	yes	≈1.25	weekly	app with real-time data on waste footprint
Bokashi Bucket	65	Fermenting process	+ 3 weeks	anaerobic process prevents bad odors	no noise	no	≈1.6	2-3 days	creates pre-compost and liquid fertilizer, app for controlling the bin
Soilkind	1490	Grinding and drying system	48 h	carbon filter	39 dB	yes	≈1	every week	regulates temperature, humidity, ventilation and compost maturity, self cleaning

Figure 5 shows the different researched products.



5
: Researched products.

2.4 Projects

After a catastrophic tsunami on ‘Atata Island, **Pacific Grow** **[Merav, 2024]** put their shoulders to the rebuilding of the island in a sustainable and innovative way. Next to installing underground powerlines and a rainwater harvesting system, they managed to install HomeBiogas systems in every household. This allowed the families to use organic waste as a fuel for cooking instead of firewood. As energy was one of the biggest hurdles, this really was a game changer. Also, the liquid fertilizer that was produced by the HomeBiogas system could be used to plant gardens. This created the first steps towards independent food security and sustainable living in the Pacific.

“**Let’s Get Growing**” **[Mary Schwarz, Jean Bonhotal, 2017]** is a guide on how to implement

different forms of composting into a school context with educational purpose. While the focus lies in composting itself, they also talk about waste management in general. You can for example organize an on site composting project and let the students help in the construction and maintenance of the different steps. On a smaller scale, you can start worm composting in a classroom so students see the composting cycle in a real application.

“Social, economic and environmental benefits of organic waste home composting in Iran” **[Haniyeh Jalalipour, et al., 2025]** is a paper that talks about a pilot project organised in Shiraz, Iran that wants to decrease 10 % of the collected organic waste in a 10-year horizon by making compost out of it with **home compost systems**. The social, economical and environmental impact are discussed. Results are that if Shiraz distributed 10 000 home composter systems, they could decrease the CO_2 emission from landfilling by 9 %. Also, 86 % of participants were willing to manage organic waste generated at home. Controlling the moisture and temperature is described as a difficult topic which can result in poor quality compost. This may reduce the commitment of the participants.

“Home Bio-Waste Composting for the Circular Economy” **[Piotr Sulewski, et al., 2021]** is a case study that tries to implement home composting systems in municipalities near Warsaw (Poland). The study concludes that participants can be motivated to try home composting by lowering the fees for waste collection. The used discount of 6 % was too low, over 80% of the participants expected a reduction of at least 15% of the fee. 40% of participants expected a discount of 30%. This shows that an active support of the local authorities is needed to promote home composting. Also, education about composting is needed as only one-third of respondents are willing to participate in home composting.

The papers that research about home composting show that this is a good solution to make useful use of food waste and decreasing the waste. Nect to that, people can be motivated to use a home composting bin by decreasing the fee for waste collection. Also, by educating kids about home composting in school, future generations may be more open to the concept.

2.5 Comparative Analysis

The market analysis already shows clear differences between the available home composting solutions. A noticeable aspect is the wide range of price categories and the variety of composting methods used, such as drying, microbial composting, worm composting, and hybrid systems.

Another distinguishing feature is the type of odor filtration that is being used. Different types of filters are used, but these need to be replaced regularly, which can limit the ease of use. In addition, some products offer additional features, such as low noise, self-cleaning or smart monitoring systems that track the composting process through an app. The duration of the composting process also varies between products.

The variety of existing solutions indicates a growing demand for home composting. This trend could be further promoted by targeted political measures, such as lower waste charges or information campaigns on environmental protection and composting, as described in **[Piotr Sulewski, et al., 2021]**.

This study identifies clear opportunities for positioning a new product that addresses weaknesses in the market and differentiates itself.

The product approach is based on a natural, microbial composting process that produces nutrient-rich and high-quality fertilizer without the use of artificial acceleration methods like heat or chemicals.

Unlike rapid composters that promise results within a few hours, the Loopbin system focuses on a continuous process. This allows users to add organic waste at any time, and the finished compost can be removed after several weeks, which provides the more ecologically device.

A comparison with existing products shows that the Greenzy Compost Bin comes closest to this concept, as it also tracks the composting process via an app. However, the Loopbin aims to go beyond this functionality by including an integrated plant box. This allows users to apply the composted fertilizer directly and experience the benefits of composting in a tangible way, providing a significant added value compared to the competition.

The only product on the market with space for growing plants is the CEERCLE Composter, but it lacks any form of digitalization, resulting in a less user-friendly experience. In addition, the aim is to reduce the relatively high price of the Greenzy Compost Bin (899 Euros) and make it accessible to a wider customer base.

By combining sustainable composting, smart functions and direct benefits through the integrated plant box, a clearly distinguishing product with real added value is created. It is clear that despite the many existing solutions, there is still potential for innovation in the market, especially when technical sophistication, environmental awareness, and user-friendliness are combined.

2.6 Summary

In this study, food waste has been identified as a major challenge, particularly in urban environments where recycling infrastructure is often inadequate, and awareness of sustainable waste management practices is low. Although many households have organic waste bins, they are frequently underutilized, and composting methods can seem complicated to some users.

To address this, the objective is to design the LeftLovers Loopbin — a smart composting system that will make recylcing organic waste easier and more efficient. As seen from the research on existing compost bins, LeftLover sets itself apart by offering a unique solution that not only simplifies composting but also integrates a garden where users can apply the fertilizer directly.

With a built-in monitoring system and a supporting app, the Loopbin offers real-time feedback on composting conditions to gain optimal results. This makes it easier for users, especially those living in urban areas without access to a garden, to effectively reuse food waste while growing their own plants. The target audience are urban dwellers looking for an eco-friendly solution for managing food waste and growing plants, combining sustainability with convenience.

3. Project Management

This chapter focuses on the important aspects of project management that are essential to its success. It covers several areas, such as defining the project scope, managing time, costs, and resources, ensuring quality and handling communication within the team. It also covers risk management, collaboration with stakeholders and procurement strategies.

The chapter is divided into several sections, each covering a specific part of the project management process. First, the project scope and the planned deadelines for each phase are discussed. Then, cost management, quality control and the people involved in the project are discussed. Communication strategies and how the team plans to manage updates and meetings are also discussed.

Finally, the chapter looks at the project plan, with a focus on sprint planning, the tasks to be completed, and the progress made. Each section of the chapter is designed to give a clear overview of how the project will be managed, tracked, and adjusted to ensure successful outcomes.

3.1 Scope

The scope of a project defines the framework needed to ensure a successful outcome. This is described in a Work Breakdown Structure (WBS), as shown in the diagram (Figure 6). The WBS serves as a tool for analyzing and organizing all relevant project components, which enables efficient management.

In the Leftlovers WBS (Figure 6), the main project areas are divided into marketing, project management, documentation, Design and Reports . Each of these categories contains specific subcomponents, allowing individual tasks to be handled and tracked in a structured way.

For example, project management includes essential methods such as creating a Gantt chart, a product backlog or a sprint plan to coordinate the progress of the work. Documentation brings all documents together that are needed before next to the actual product such as the state of the art, the list of components and the requirement list.

Using this WBS offers flexibility, because project components can be added or modified as needed to ensure a complete overview of project progress and requirements. This helps minimize risks and ensures targeted project control.

Next to the project WBS, a product WBS (Figure 7) was made. This makes it clear on what is included in the actual end product. It is divided into structure, hardware, electronics and application. These are the main pieces out of which the product exists. For example, the hardware discusses all parts that have to be placed in the bin that are not related to electronics: mixing part, cutting part,layer sheets, lock.

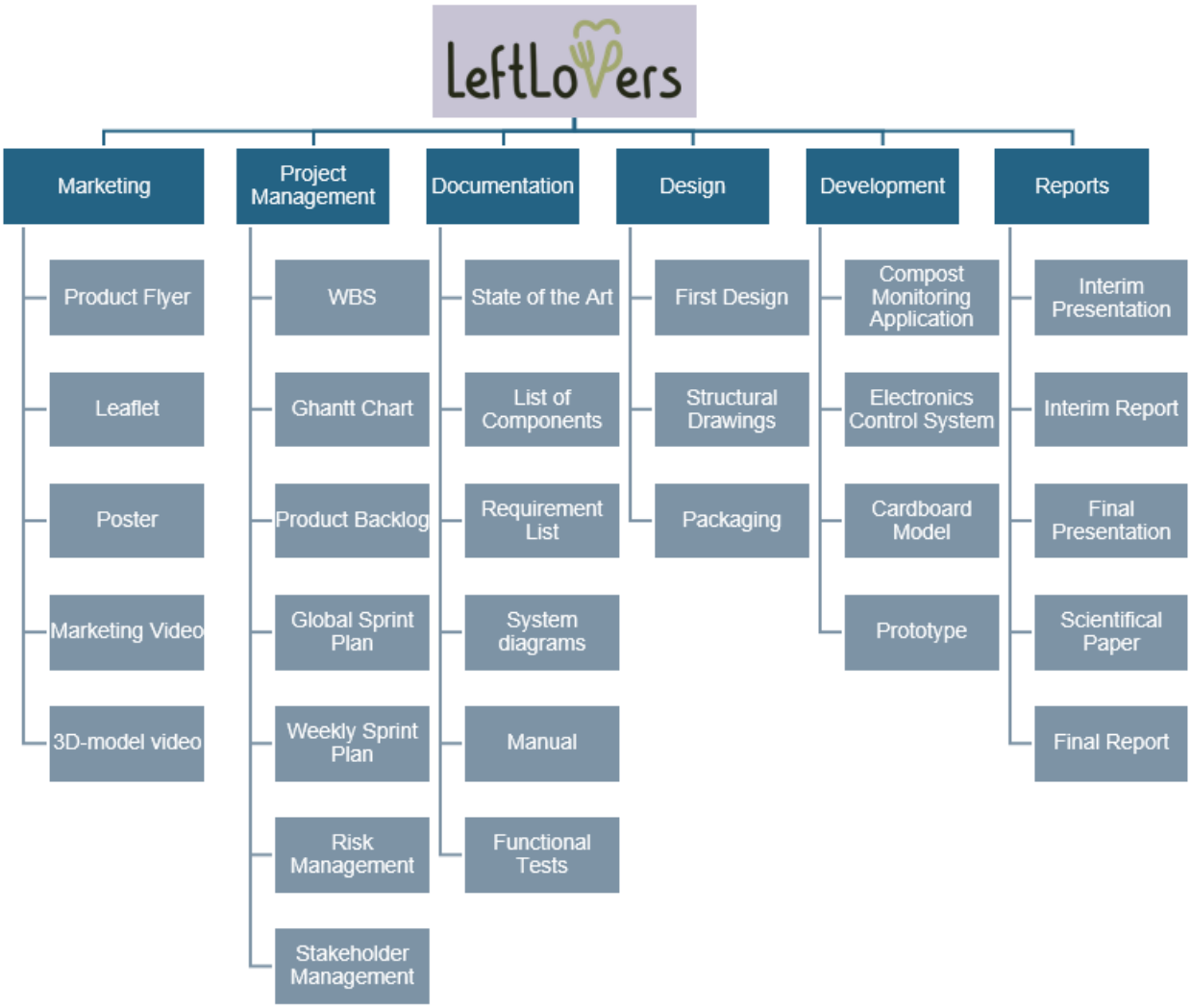


Figure 6: Work Breakdown Structure - LeftLovers (project)

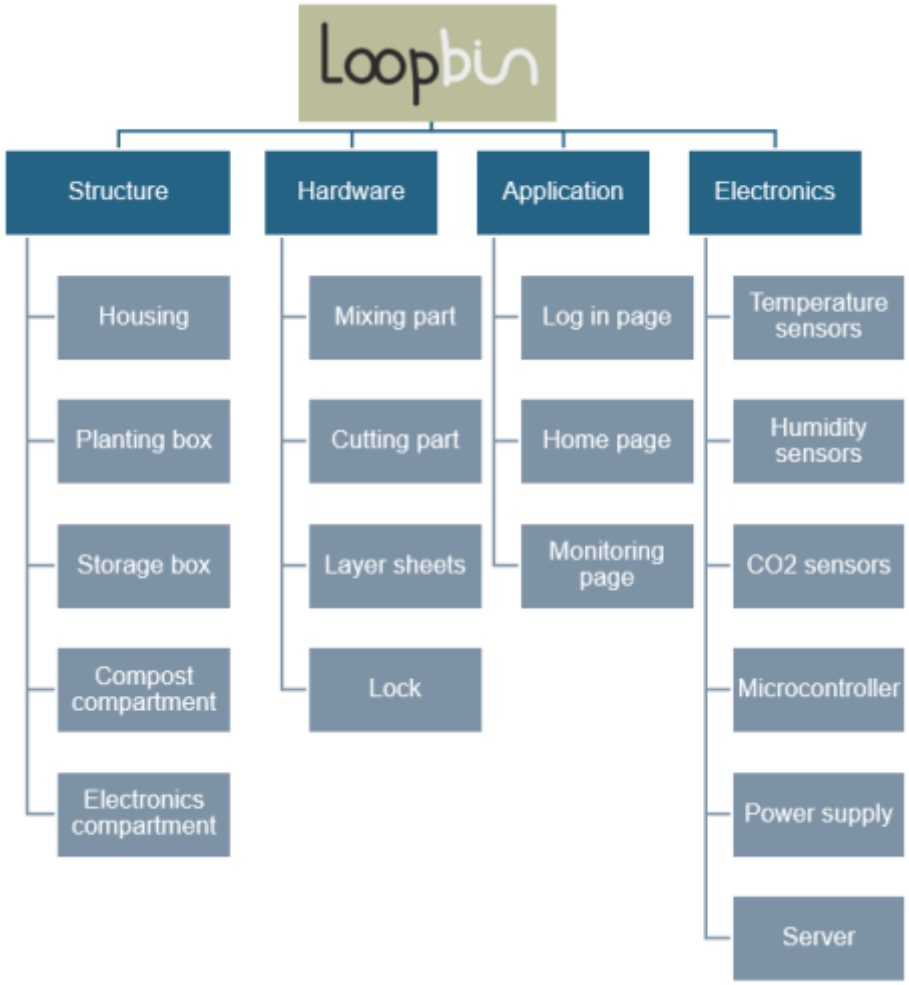


Figure 7: Work Breakdown Structure - LoopBin (product)

3.2 Time

Table 3 shows the deadlines the team has set for the project.

Table 3: Key Milestones of the Project

Date	Description
2025-03-01	top-3 preferred project proposals
2025-03-12	Black-Box
2025-03-12	System Diagrams
2025-03-12	Structural Drafts
2025-03-15	Project Backlog
2025-03-15	Global Sprint Plan
2025-03-15	Initial Sprint Plan
2025-03-15	Gantt Chart
2025-03-19	List of Components and Materials
2025-03-26	System Schematics
2025-03-26	Structural Drawings
2025-03-26	cardboard scale model
2025-04-06	Interim Report
2025-04-06	Interim Presentation

Date	Description
2025-04-10	Present Interim Presentation
2025-04-15	3D model video
2025-04-29	Final List of Materials
2025-05-02	Refined Interim Report
2025-05-14	Packaging Solution
2025-05-28	Functional Tests
2025-06-15	Final Report
2025-06-15	Final Presentation
2025-06-15	Video
2025-06-15	Paper
2025-06-15	Poster
2025-06-15	Manual
2025-06-18	Final Presentation
2025-06-25	Suggested corrections
2025-06-25	MS Teams delivery
2025-06-25	Printed Handout

3.3 Cost

The planned and effective costs of the five-month Leftlovers project in 2025 are presented in this section.

As being directly connected to resource and material distribution, effective cost management is crucial. It gives the project team an insight into anticipated costs and enables the identification of areas where costs can be reduced without affecting quality.

Table 4 illustrates the planned costs of labor, product components, prototyping, and marketing activities. The cost of labor calculation is six engineers, five months at the minimum month's wage. As outlined in Section 1.6 Requirements, the prototype cost is 100 €. Product costs, excluding manufacturing costs, are calculated in terms of the mechanical, electrical, and material components required. The marketing budget for a monthly period is also included in the plan because the end product will be introduced into the market.

Table 4: Planned costs

Type	Amount	Cost in 5 months
Salary in 2025	1051.00 € / engineer	31530.00 €
Prototype budget	100.00 €	100.00 €
Product	220.93 € / product	-
Marketing / Adverstiment (Social Media Management)	250.00 € / month	1250.00 €
Total project costs		32880.00 € + product costs

The effective costs, which are the cost-optimal version of the project, are also illustrated in Table 5. Since the students work for free, labour costs are zero. Using in-house flyers and posters rather than externally hired promotion materials saves significantly on promotional costs. The prototype cost is 7.03 € over the planned cost. However, through the exploitation of a university's facilities to obtain construction materials like PVC boards and electrical products, this excess can be covered. Besides, composting tests are conducted using household food waste, so they bring a little costs to the project as well. The test devices and equipments are borrowed from the university.

Table 5: Effective costs

Type	Amount
Prototype budget	107.03 €
Product	220.93 € / product
Total project costs	110.03 € + product costs

3.4 Quality

To make sure that a quality product is delivered, quality metrics should be defined so that the developed product meets the required standards. This way stakeholders will be satisfied and more eager to invest in, work together or be associated with the project.

Compost bin quality

The structure of the compost bin should be able to withstand 500N (50kg) on top of the bin. From the sides, it should withstand an impact of 200N (kicking, pushing…). Inside the bin, each layer should be able to carry 10 kg of food waste.

The cutting and mechanical mixing part should withstand forces up until 200N. The handle should withstand forces up until 200N

Application quality

The quality of the application can be divided into different parts:

- Functionality: the application should perform it’s intended functions without errors, all features

and functionalities should be implemented and operational.
- Performance: the application should be quickly in responding to user inputs and do tasks in an efficient manner, it should use system resources efficiently.
- Security: user data should be protected from unauthorized access, breaches and leaks.
- The application should comply with relevant security standards and regulations.
- Accuracy: sensor data should have an error margin of no more than X%?

Electronics quality

The different electronic components should have the following requirements in order to be considered suitable for the developed compost bin. In this case, the following components are needed and should have the following requirements:

Temperature sensors:

- Accuracy: 1 integer
- Voltage: 5 V
- Electric Current (I): 100 mA
- Electric Power (P): 0.500 W
- Measure Cycle : every 5 minutes

CO2 sensors

- Accuracy: 1 integer
- Voltage: 3-30V, can work with 5 V
- Electric Current (I): 137 mA
- Electric Power (P): 0.685 W
- Measure cycle : every 5 minutes

Fan

- Voltage: 5 V
- Electric Current (I): 120 mA
- Electric Power (P): 0.600 W

Microcontroller and WIFI chip

- Voltage: 3-30V, can work with 5 V
- Electric Current (I): 300 mA
- Electric Power (P): 1.5 W
- Measure cycle : every 5 minutes

Battery cell

- Voltage: 5 V
- Electric Current (I): 300 mA
- Electric Power (P): 1.5 W

Server

- Security: https certificate
- Storage amount: 19 GB (prototype)

3.5 People

Team members/students

The team members are responsible for developing the product and making the project work. They do this by meeting up every week, dividing tasks and documenting everything they do. Team members should take up responsibilities to finish tasks on time, be flexible and work together with the team. To have an idea about the work efficiency, it is important that everyone monitors their work so the team can look back on it.

Teachers from ISEP

The teachers from ISEP provide the students with knowledge and advice. The teachers also help to break the whole project down into smaller parts which make it more manageable for the team. The key role of the teachers is to give feedback so the team can improve their work and provide the best possible product.

Suppliers

The suppliers role is to provide LeftLovers with a high quality product (outsourcing). Without a good supplier, there won’t be a high quality product to sell. To satisfy the customer, it is important to deliver a quality product that gets delivered on time.

Government

The government makes rules and decides about taxes. This is why it is important to keep it in mind.

Competitors

As there are already different products on the market. The competitors will have an influence on the price of the product.

Customers

Customers decide if this product is a success. Without customers the product won’t be sold and will not be viable.

Charities

There are a lot of charities that focus on reducing foodwaste and using it a proper way. Working together with these charities can help to grow the project and the reputation of the brand.

3.6 Communications

To keep everyone included and informed about the project, the team made a Whatsapp chatgroup with all team members. This makes it easy to communicate in an informal way and to share ideas and designs if some feedback is needed when not working together. Also, the Teams channel is used to store all documents in an organized way so everyone can find everything if needed.

In the project meetings with the teachers on Thursday, the team and the teachers can share ideas, doubts and the progress of the project. The team prepares this meeting by defining the agenda and

discussing what they want to ask and present. After every project meeting, the team looks back on the past week and the project meeting to define the sprint for the next week. This way, the team divides the work in a fair way and everyone has the opportunity to share their ideas and thoughts. Before starting the new sprint, the team discusses and documents what went good or bad and what they need to start, stop or keeping doing in a retrospective.

The sprint is documented in the JIRA platform where all team members can update their tasks when finished or in progress. This keeps the sprint clear for everyone. Next to that, there is also in person communication on the campus of ISEP for sharing ideas and knowledge.

To keep a good contact with the suppliers, it is important to keep eachother informed. That’s why regular meetings seem useful. Every 1 or 2 months a meeting will be planned. This way the supplier and Leftlovers can gather all the information and questions they have and discuss everything together instead of mailing multiple times during the week or month. This safes everyone from being busy with a lot of small things.

Customers will have the opportunity to subscribe to a free newsletter that will update them about new goals of the company and provide them with some extra tips for composting. Also, the application will include an easy connection to the customer help desk to make sure all customers can reach the company in an easy way. Next to acces to a helpdesk, the application will also contain tips and tricks to help them with their compostr bin.

To keep charities involved, the company will also have meetings with them and discuss topics that are relevant for the charities. This keeps the charities included to keep a quality partnership going.

Table 6 gives a summary of the communcation strategy:

Table 6: Soil Sensor Comparison

Contact	**Channel**	**Frequency**	**Formal/Informal**
Team	Jira	weekly	Formal
	Whatsapp	when needed	Informal
	Face to Face	daily	Informal
Teachers	Teams	when needed	Formal
	Thursday meetings	weekly	Formal
Suppliers	Meeting	monthly	Formal
	Email	When Needed (emergency)	Formal
Customers	Newsletter	monthly	Formal
	Helpdesk	when needed	Formal
	tips and tricks in application	always available	Informal
Charities	meeting	monthly	Formal

3.7 Risk

By making a risk management analysis, different risks are analyzed to make sure to know what the impact is in a positive or negative way. By using a risk management strategy, companies can prepare for situations and react quickly to them.

To analyze the risks the following steps were followed:

- Risk identification: to identify the risks and their sources
- Risk evaluation: evaluate the probability and the impact of the risk
- Risk handling: planning risk responses
- Risk controlling: monitor and control risks

The different risks are divided into project risks and product risks in table 7. The probability and impact of the risks were given a score from 1 to 5 based on Figure 8 and put in a timeframe:

- Short term: now - 1 month
- Mid-term: 2 - 6 months
- Long term: more than 6 months

Next to that, an explanation was given on how to handle and monitor the different risks.

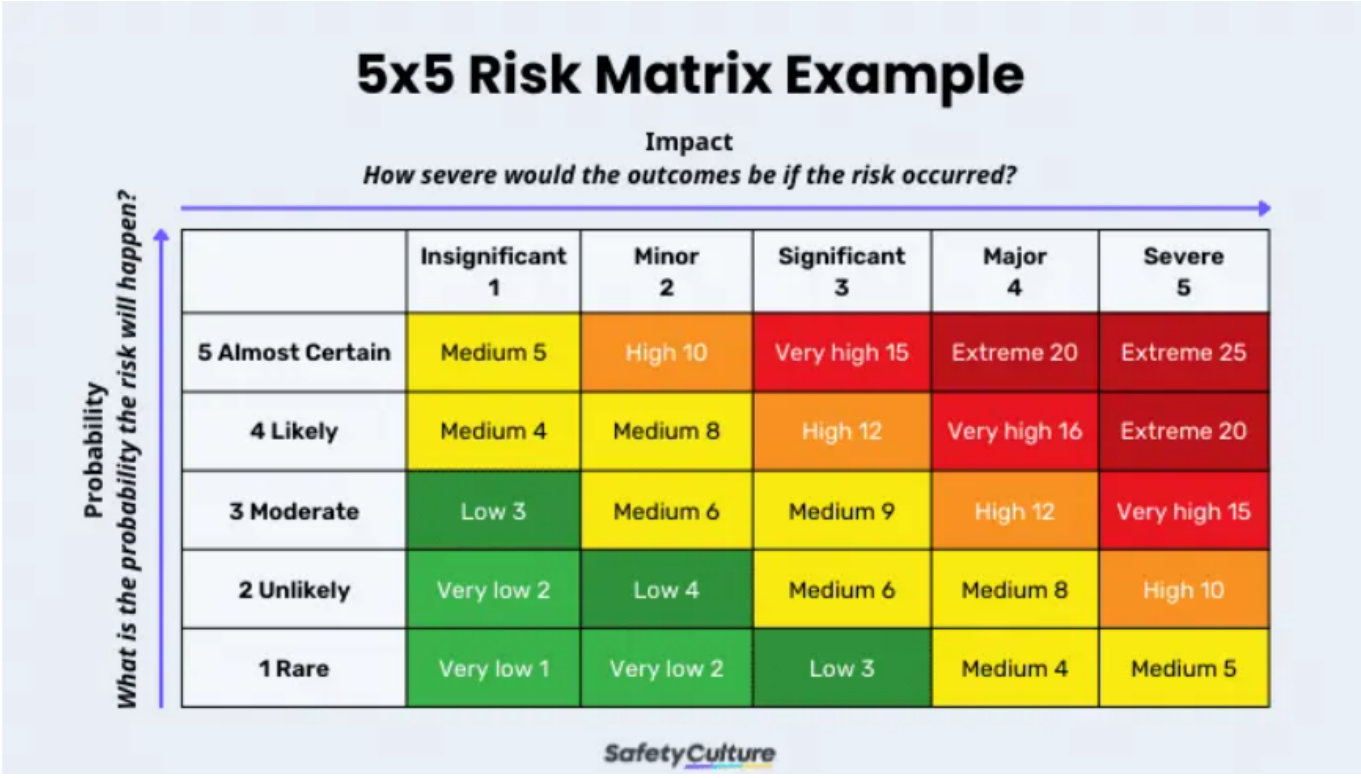


Figure 8: 5×5 Risk Matrix

Table 7: Risk Management

Risk	Probability	Impact	Risk Level	Risk Response	Timeframe	Handling	Monitoring

Risk	Probability	Impact	Risk Level	Risk Response	Timeframe	Handling	Monitoring
Project							
Demotivated team members	1	4	Medium	Reduce	Short term	Listen to each other, Motivate each other, Keep everyone included	Have meetings where the team shares how they feel
Lack of money to scale the project	2	5	High	Avoid	Mid term	Look for investors	Calculating how much money is needed to scale
Problems with supplier	2	4	High	Avoid	Long term	Work with multiple suppliers so the deliveries do not depend on one supplier	Keep good contacts with the suppliers
Product							
Customer gets injured by using the compost bin	1	4	Medium	Reduce	Long term	Make a safe design, Inform people on how to use the product in a safe way, Warn them for dangerous parts	Keep track of accidents that happen
Broken product	1	3	Low	Accept	Long term	Providing a service that can repair or replace the product	Have a good customer service
Low quality compost	1	4	Medium	Reduce	Mid term	Improve the mix if needed	Keep track of the compost quality
Adding wrong leftovers to the compost bin	1	4	Medium	Reduce	Long term	Having a good explanation for what can be added and cannot be added to the bin.	Monitoring the compost to be able to improve it if the quality is low.
Bad smell	1	3	Low	Accept	Long term	A carbon filter can improve the smell, The application gives instructions on how to avoid a bad smell	Use the sensors to monitor the smell

Risks that are defined as high should be avoided at any cost. In this case these risks are Lack of money for the project and having problems with the supplier. These are difficult risks to control as there are stakeholders involved. It will be important to have a good stakeholder management strategy to make sure to keep these stakeholders involved.

3.8 Procurement

The goal of Procurement Management is to identify the procurement requirements of the product and to know how these requirements will be managed from developing to delivering the product. In this chapter the procurements for the prototype and the actual product are discussed.

Prototype

To build the prototype there is a budget of €100 provided by the university. Earlier a material list was made with specific components, products and the suppliers to buy from. Based on this list, components and materials that were available from the university were provided by the university. The other parts were build by the team in the workshop, 3D printed or ordered from local suppliers (Leroy Merlin, Mouser).

The team chose for a “make” approach, this gives the team control and flexibility while developing the prototype. To make sure that the different components can be tested, the electronics and mixing parts should be assembled first. The structure itself is less urgent. No formal contracts were made. Agreements were informal and purchases were made directly after permission because of the small scale.

Product

For the actual product, the manufacturing will be outsourced to another company to keep the costs lower and to streamline the production process. This will keep the process more easy for the project team. By outsourcing the manufacturing, the team choses for a “buy” approach. This allows the team to focus on design and quality control.

However, the project team will decide how and with which components the product will be manufactured to make sure to have a high-quality product. They will provide the supplier with all information needed. To make sure all parties do what is expected of them, formal contracts will be established.

The electronic components will be provided by local suppliers such as Mauser, or by suppliers with a local department (Farnell and DigiKey). The other parts of the compost bin will be provided by different suppliers (Acerinox, Schrauben expert, Altamira, Motedis, Norelem, Madler, Verbas b.v.)

3.9 Stakeholders Management

An important task for the project is the Stakeholder Management. By analyzing all possible stakeholders and keeping them involved, problems can be avoided when making decisions or changes in the product or company. That is why in this chapter, the stakeholders for the LeftLovers Loopbin are defined and analyzed.

In table 8 all the stakeholders are listed and given a score from 1 to 5 in terms of power and support. This gives an idea about how important the stakeholders are to make the project a success.

Table 8: Overview of Stakeholders LeftLovers

Stakeholder	**Function**	**Power**	**Support**
Teachers	Guiding the team, providing advice	4	4
ISEP	Providing budget, knowledge, and materials for the prototype	5	4
Suppliers	Delivering the product	4	2
Government	Defining regulations about food waste, motivate people to sort their waste	3	2
Competitors	Compete, push prices, buying the product	4	5
Customers	Sharing their experience, promoting the product	5	4
Charities	Promoting the product	5	5

ISEP and the Teachers both have a high power and support in the project. These stakeholders are important for starting up the project (Influence) and are involved as a succeeding project can give the university a positive image (support). Also, the Customers and Charities are given a high score in terms of power as these stakeholders can provide new customers to the company. The Governement has a lower power and support as they can change regulations to support (food)waste sorting what can result in more customers. Suppliers have a high power score but a low support score. This because they provide the product to be sold (power) but are not involved in the story LeftLovers wants to bring (support). To improve the Suppliers interest, it is important to convince them of the importance of LeftLovers.

When translating the table into a chart (based on Figure 9 from **[Pedro Serrador, 2025]**). An overview is shown that easily summarizes the position of each stakeholder (Figure 10):

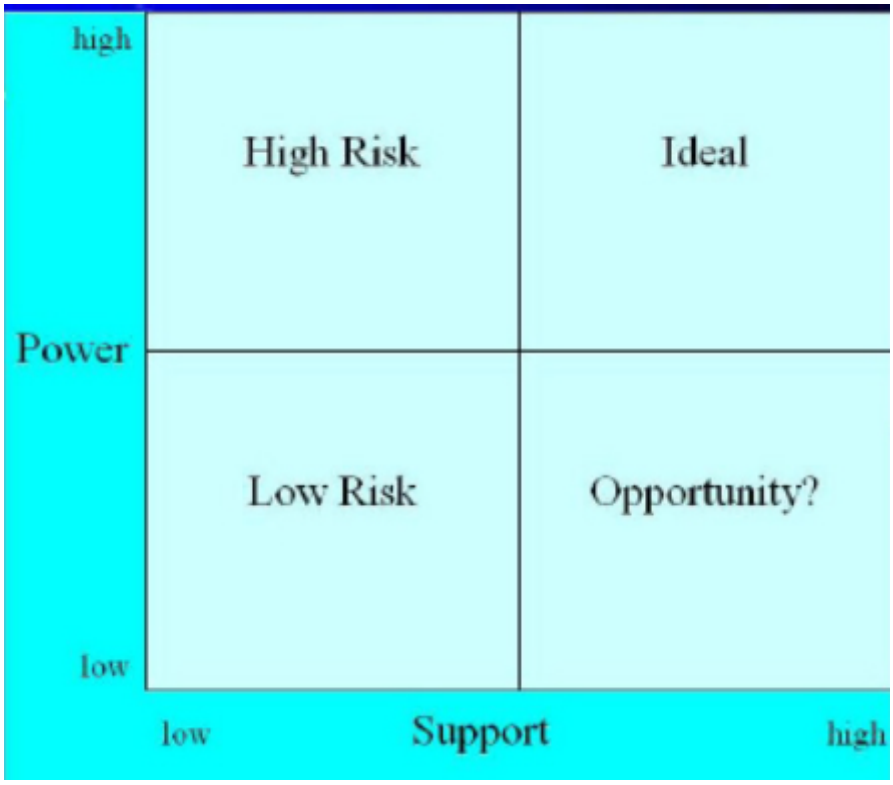


Figure 9: Example of Stakeholder Chart

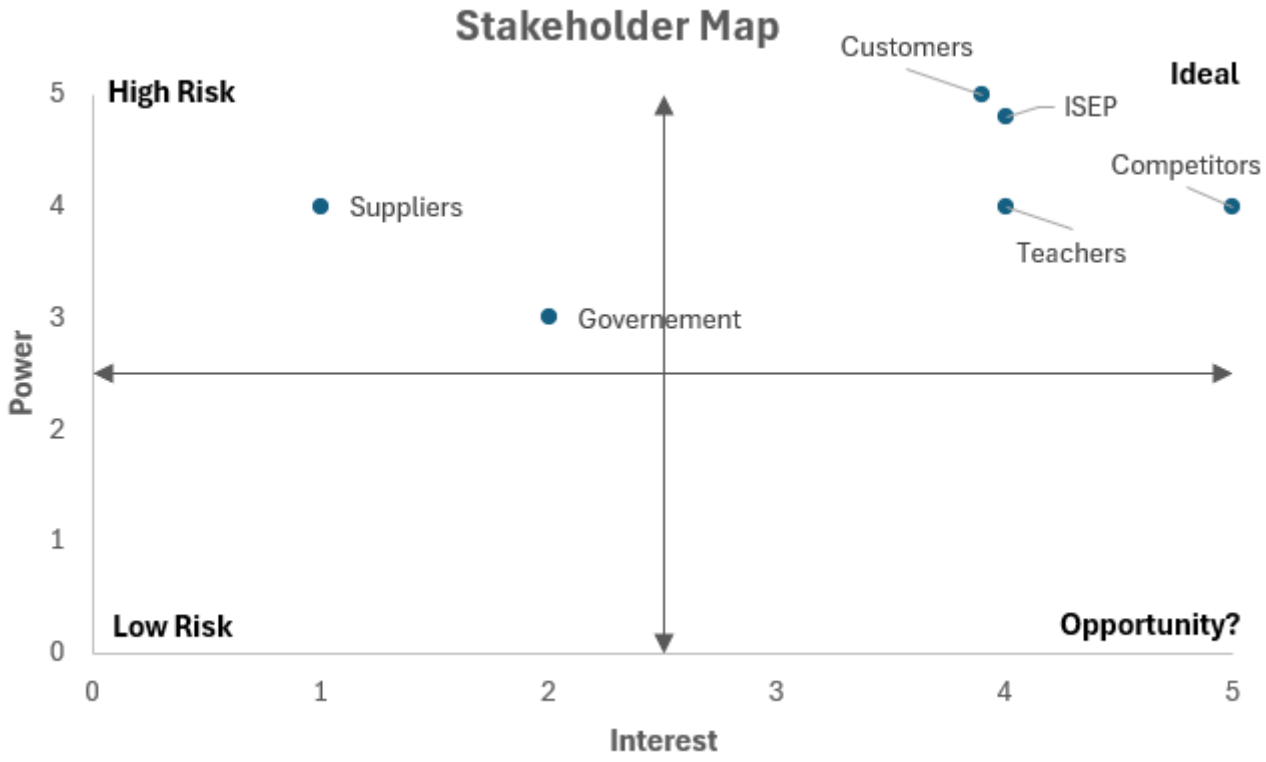


Figure 10: Stakeholder Map Leftlovers

In general, it is important to keep al stakeholders in mind to maintain and improve the relationships. This can be done by organizing meetings with suppliers, government and charities, giving credits to teachers and ISEP, providing a good price-quality product to compete with the market and being accessible to customers.

3.10 Project Plan

The ideal sprint duration is one week, starting on Thursday and ending on Wednesday. Thursday was chosen as the starting day because it aligns with the project meetings. Each sprint begins with a project meeting, where the previous week's sprint is reflected and the plan for the upcoming week is made. Tabel 1 shows the Global Sprint Plan 9.

Table 9: Global Sprint Plan

Sprint	Start	Finish
0	27/02/2025	05/03/2025
1	06/03/2025	12/03/2025
2	13/03/2025	19/03/2025
3	20/03/2025	26/03/2025
4	27/03/2025	02/04/2025
5	03/04/2025	09/04/2025
6	10/04/2025	16/04/2025
7	17/04/2025	30/04/2025
8	30/04/2025	15/05/2025
9	15/05/2025	21/05/2025
10	22/05/2025	28/05/2025
11	29/05/2025	04/06/2025
12	05/06/2025	11/06/2025
13	12/06/2025	18/06/2025

The Project Backlog Table 10 lists all relevant tasks and deliverables of the project. Items are prioritized, with higher-priority entries at the top and lower-priority ones further down.

Table 10: Project Backlog

PBI	Title	Status
A	Define project proposal	Done
B	System Diagrams & Structural Drafts	Done
C	Build WBS	Done
D	Define Project Backlog	Done
E	Define Global Sprint Plan	Done
F	Define Initial Sprint Plan	Done
G	Release Gantt Chart	Done
H	Upload List of Components and Materials	Done
I	Risk Management	Done
J	Stakeholder Management	Done
K	Upload System Schematics & Structural Drawings	Done
L	Do the cardboard scale model	Done
M	Upload Interim Report and Presentation	Done
N	Interim Presentation, Discussion and Feedback	Done

PBI	Title	Status
O	Upload 3D model video	Done
P	Upload final List of Materials	Done
Q	Upload refined Interim Report	Done
R	Upload packaging solution	Done
S	Upload results Functional Test	In progress
T	Upload Final Report, Presentation, Video, Paper, Poster and Manual	In progress
U	Final Presentation, Individual Discussion and Assessment	In progress
V	Update the wiki with all suggested corrections	To do
W	Place a folder with the refined deliverables	To do
X	Hand in a printed copy of the poster, brochure and leaflet	In progress
Y	Hand in prototype and user manual	In progress

The Sprint Plan Table 11 outlines the planning for each sprint at its start, as determined during the Sprint Planning session.

Table 11: Sprint Plan

Sprint	Task	Duration (d)	Responsible	Involved
0	A	5	all	all
1	B	5	NA, CD, SL	all
2	C, D, E, F, G, H	5	all	all
3	H, K, L	5	all	all
4	H, K, M	5	all	all
5	M, N	5	all	all
6	O, P, Q	5	all	all
7	O, P, Q, I, J	5	all	all
8	X, R, S, I	10	all	all
9	R, S, X, Y	5	all	all
10	R, S, X, Y	5	all	all
11	S, X, Y	5	all	all
12	S, Y	5	all	all
13	S,Y, X	5	all	all

The Progress Register Table 12 records the review of each sprint at its conclusion, including updates to the status of each item.

Table 12: Project Progress Register

Sprint	PBI	Responsible	Involved	Status
0	A	all	all	Done
1	B	NA,CD,SL	all	Done
2	C, D, E, F, G, H	all	all	Done
3	H,K,L	all	all	Done

Sprint	PBI	Responsible	Involved	Status
4	H, K, M	all	all	Done
5	M, N	all	all	Done
6	O, P, Q	all	all	Done
7	O, P, Q, I, J	all	all	Done
8	X, R, S, I	all	all	Done
9	R, S, X, Y	all	all	Done
10	R, S, X, Y	all	all	Done
11	R, S, X, Y	all	all	Done
12	R, S, Y	all	all	Done
13	S,Y, X	all	all	Done

The release Gantt chart visualizes the timeline for key project deliverables, including their start and completion dates, as illustrated in Figure 11.

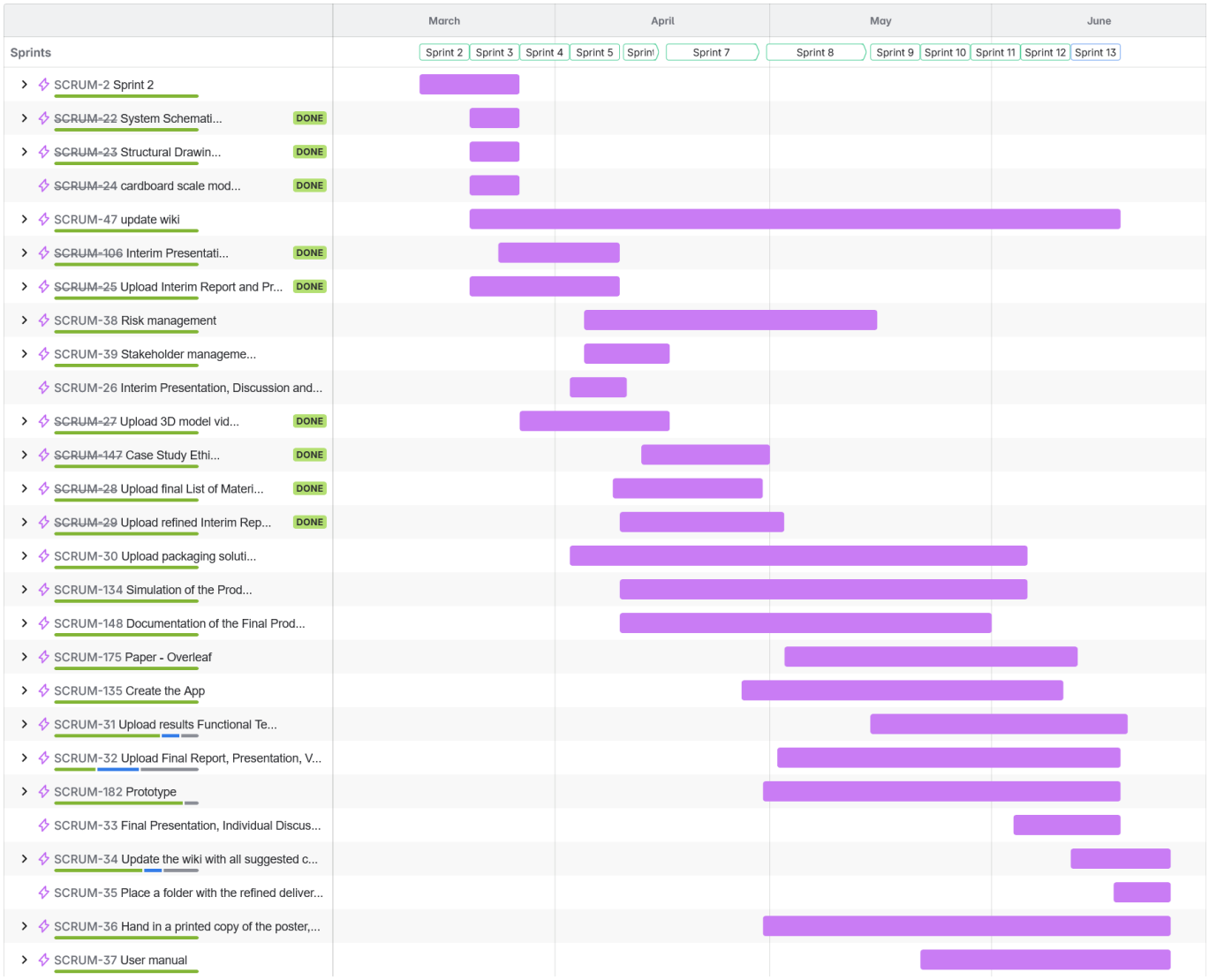


Figure 11: Release Gantt chart

3.11 Sprint Outcomes

This chapter discusses the different sprints and their outcomes.

3.11.1 Sprint 1 6/03/2025 – 12/03/2025

In the first sprint (Table 13), the team defined the project with the help of the Design Thinking workshop. After that, the team started researching existing products to write the state of the art and created the first structural drafts and first BlackBox.

Table 13: Sprint 1 Outcome

Tasks Sprint 1	Planned Duration (h)	Real Duration (h)	Involved Members	Status
Define Project	12	14	Everyone	Done
System Diagrams	4	5	N, S	Done
First Structural Drafts	2	3	C	Done
Research	4	5	Everyone	Done

After the Design Thinking workshop, the team had the idea to make a compost bin and an application that combines different topics to prevent foodwaste in general. After discussing this, the team decided that the concept of a bin and an application with different functions and partnerships would be too complex to develop. That’s why the focus was shifted to developing a bin with an application that focuses on monitoring the composting process.

3.11.2 Sprint 2 13/03/2025 – 19/03/2025

In the second sprint (Table 14), the team defined the Project Backlog, Global Sprint Plan, the first initial sprint plan and the WBS. These all help to get a better overview of the project and to break it down in main tasks. Also, the team started working on the material list and drafting the first structural drawings. After feedback from the teachers, the Black Box model was improved.

Table 14: Sprint 2 Outcome

Tasks Sprint 2	Planned Duration (h)	Real Duration (h)	Involved Members	Status
Project Backlog	1	1	C, Q	Done
Global Sprint Plan	0.5	0.5	C, Q	Done
First Initial Sprint	0.5	0.5	C, Q	Done
Gantt Chart	1	1	E	Done
State of the Art	2	3	Everyone	Done
First Component List	2	3	S, N	Done
First Material List	1	3	E, C, L, Q	Done

Tasks Sprint 2	Planned Duration (h)	Real Duration (h)	Involved Members	Status
Flyer and Logo	2	3	C, L	Done
Marketing Plan	2	2	Everyone	Done

The teachers told us to keep attention to write in a scientific way without using “we” and by staying objective. Also, the material list is more an analyzation and not a final list. The team should try to focus on completing tasks from the beginning in a proper way so they can start working on next tasks.

3.11.3 Sprint 3 20/03/2025 – 26/03/2025

In the third sprint (Table 15), the team managed to make a first 3D design and cardboard model of the product. Also, the first electronical scheme was created. Next to that, there was a first presentation of the business model and flyer. The final material list wasn’t properly finished due to still being busy with the design of the product.

Table 15: Sprint 3 Outcome

Tasks Sprint 3	Planned Duration (h)	Real Duration (h)	Involved Members	Status
First 3D Model	5	7	C, N, Q	Done
Cardboard Model	2	2	E, L, Q	Done
System Schematics	4	4	S, N	Done
Structural Drawings	4	4	C	Not Done
Material List	5	5	N, S	Not Done

After evaluating the third sprint. The team concluded that tasks should be more divided so everyone knows what is expected and is able to work on different tasks instead of working all together on the same task. Also, for every chapter one teammember is responsible but will not have to write the whole chapter alone.

3.11.4 Sprint 4 27/03/2025 – 02/04/2025

Starting from the 4th sprint (Table 16), all tasks are properly divided and assigned to the team members with mentioning the estimated time needed. This sprint the team focuses on improving the different chapters of the wiki as the deadline for the interim report is coming closer. some tasks are

not fulfilled completely as these are tasks that always will be adapted such as the Bibliography and the Projectmanagement.

Table 16: Sprint 4 Outcome

Tasks Sprint 4	Planned Duration (h)	Real Duration (h)	Involved Members	Status
Chapter 1	1	2	N, Q	Done
Chapter 2	5	5	E, S	In Progress
Chapter 3	2	2	E, S	In Progress
Chapter 4	4	4	L	Done
Chapter 5	3	3	N	Done
Chapter 6	7	6	Q	Done
Chapter 7	4	4	S, C, E	Done
Bibliography	2	2	S	In Progress
Project Management	2	2	E	In Progress
3D Model	7	22	C, Q	Done
Component List	5	7	S, N	Done

After finishing Sprint 4, the time logged in the child issues isn’t shown in the sprint report on the confluence platform or the sprint burndown chart (Figure 12). To keep it more easy, the team will try to keep the tasks simple without child issues.

The peak in the curve at the beginning of the sprint shows that more work was added to the sprint after starting it. In the future, the team should first define all the tasks and estimate the needed time before starting the sprint. Also, the curve only goes down when tasks are finished completely, the team may log time but progress will only be shown when the tasks are changed to “done”. This explains why only at the end of the curve it goes down. The team logged time during the week but only registered the tasks as finished at the end of the sprint.

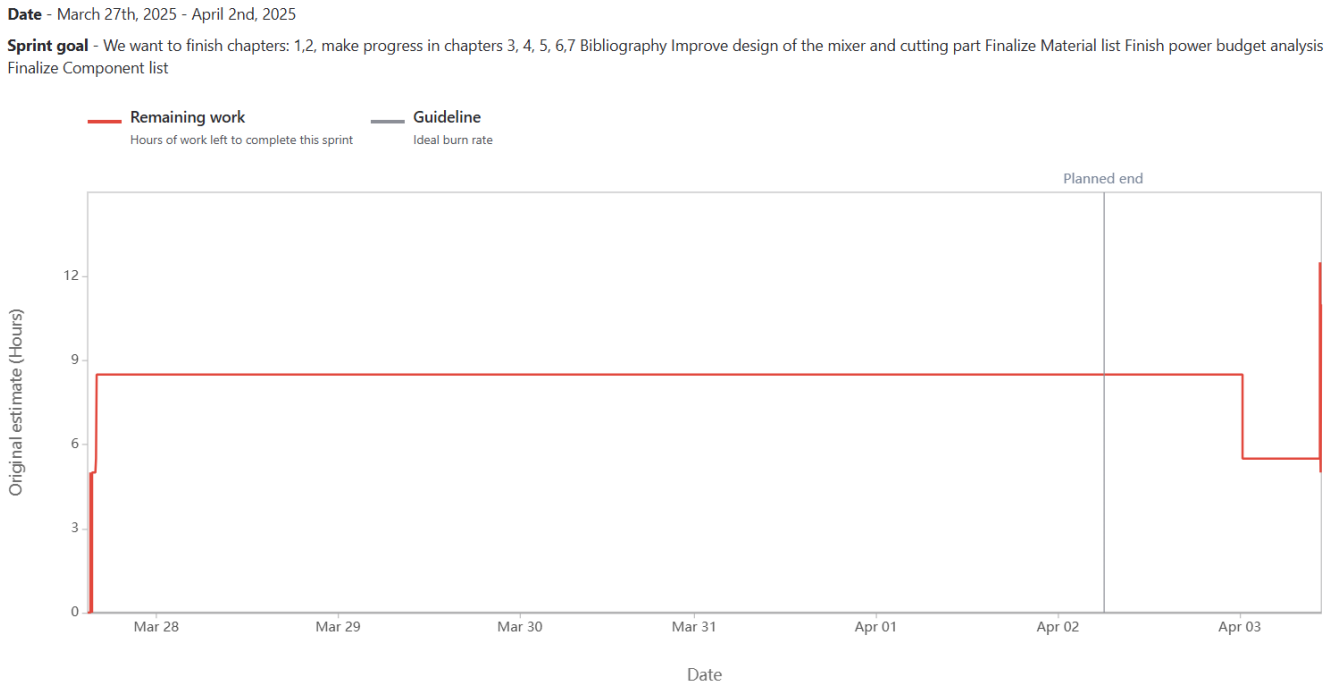


Figure 12: Burndown Chart Sprint 4

3.11.5 Sprint 5 03/04/2025 – 09/04/2025

The team focused on making the Interim Presentation and finalizing the Interim Report in the fifth sprint (Table 17) as the deadline for these deliverables was on 06/04. The team succeeded in completing the report and the presentation on time and got positive feedback from the teachers.

Table 17: Sprint 5 Outcome

Tasks Sprint 5	Planned Duration (h)	Real Duration (h)	Involved Members	Status
Introduction	2	2	Q	done
State of the Art	1	1.5	E	done
Product - prototype	1	1	S	done
Product - 3D model	5	20	C	done
Sustainability	3	2	N	done
Marketing	3	3	L	done
Ethics & Deontology	1	1	Q	done
Next steps	2	1	E	done
layout	2	2	C	done
upload presentation	1	1	S	done

The burndown chart of sprint 5 (Figure13) shows a steady working flow , almost all tasks were finished by the end of the sprint. The start of the chart still shows an increase in work as not all estimated time was logged before starting the sprint.

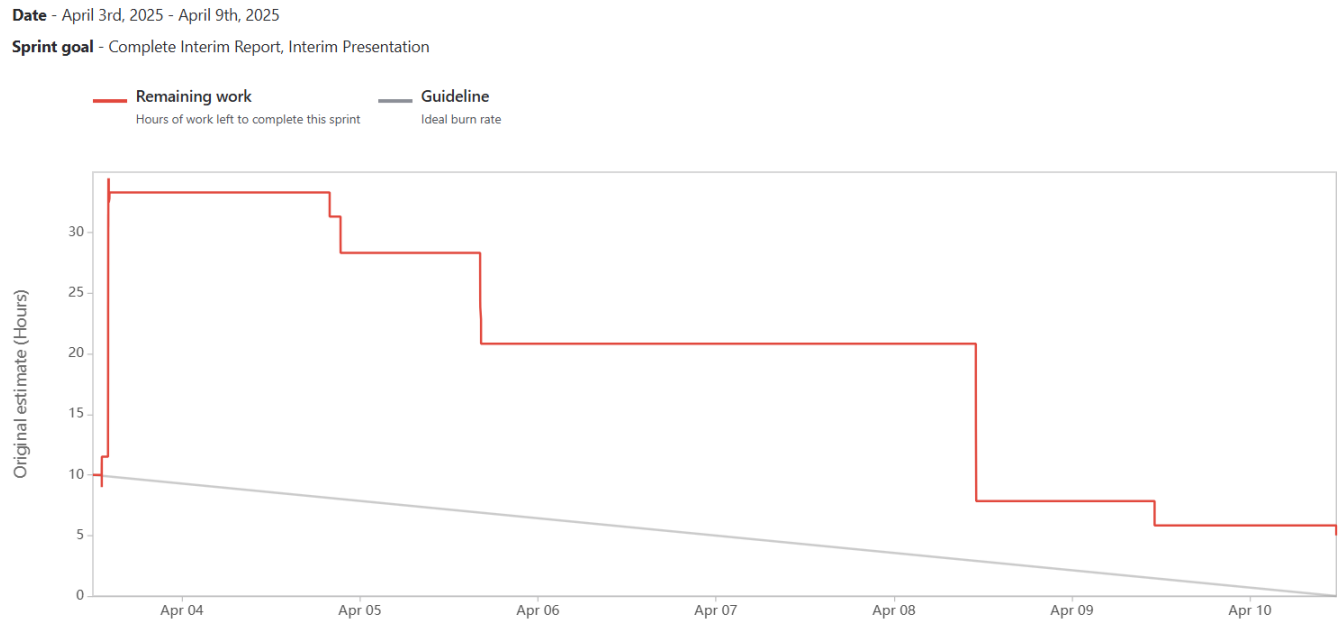


Figure 13: Burndown Chart Sprint 5

3.11.6 Sprint 6 10/04/2025 – 15/04/2025

Different tasks were worked on during sprint 6 (Table 18) . The team made a first version of the 3D model video, made calculations for the use of power and an estimateted cost price for the prototype and started looking for material for the testing procedure. Also, the team made a first Load and Stress analysis and and analysis of the UN Sustainable Development Goals.

Table 18: Sprint 6 Outcome

Tasks Sprint 6	Planned Duration (h)	Real Duration (h)	Involved Members	Status
upload 3D model video	0,25	0,25	C	done
develop 3D model	10	15	S,C	done
create 3D model video	3	16	C	done
power calculation	1,5	1,5	N	done
ideation of testing composting process	2,5	2,5	L	done
prepare load and stress analysis	2,5	2,5	S	done
calculate expected & selling price product	3	5	Q	done
calculate expected costs of prototype	0,5	2	Q	done
UN Sustainability Development Goals	2	2	L	done
Expected operation costs	1	1	N	done
Stake Holder management	2,5	3	E	done
material and component list	5	5	N	in progress
project management cost	2	2	Q	in progress
risk management	2,5	2	E	in progress

The burndown chart of sprint 6 (Figure 14) shows that no time was added during the sprint, this is an improvement from sprint 5. Also, most of the planned work was completed.

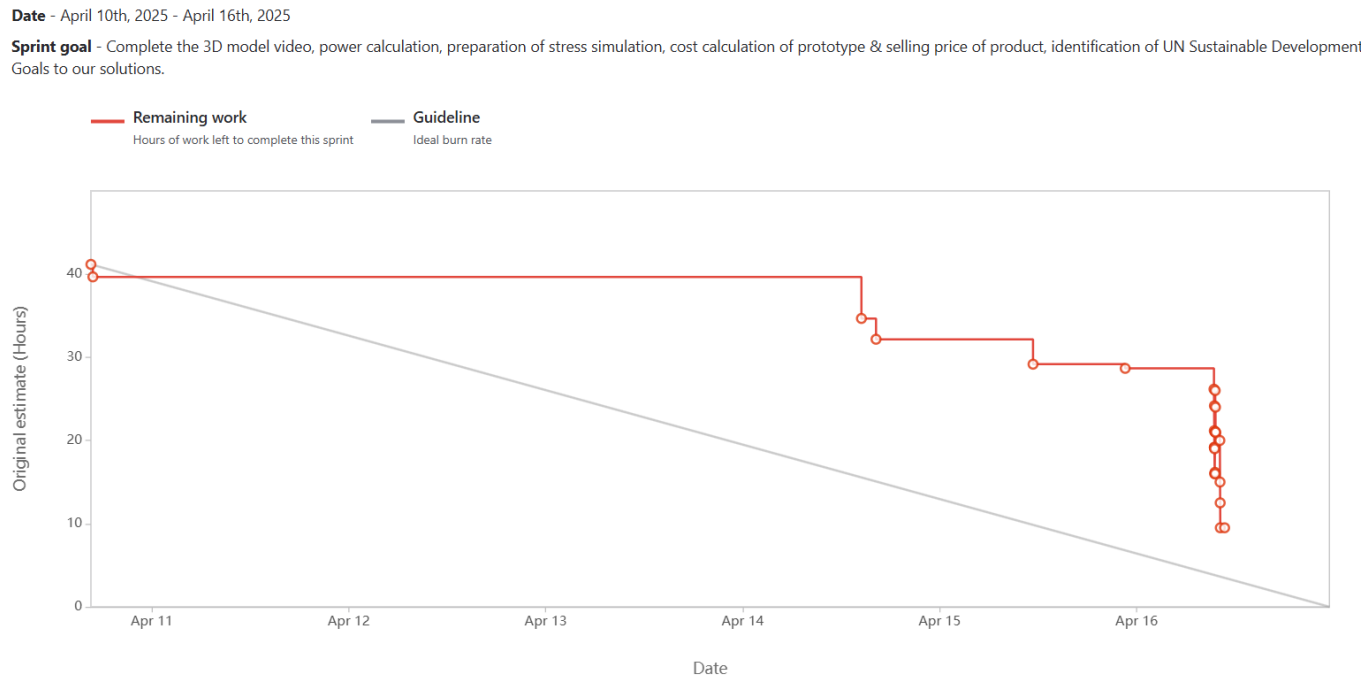


Figure 14: Burndown Chart Sprint 6

3.11.7 Sprint 7 16/04/2025 – 30/04/2025

During the Easter break, the team didn't work on the project, this explains why the sprint (Table 19) is longer than the other sprints but has around the same amount of work as the other sprints. This sprint, the team improved the report based on the feedback, improved the stress analysis and started the tests on the composting process.

Table 19: Sprint 7 Outcome

sprint 7	**planned duration (h)**	**real duration (h)**	**involved members**	**status**
Case study: Layout, Prevention, Consequences	3	3	Q	done
Case study: Overview, Causes, Lessons Learned	3	3	N	done
Final material list	5,5	6	N	done
Revise 3D model	6	8	C	done
Load and stress analysis	6	7	S	done
preparation of composting process	1	1	L	done
start composting process	1	1	L	done
Revise interim report	2,5	3	L	In progress
update weekly reports	1,5	1,5	E	done
calculate project management costs	2	2	Q	in progress
risk management	2,5	2	E	in progress

As there was a vacation in this sprint, no tasks were finished during these period. This explains why only in the end of the sprint, the graph (Figure 15) descends. Not all work was finished but progress was made. This is not shown in the graph as the graph only goes down if tasks are completely finished.

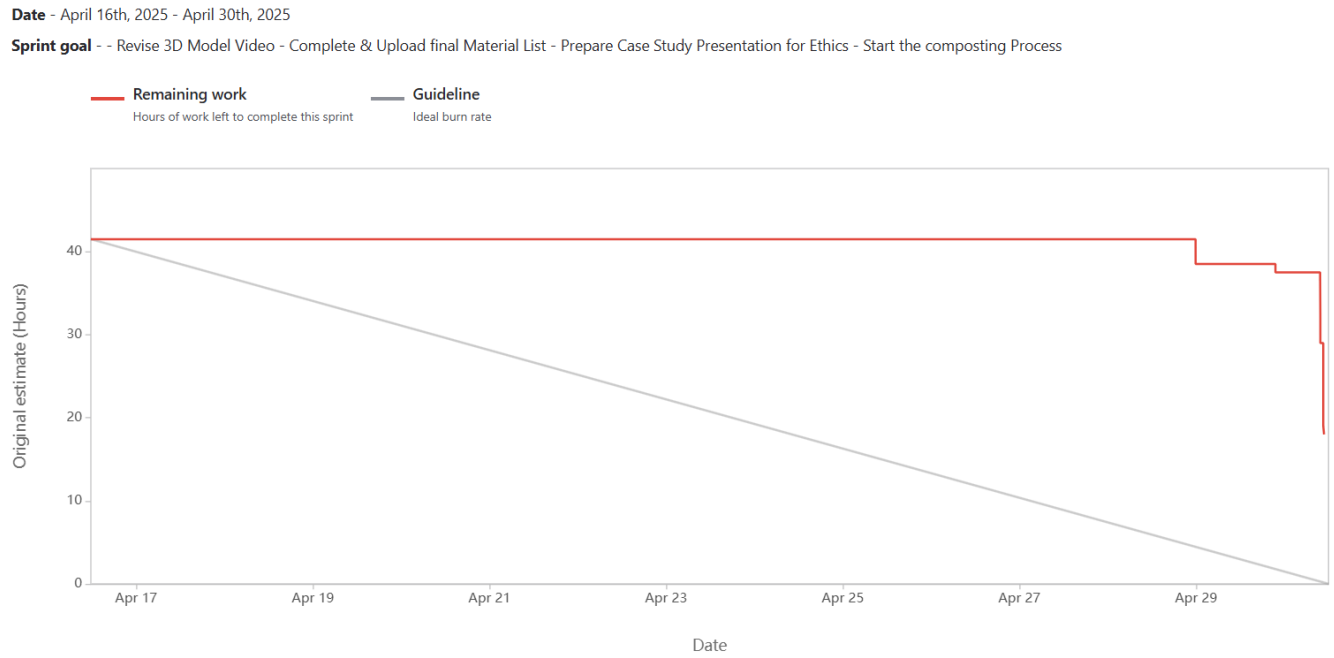


Figure 15: Burndown Chart Sprint 7

3.11.8 Sprint 8 01/05/2025 – 15/05/2025

This sprint (Table 20) is stretched over 2 weeks because the student week is in between the start and the end of the originally planned sprints. Different tasks were finished: the stress analysis, the wiki was improved and the team started to work on the paper. The packaging solution was finished but should be improved in the next sprint.

Table 20: Sprint 8 Outcome

sprint 8	**planned duration (h)**	**real duration (h)**	**involved members**	**status**
First version of Leaflet	3	3	L	Done
First version of Poster	3	2	C	Done
Paper - Abstract	2	1	E	Done
Lay out in Overleaf	4	0,5	S	Done
Preparation and implementation for Composting Process	1	1	L	Done
Revise interim report	2,5	2,5	L	Done
design packaging solution	4	4	N	Done

sprint 8	**planned duration (h)**	**real duration (h)**	**involved members**	**status**
complete load and stress analysis	6	6,5	S	Done
collect materials	2	1	Q	In progress
document composting process	1,5	1,5	L	In progress
Cost calculation project management	2	2	Q	Done
Risk management	2,5	3	E	Done
Project management wiki: People and Communication	3	1,75	E	Done
update wiki: selection of components	1	1	N	Done

The graph (Figure 16) doesn't go down during the student week because no work was finished during this period. Almost all planned work was finished during this sprint.

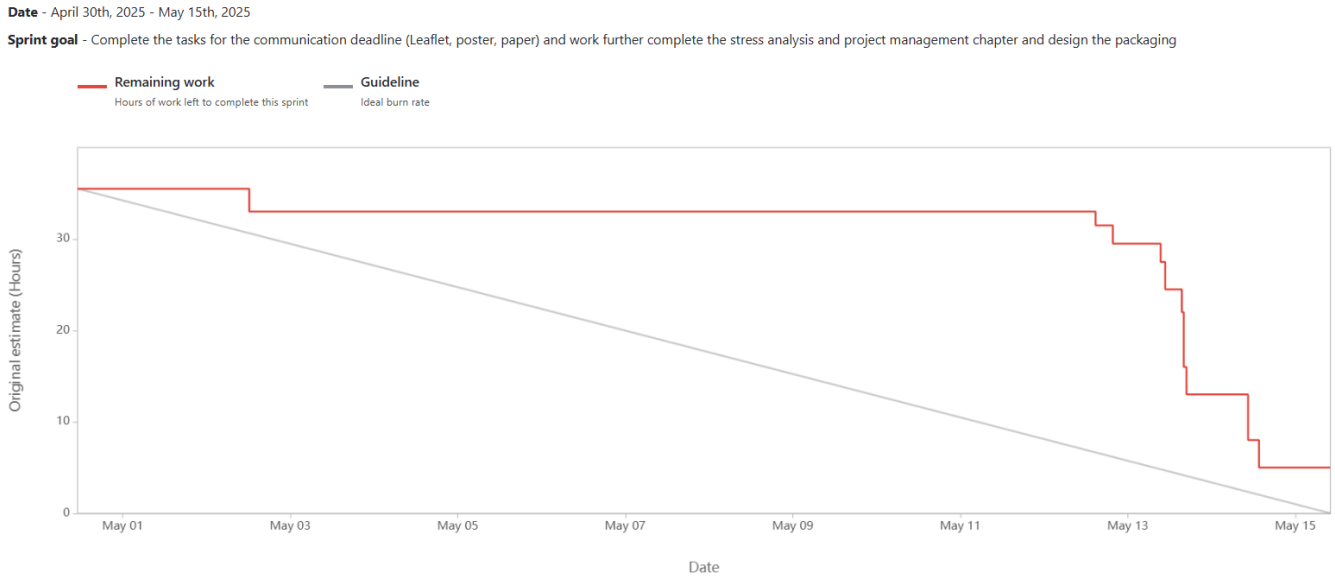


Figure 16: Burndown Chart Sprint 8

3.11.9 Sprint 9 16/05/2025 – 21/05/2025

A new packaging design was presented and approved by the teachers. The team started to build the prototype (programming and mixing parts) and finished chapters 1 and 2 of the paper. A summary of the sprint is shown in Table 21

Table 21: Sprint 9 Outcome

sprint 9	**planned duration (h)**	**real duration (h)**	**involved members**	**status**
document composting process	2	2	L	Done

sprint 9	**planned duration (h)**	**real duration (h)**	**involved members**	**status**
Preparation and implementation measurement for Composting Process	2	2	L	Done
coding first version of application	8	10	N	Done
manufacture 3D model METAL	10	7	S	In Progress
Complete Ethics chapter 5.3 and 6.6, improve 6.1	3	3	Q	Done
new version of packaging solution	1	1	L	Done
manufacture 3D printing parts	3	1	C	In Progress
Paper 1 Introduction	0,75	1	E	Done
Paper 1.1 Context	1,5	2	E	Done
Paper 2.1 Related Work	1,5	2	E	Done
Paper 3.2 Design	2	1	C	In Progress
Hand in first version of Paper	0,1	0,1	E	Done
collect materials	2	2	Q	Done
manufacture PVC parts	3	3	E	In progress
3D model prototype	5	5	S	Done
programming micro controller	4	4	N	Done
Paper 2.2 Ethics	1	1	Q	Done
Paper 2.3 Marketing	1	1	L	Done
Paper 2.4 Sustainability	1	1	Q	Done

In this sprint, the burndown chart (Figure 17) shows a peak. This is because the sprint first wasn't started while the team updated and finished some tasks. To try to make up for it, the finished tasks were deleted and added again to the sprint. After this, the sprint was started properly and the team updated their finished tasks again. Not all tasks were finished because some tasks are bigger then one sprint. To prevent this, the tasks should be smaller so they fit in the sprint.

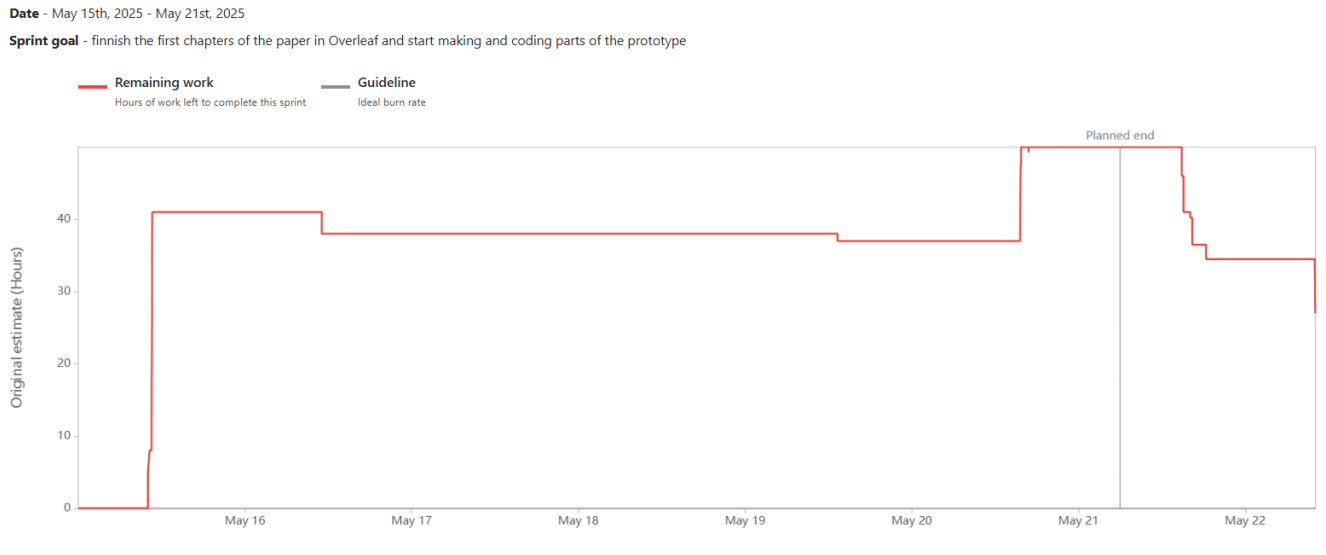


Figure 17: Burndown Chart Sprint 9

3.11.10 Sprint 10 22/05/2025 – 28/05/2025

In this sprint (Table 22), the team started to work on the manual and continued working on the prototype and the paper. Some tasks couldn't be finished because the building of the prototype was delayed. This is why the mechanical testing couldn't be continued.

Table 22: Sprint 10 Outcome

sprint 10	planned duration (h)	real duration (h)	involved members	status
finish design packaging solution	3	6	C	In progress
coding first version of application	8	8	N	In progress
lay out of the app	3	3	N, C	In progress
test mechanical parts	3	2	E, S	In progress
assemble prototype	8	8	S, E	In progress
document compost process week 3	1	1	L	In progress
Manual - Instructions	3	3	Q	In progress
Improve project management chapter 3	2	3	E	In progress
Improve paper chapter 2	1,5	1,5	E	In progress
manufacture PVC parts	3	3	E	Done
manufacture 3D printing parts	3	3	S, E	Done
Paper 3.2 Design	10	10	S, E	Done
test electronics	2	2	C	Done
assemble electronics	0,2	0,2	N	Done
Manual - Introduction	2	2	N	Done
Manual - Index	2	2	Q	Done
Manual Warranty	0,2	0,2	Q	Done
Improve Poster & Leaflet	1	2	C	Done
Improve marketing chapter 4	2	2	I	Done
Paper 3.2 Smart Control	1,5	1,5	N	Done
Paper 3.2 Packaging	1	1	L	Done
Wiki 7.4.4 Packaging	1	1	Q	Done

The burndown chart (Figure 18) shows a steady decreased curve. As explained before, not all work could be finished this sprint because of delays.

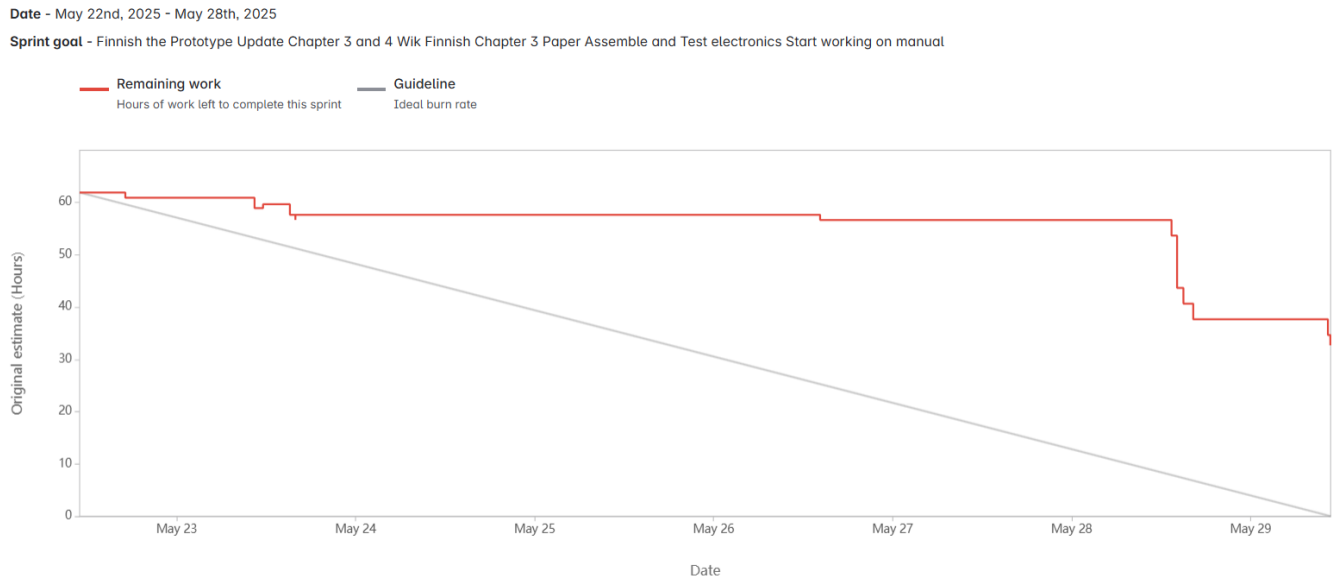


Figure 18: Burndown Chart Sprint 10

3.11.11 Sprint 11 29/05/2025 – 04/06/2025

During the 11th sprint (Table 23), practically all tasks were completely finished: manual, prototype and application.

Table 23: Sprint 11 Outcome

sprint 11	planned duration (h)	real duration (h)	involved members	status
lay out app	3	3	N	Done
Manual - Instructions	3	4	Q	Done
assemble prototype	8	8	S	Done
Improve Paper Chapter 2	1,5	2	E	Done
finish design packaging solution	3	6	C	Done
coding first version of application	8		N	Done
test mechanical parts	3	3	E	Done
Improve project management	2	2	E	Done
document composting process	1	1	L	Done
Edit Paper with comments	2	2	E	Done
Packaging in WIKI	1	1	L	Done
Packaging in overleaf	0,5	0,5	L	Done
Packaging deliverables	1	1	L	Done
Paper 4.1 Structure	1	1	S	Done
Paper 4.2 Test & Results Structure	3	2	E	Done
Paper 4.2 Test & Result Smart control	3	3	N	Done
Paper 5 Conclusion	3	2	Q	Done
create images for user manual	3	3	C	Done
power budget calculations WIKI	2	2	Q	Done

document composting process week 4	1	1	L	Done
functional tests document	2,5	2,5	L	Done
Stress Analysis Wiki	5	4	S	Done
Poster & Flyer in Wiki and Deliverables	2	2	C	Done
Chapter 3 Project management	4	4	E	Done
Ideation about technical drawings	1	1	C	Done
Logbook + agenda next meeting	1	1	Q	Done
Detailed drawings Wiki	1	1	C	In progress

The graph in the burndown chart of sprint 11 (Figure 19) shows that almost all tasks are finished during the whole sprint, not only in the end. This shows that the team worked consistently on their tasks during the whole week. The start of the graph goes up because the team forgot to at estimated time to multiple tasks.

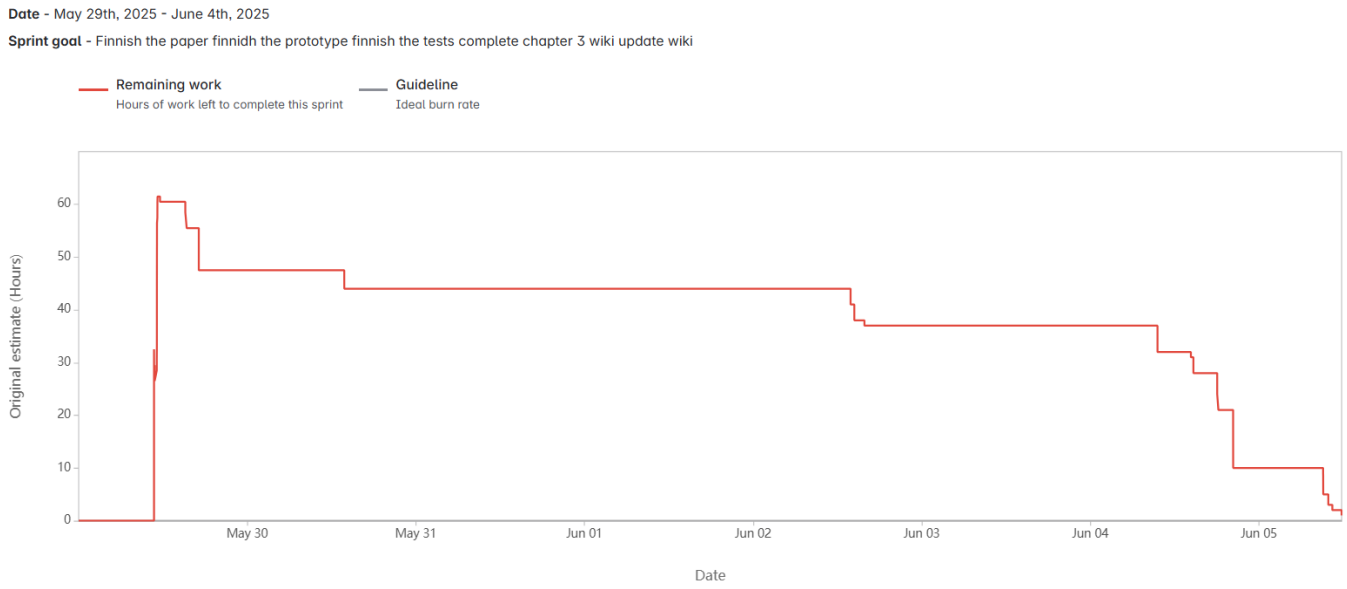


Figure 19: Burndown Chart Sprint 11

3.11.12 Sprint 12 05/06/2025 – 11/06/2025

This sprint the team worked on finalizing the Wiki. Chapters that weren't yet completed were written and some drawings were added. Also, the compost testing was finished, the first version of the final video was made and the application was improved.

Table 24: Sprint 12 Outcome

sprint 12	planned duration (h)	real duration (h)	involved members	status
Detailed drawings wiki	1	2	C	Done

new 3D design layer opener	2	2	S	Done
Improve chapter 3 project management	2	1,45	E	Done
update paper	1,5	1,45	S	Done
compost testing week 5	1	1	L	Done
Improve Application	8	8	N	Done
Improve test result WIKI	1	1	L	Done
Technical drawings	6	10	C	Done
detailed product information in WIKI	2	0,5	E	Done
WIKI 7.5 Prototype Structure & Hardware	3	1,5	E	Done
WIKI 7.5 Prototype Software	2	3	N	Done
WIKI 7.5 Test & Results + 7.6 Summary	2	2	L	In Progress
mechanical tests ⇒ functional tests + upload	2	1	E	Done
WIKI Chapter 8 Conclusion	3	1,5	Q	Done
WIKI 7.4.2 Smart System	3	4	N	Done
WIKI 7.4.3 Software	3	3	N	Done
First version Video	16	11	Q	Done

The burndown chart shows that all work was finnished in time. Only most tasks were finished on the final day of the sprint.

The graph of the burndown chart (Figure 20) rises in the beginning of the sprint. This because a mistake was made while starting the sprint. The starting time of the sprint was set at 12.30AM on Thursday morning instead of 12.30 PM. The time of the sprint was defined after the start of the sprint. This is why it shows the rise in the graph. Also, at the end of the sprint a peak is shown. This because the estimated time of a task was increased instead of only adding the time spent on the task.

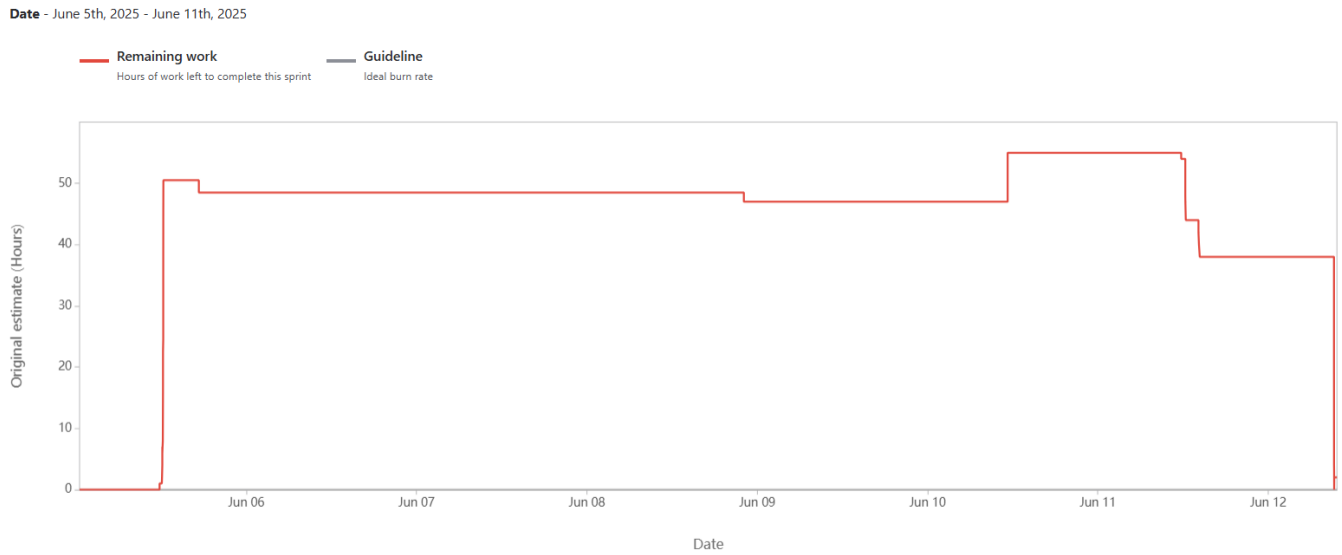


Figure 20: Burndown Chart Sprint 12

3.11.13 Sprint 13 12/06/2025 – 18/06/2025

During the last sprint all detail small details of the wiki were finished, the final presentation was prepared and the project was finished.

Table 25: Sprint 13 Outcome

Tasks Sprint 13	Planned Duration (h)	Real Duration (h)	Involved Members	Status
WIKI 7.5 Test &c Results + 7.6 Summary	2	2	L	Done
Testing mixing and cutting with Orbeez	1	0.75	E	Done
Uploading functional testing document	0.5	0.5	L	Done
Improving video	2	2	Q	Done
WIKI 7.4.3 Software	2	2	N	Done
Include Electronics to prototype	3	4	S	Done
Logbook: Report, Minute	0.2	0.2	Q	Done
Upload Code to Deliverables	0.2	0.2	N	Done
Lay out + upload Final Report	2	2	S	Done
Lay out Final Presentation + upload	2	2	C	Done
Home Page WIKI: Brief Goals & Requirements	0.75	0.75	E	Done
WIKI Report Acknowledgements & Abstract	1	1	Q	Done
WIKI: Update project management sprint 12 & 13	3	3	E	Done
7.5.4 Test & Results - Mechanical	1	1	E	Done
7.6 Summary	0.75	0.75	L	Done
Slides: Problem + UN Sustainability	0.5	0.5	L	Done
Slides: Requirements & Concept	2	2	E	Done
Slides: Solution (product + app)	2	2	C	Done
Slides: Prototype	1	1	S	Done
Slides: Functional results - mechanical	1	1	S	Done
Slides: Conclusion + future development	2	2	Q	Done
Slides: Functional results - electronics	1	1	N	Done
Final slide: Flyer + leaflet	1	1	C	Done
7.4.4 Test & Results - Compost	0.5	0.5	L	Done

The final burndown chart shows a good workflow as the curve is going down very steady during the week.

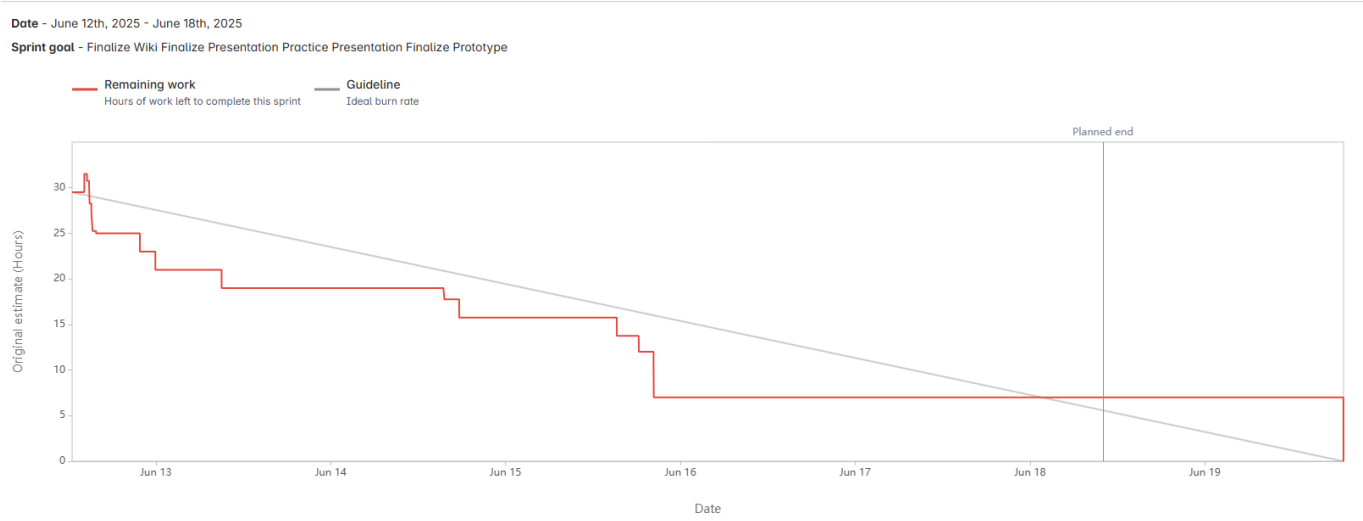


Figure 21: Burndown Chart Sprint 13

3.12 Sprint Evaluations

To evaluate every sprint, the team discusses every sprint in a retrospective in Atlassin. They started doing this properly from sprint 3. A summary of these retrospectives is found in Table 26

Table 26: Summary Retrospectives

Sprint	Positive	Negative	Start Doing	Stop Doing	Keep Doing
3	progress was made	sometimes demotivated	using Jira more detailed	doing everything together if not necessary	delivering good work
	first concrete idea about product	forgot to start sprint	dividing work properly		
	very good marketing presentation	work inefficient		choose responsibilities	
	start using Jira	tasks not properly divided			
	making smaller groups to divide work				
4	Big progress in the Wiki	definition of tasks are sometimes not precise enough	break down tasks in a more clear way	vague descriptions of tasks	delivering good work
	Better use of Jira		better communication about tasks in Jira		
5	We did a good Interim Presentation	Interim Presentation was a little bit too long	practice future presentations together	too much information in presentation	breaking the work down into clear tasks in Jira
	very positive feedback from the teachers				

Sprint	Positive	Negative	Start Doing	Stop Doing	Keep Doing
	We finished almost all tasks of the sprint				
6	Delivered a good 3D video	timing of presentation	practice presentations together		delivering good work
	positive feedback on interim presentation				
7	good teamwork	keep reports documented	keeping the reports up to date	-	help eachother
8	almost finished the whole sprint	not all work is directly logged in Jira	logging tasks better in Jira	procastinating	good work
	good workload				finishing tasks on time
9	prototype building went well	need to update eachother more	more updating in WhatsApp		keep defining double sprints
	finished almost all the planned work				
10	prototype is finished	better prepare deliverables and presentation	better communicating about tasks in progress	procastinating	delivering good work
		procrastinating			
		communication			
11	finished all tasks				finnish all tasks in time
	good composting tests				
	planning teambuilding with team 1				
12	finished all tasks	Changing estimated times in Jira		change estimated times in Jira	
	working in library together				
13	finished all tasks				
	Final presentation went well				
	positive feedback after the final presentation				

3.13 Summary

After analyzing the stakeholders, procurement and communication. It will be important for LeftLovers to keep communicating to keep all stakeholders interested and involved. This to make sure that the product can be financed by investors, supported by charities and the university, that suppliers keep providing components and new clients keep buying the product.

In terms of defining sprints, there is still room for improvement. There were sprints where all tasks were finished and sometimes not. Small mistakes made a big difference in the burndown charts. Also, tasks were often not clear enough or too big for one sprint. In future, tasks should be more defined and made smaller so they can be finished during a sprint and mistakes should be avoided by doublechecking the sprint before starting it.

4. Marketing Plan

4.1 Introduction

This chapter outlines the strategy for successfully introducing the Leftlovers Loopbin to the market. It includes a thorough analysis of the market, target audience, and competitors. A SWOT analysis is carried out to identify the strengths, weaknesses, opportunities and threats. These discoveries form the basis for a well-defined marketing strategy and a strong brand identity. The goal is to launch a successful product of good quality at an affordable price with satisfaction of the costumers.

4.2 Business Idea Formulation

Before reaching out to potential customers or developing prototypes, the value proposition must be refined and well-defined. This process involves considering the Big Idea Hypothesis, which consists of six key elements: target customer, statement of monetizable pain, product name and category, statement of key benefit, primary competitive alternative, and primary differentiation. The concept has been summarized in an elevator pitch:

The goal is to develop a product for urban residents without access to a garden who wish to engage in gardening and efficiently repurpose their food waste. To address this need, the LeftLovers Compost Bin has been designed. This solution combines a smart organic waste bin with a garden on top, which allows users to compost easily while producing compost of good quality that can be used to feed plants growing on top of the bin.

While there are other kitchen compost bins available on the market, the LeftLovers Compost Bin stands out by giving users the opportunity to monitor the composting process and create a fertilizer that is made for their specific choice of plants. This way the composting experience is more personalized and effective.

4.3 Business Model

To establish a strong market position, it is crucial to define clear objectives within the market. In order to achieve this, a Business Model Canvas was developed, which can be seen in Figure 22

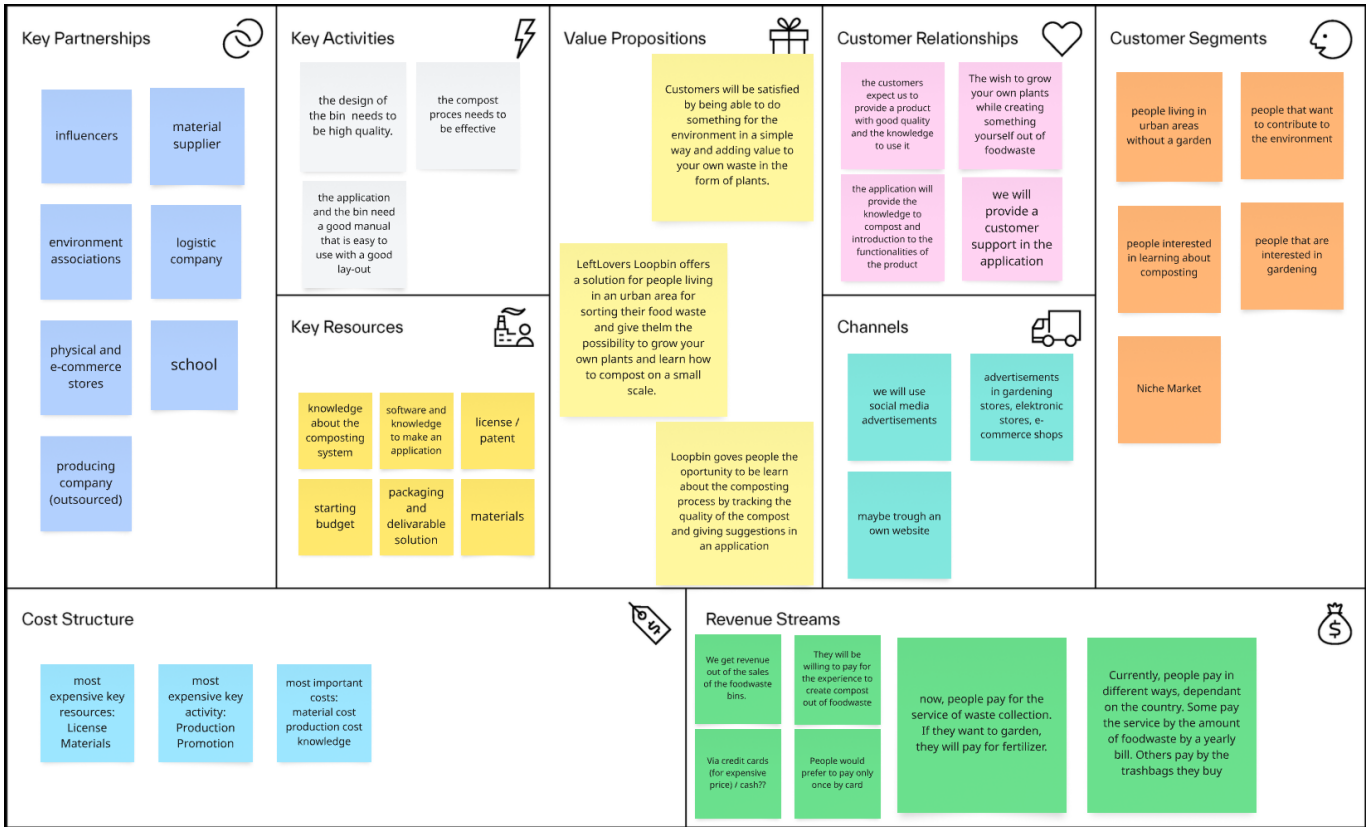


Figure 22: Business Model Canvas

4.4 Market Analysis

To gain a thorough understanding of market dynamics, customer needs, competition, and external factors that may influence the success of a product, conducting a market analysis is essential. This analysis allows for a deeper exploration of the market conditions in which the company operates. A market analysis can be divided into two components: micro and macro.

4.4.1 Micro Analysis

The micro analysis focuses on the factors that are closely related to the company and affect its ability to serve its customers.

One of these factors is the **company's internal environment**, which includes all departments within the organization that influence the marketing department. This encompasses the company's vision and strategic goals. In this case, the objective is to raise awareness about food waste and encourage individuals to take more sustainable actions with their food waste. Another critical element is the budget allocated by the company, which plays a vital role in shaping the marketing and product development strategies.

Another factor in the micro analysis is **suppliers**. Companies rely on suppliers to provide the necessary parts and materials for production. In this case, a strategy is implemented to collaborate with suppliers in Portugal. This way the operations are local and import costs are being avoided.

Customers are another important element, and they can be divided into five different groups:

1. Consumer markets: These are customers who want to buy the product for personal use. This group represents the target audience, particularly urban residents without access to a garden

who wish to engage in gardening and efficiently repurpose their food waste.
2. Business markets: These include companies that purchase the product to resell it. This group is not the focus of this product.
3. Reseller markets: These intermediaries can help with the promotion and sales of the product. The product will mainly be sold through an online platform, but there are also plans to explore opportunities for sales in, for example, gardening centres, in order to reacht the target audience.
4. Government markets: These are government institutions that purchase products for public use. Since the product is designed for home kitchens, it is not targeted at government markets as it is too small for communal spaces.
5. International markets: These are foreign markets where a company sells its product. Given the global population of urban residents, there is potential to expand and sell the product internationally.

Another factor are **competitors**; businesses offering similar products to the same target audience. The analysis in the state of the art has revealed that many kitchen compostbins are expensive, with few offering a built-in garden and an app. To gain a strategic advantage, the goal is to distinguish the product by offering a more affordable and unique solution.

The final element is **publics**. These are groups such as the media or shareholders that have an interest in or influence over the company's success. Maintaining a positive relationship with these groups is essential to avoid damaging the company's reputation. The aim is to create an image of contributing to a better planet by reducing food waste, thereby building a brand that resonates with environmental sustainability.

4.4.2 Macro Analysis

The **macro analysis** focuses on larger societal forces that affect the microenvironment.

The first factor is **economic**. This refers to the economic conditions that affect the purchasing power of consumers. Factors such as income levels, inflation and unemployment affect how much consumers are willing to spend. The goal is to provide an affordable solution for urban residents with modest incomes.

Another factor is **natural**. This pertains to the raw materials used in the production of the product. While composting itself is not a challenge, as there will always be leftovers, the product will be made of plastic, which requires some consideration. Given the increasing trend of replacing plastic in everyday products with alternative materials, it may be worth exploring other materials in the future. More sustainable options may be discovered over time. For now, plastic is chosen for its ease of use. Additionally the aim is to create a high-quality product that can last long for the consumer. Considering the fact that the product contributes to reducing food waste, it is hoped that this will ultimately help reduce the ecological footprint.

Another factor is **technological**. This is also crucial for the product, because the technological environment changes rapidly which can create new opportunities. The compost bin comes with an app, which needs to be updated over time to ensure the security and stability of the app. It is also essential to ensure that all data collected via the app remains private.

Political factors, like regulations and government policies, play a role as well. In many countries, residents can dispose of their green waste for free in designated bins. If the government were to introduce a fee to encourage the reduction of food waste, it could make it more appealing for

consumers to use the compost bin instead.

The final factor is **cultural**. This pertains to the values and norms within a society that influence consumer behavior. The aim is to change how people perceive food waste and to instill a new norm that discourages the careless disposal of food. The goal is to foster a shift in behavior, encouraging people to rethink their approach to food waste and adopt more sustainable practices.

4.5 SWOT Analysis

SWOT stands for Strengths, Weaknesses, Opportunities, and Threats. A SWOT analysis examines these four aspects to identify areas for improvement and strategic growth. **[Asana, 2025]**

Strengths refer to internal factors that contribute to the product's uniqueness and appeal to the target audience:

- **Innovative design** – The Leftlovers Loopbin is more than just a compost bin, this product features an integrated garden on top, making it a unique and multifunctional solution.
- **Smart technology** – Equipped with sensors and an accompanying app, the bin provides users with real-time insights into the composting process, including notifications on when to add materials.
- **Sustainability** – Helps reduce food waste, making it highly attractive to environmentally conscious consumers.
- **Targeted at urban residents** – As the number of people living in small apartments continues to grow, so does the potential customer base.

Weaknesses highlight internal challenges that could hinder success and may require improvement:

- **Material choice** – Although durable, the use of plastic may be perceived negatively by eco-conscious consumers.
- **Limited food waste compatibility** – Certain types of waste, such as meat, are difficult to compost and can produce unpleasant odors. Therefore they can not be thrown into the Leftlovers Loopbin.

Opportunities represent external factors that could enhance success and market growth:

- **Rising awareness of food waste issues** – People are becoming more conscious of the environmental impact of food waste, leading to a growing demand for sustainable solutions such as home composting
  * **Changing government policies on waste** – Governments are increasingly considering policies such as landfill bans or higher taxes on organic waste, which could encourage people to look for home composting solutions.
- **Environmentally friendly brands** - collaboration with these brands, such as Patagonia, could offer potential visibility and credibility.
- **There are several countries with high urban populations** - which could be interested in buying eco-friendly products, like Canada or Sweden.

Threats are external risks that could negatively impact success:

- **Competition** – The presence of alternative composting solutions may challenge market positioning.
- **Stricter regulations on plastic use** – Potential restrictions on plastic materials could require

adjustments in product design and production.
- **Economic downturns** – Reduced consumer spending power may lead to lower demand for non-essential products.

4.6 Strategy

4.6.1 Strategic Objectives

The strategic objectives are composed of several components. One of them is the target audience, which consists of individuals who live in urban areas, lack access to a garden, are environmentally conscious, lead busy lives, earn a modest income, and seek a durable, cost-effective solution.

The goal of the product is to provide a composting solution to people who have no knowledge of composting and no outdoor space. In addition, the goal is to let users to experience the value of turning food waste into plants, instead of throwing it away. The target audience will be reached through various channels, including the company's own website, social media advertising, e-commerce platforms and advertisements in garden centeres. Word of mouth will also play an important role in generating interest. An interactive relationship with users will be fostered by giving tips throught the app, encouraging user to participate in the composting process and showing physical results through plant growth.

Behind the scenes, several activities are necessary for the business. This includes developing a user-friendly solution, creating an attractive design, setting up an effective composting process and implementing an active user solution. Partnerships are essential for the success of the product. Collaboration with material suppliers and ISEP is planned for the product development. To support the product lifecycle, partnerships will be sought with logistics companies, retailers, influencers, and environmental organizations. The main resources are an initial budget, knowledge or licensing for the app, expertise in composting systems and the raw materials. With these elements combined, the creation of the Loopbin will be possible.

For the positive side of the financial model, revenue will be generated from bin sales and the premium app. On the negative side, the costs will include material expenses, production costs, app licensing fees, and advertising expenses.

4.6.2 Segmentation and Targeting

Market segmentation can be analyzed using three key criteria: demographic, psychographic, and behavioral.

Demographic segmentation; who is the customer? This criterion focuses on measurable characteristics, such as:

- Age: Adults, mainly between 20 and 50 years old.
- Living Environment: Urban residents living in apartments without a garden, especially in densely populated areas in developed countries.
- Income: People with a medium to high level of education with a modest income who are willing to invest in sustainable solutions.
- Household composition: Suitable for singles, couples, and small families.

Psychographic segmentation; what motivates the customer? This category considers values and beliefs that drive consumer behavior:

- Environmental awareness: The target audience seeks to contribute to a more sustainable world by reducing food waste.
- Innovation-oriented: Open to new ideas and solutions that enhance daily life.
- Healthy lifestyle: A strong interest in growing herbs or vegetables at home.

Behavioral segmentation; how does the customer behave? This criterion examines purchasing behavior and decision-making:

- Cost-conscious: Individuals who have a limited budget and carefully consider their expenses.
- Value-oriented: Consumers who prioritize high product quality and seek value for money.

By defining the LeftLovers Compost Bin's target audience through demographic, psychographic, and behavioral segmentation, the marketing strategy can be effectively tailored to align with their specific needs and preferences.

4.6.3 Positioning

As part of state-of-the-art research, an extensive analysis was conducted on existing kitchen compost bins available on the market. Findings indicate that many of these products share similar characteristics. To introduce innovation in this market, differentiation will be pursued in two key areas: pricing and additional features.

The aim is to minimize production costs so that the product can be offered at an affordable price. In addition, new features are being introduced, including compost monitoring through an app. This app provides users with valuable insights, helps to create the ideal fertilizer for their plants and improves the overall composting experience. Another distinguishing feature of the LeftLovers Loopbin is the integrated mini-garden, which allows users to immediately start growing plants while using the compost produced.

Figure 23 illustrates the market positioning of this product. It is placed in the upper-left quadrant, as it offers an affordable price along with unique features. In comparison:

- Bokashi bins are inexpensive but lack additional features.
- CEERCLE bins include an integrated garden but are high-priced.
- Lomi bins offer an app but are also high-priced.
- GEME bins are both expensive and lack additional features.



Figure 23: Marketing Position

4.6.4 Marketing-Mix

The marketing mix consists of the four P’s of marketing, which include four key elements: product, price, place, and promotion. This framework serves as a strategic guide to effectively market a product to consumers. **[Alexandra Twin, 2010]**

The first P stands for **Product**. The LeftLovers LoopBin is an innovative compost bin with a garden on top, specifically designed for urban residents who do not have a garden. It comes with unique features, such as monitoring of the compost and personalized fertilization based on the selected plants, which provides a customized and efficient composting experience.

The second P stands for **Price**. The price is determined based on several factors, including production costs, a reasonable profit margin and the consumer's willingness to pay for the solution. The main goal is to keep the price as affordable as possible while maintaining customer satisfaction and profitability. So the price came down to €400, with a profit margin of 45%.

The third P stands for **Place**. The product will be made available for purchase through a dedicated website. Additionally, opportunities for retail partnerships in gardening stores are being explored, as these locations attract individuals passionate about gardening, who align with the target audience.

The fourth P stands for **Promotion**. The marketing strategy includes a dedicated website featuring

tips and insights on composting. Social media marketing will also play a key role, with educational posts on platforms such as Instagram to engage potential buyers. Furthermore, advertisements will be placed in locations frequented by the target audience, such as gardening stores, to increase product visibility.

4.6.5 Brand

The name of the company is Leftlovers, a play on the words “leftovers” and “lovers”. The goal is to encourage people to fall in love with their leftovers by showing them how to create something useful out of their foodwaste. The original logo featured a plate with cutlery, which formed a heart shape. The name Leftlovers appeared underneath, with the letter “L” in a different font to emphasize the word “leftover”.

Over time, the logo was simplified. The inclusion of the “L” in the original design could have caused confusion. The updated logo now consists solely of the word “LeftLovers”, with a capitalized “L” in the center to continue highlighting the word “leftover”, as shown in Figure 24. The “V” in the logo is represented by the cutlery from the original design, and a heart symbol is placed above to represent “Lovers.”



Figure 24: LeftLovers Logo

The product, the smart compost bin from LeftLovers, is called Loopbin. The logo comes in two versions, as shown in figure 25. The larger logo simply displays the word “Loopbin.” The name “Loopbin” was chosen because, as the name suggests, it’s a bin that, when used correctly, creates a loop. The compost inside the bin is transformed into fertilizer, which is automatically collected in a planting box, allowing you to grow new herbs and vegetables from your old waste. In the logo design, the two “o”s are connected, as are the “i” and “n,” symbolizing the continuous cycle of waste transformation. The smaller logo features the connected “o”s, with the “i” and “n” linked above, creating a loop-like shape.



Figure 25: Loopbin logo

The logos have different versions based on the chromatics of the colours palette. These variations are presented in Figure 26.

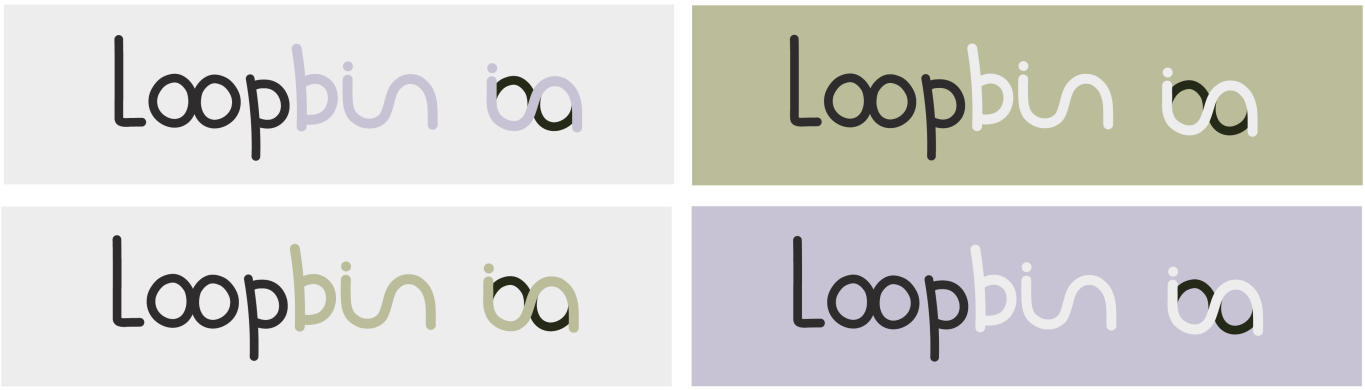


Figure 26: Logos variations

In order to show this concept to the audience, a flyer was developed.

Flyer

Link

The poster provides the basic and general information about the Loopbin.

Poster

Link

The leaflet has more information about the product. Is is given using images and simple explanations.

Leaflet

Link

4.7 Marketing Programmmes

4.7.1 Programmes

In order to successfully introduce the LeftLovers Loopbin to the market and build a relation with the target audience, different marketing programs will be launched. These programs are aimed at increasing awareness about foodwaste and creating a community around composting and the brand.

1. Awareness program

The first step is to raise awareness about food waste. To achieve this, flyers, leaflets and posters will be distributed in locations where people with a sustainable mindset gather, such as garden centres and eco-friendly stores. To further engage with the audience, LeftLovers will participate in local markets and urban gardening events. During these events, possible costumers will be able to see the Loopbin in action, ask questions and even try it out. By seeing how food waste is transformed into fresh compost and plants, the audience can connect with the product and its purpose.

2. Digital marketing campaign

The target audience is expected to be active online, so a digital campaign will be launched. Advertisements via Instagram and Facebook will show how the Loopbin will look in modern kitchens. These ads will not only highlight features such as the integrated mini garden and the smart

monitoring app, but also tell the story of a more sustainable life. In addition, Google Ads will target specific searches, such as “how to compost indoors”, “urban gardening tips” or “ecological kitchen solutions”. These ads will lead directly to the LeftLovers website, where users can discover the product and learn more about composting. Lastly, the LeftLovers app will play a central role in the digital interaction. After purchase, users are encouraged to document their composting journey through the app: sharing photos of their plants, tracking the quality of their compost, and sharing experiences with others in the community.

3. Collaborations and Content

To build credibility and reach a wider audience, LeftLovers will partner with eco-conscious influencers and business who are passionate about sustainable living. Influencers will receive a Loopbin to try at home and share their honest experiences with their followers. Whether it’s a YouTube video or an Instagram story, their content will give potential buyers an authentic view of what the product has to offer. Additionally, the brand will partner up with eco-conscious business to reach the target audience.

4.7.2 Budget

In order to increase the visibility of the Loopbin and to raise awareness of composting, a small-scale but targeted marketing campaign has been chosen. Since the product is primarily intended for customers in urban areas, flyers and leaflets will be distributed and posters will be hung in those cities. The personal distribution of the materials is intended to attract more attention to the product. A limited number of flyers, leaflets and posters will be printed, so that there is enough to hand out, but not too much to support the principle of waste reduction. The prices are based on websites from Portuguese suppliers. **[Europress, 2025]**, **[a minha gráfica, 2025]**, **[Oficina d'Arquitectura, 2025]** Advertising on social media is also included, the cost of which is estimated at 250 € per month (3 000 € per year), according to a Portuguese source. **[Global Pixel, 2022]**

Table 27: Budget Marketing per year

Expense	**Amount**	**Price**
Flyers, A5	500	24 €
Leaflets, A4	125	117,25 €
Posters, A3	20	60 €
Social Media	-	3000 €
Total		3 201.25 €

4.7.3 Control

To ensure the success of the marketing strategy, a structured monitoring plan is implemented. This plan focuses on tracking progress, evaluating effectiveness and making adjustments where necessary. By combining data-driven insights with user feedback, LeftLovers remains flexible and

responsive throughout the launch and growth phase.

Customer Feedback User experience is very important for the brand. Therefore, qualitative feedback is actively collected via in-app surveys, product reviews, and direct interactions with customer service. Early adopters are also invited to participate in a dedicated feedback group where they can share suggestions and report issues. Their insights help refine not only the marketing approach, but also the product itself.

Marketing Adjustments The marketing strategy remains flexible based on the collected data and user insights. Underperforming campaigns are reviewed or paused, while high-performing initiatives receive additional budget and support. For example, if a particular influencer is generating unusually high levels of engagement, further collaborations can be explored.

Sustainability & Impact Reporting Finally, LeftLovers strives to not only monitor business performance, but also measure impact. Through the app, we track how much food waste is composted and how many plants are grown with the Loopbin. These insights are shared transparently with the community and used in storytelling to create a sense of collective achievement.

4.8 Summary

Based on the market/economic analysis, the team decided to create a smart compost bin with an integrated garden – the LeftLovers Loopbin – intended for urban dwellers without access to a garden who want to live more sustainably. This decision was driven by the increasing awareness of food waste, the lack of affordable and easy-to-use compost solutions, and the growing interest in gardening. To meet these needs, the product was designed with features such as app-based compost monitoring, personalized fertilization, and a mini garden on top. These market-driven choices ensure that the Loopbin stands out as both practical and attractive.

The next chapter outlines the ecological side and choices made for a sustainable solution.

5. Eco-efficiency Measures for Sustainability

This section presents the measures put in place to ensure a reduced environmental impact. Initially, the focus will be on environmental considerations, analyzing the reduction of waste and pollutant emissions. The economic aspect is then examined to assess the financial viability of the project while ensuring responsible management of resources. The social dimensions are also examined, focusing on the impact on the community and the possibilities to raise awareness of eco-friendly practices. A life cycle analysis assesses the environmental footprint of the product at each stage, from design to recycling. Finally, the conclusion highlights the technical and strategic choices made to ensure a sustainable and effective solution.

5.1 Introduction

Ecology is an important topic in today's world and requires systematic attention to environmental impacts in the development of new products and technologies. The increasing autonomy of many aspects of daily life underlines the importance of integrating a sustainable approach into these developments.

When defining the project, it was important for the group to consider the ecological as well as the technical aspects. So, the theme chosen was “Smart food production in small spaces”. The idea that quickly emerged was to propose a solution for managing food waste. The decision to develop a food waste management solution was prompted by the lack of accessible and effective measures deployed on a large scale by local authorities and governments.

5.2 Environmental

Composting is a good way of treating food waste yourself. The compost produced can be reused to nourish plants, flowers and so on. However, you'll need a large enough outdoor space for the process to take place.

This is not a feasible solution for people living in cities with little or no green space available. The proposed solution remedies this problem, preventing food waste from being thrown away.

Having this solution at home means you can grow your own plants or herbs for cooking, for example, while making healthier use of your food waste. What's more, the active participation of the user considerably reduces the consumption of the product.

The final environmental aspect of this prototype is the use of PVC as the main material. This is a polymer that can be recycled. This means that most of the product is made from recycled material that can be recycled again. The other components are mainly made of stainless steel, to prevent them from being damaged by contact with the compost.

5.3 Economical

One of the major aspects of developing the prototype is durability. The aim is to create a hard-wearing product that will last for years. It must be easy to use for the user and not require regular maintenance or other breakdowns.

This is part of the economic aspect of LoopBin, as its purchase implies a long-term solution, with no additional maintenance costs.

What's more, as mentioned above, it consumes very little electricity. This means that there are no excessive electricity costs like some other household appliances, just a battery that must be recharged periodically. It also reduces the cost of the prototype, which has fewer electronic components (often very expensive).

Finally, monitoring the process using sensors ensures that compost is optimal, and therefore odor-free. Some existing solutions use carbon filters to reduce odors. These must be changed regularly and involve additional costs (around € 10/month). This is not the case here, so the only expense is the purchase of the product!

5.4 Social

The original idea behind the product is to provide a popular solution for managing food waste. The target audience is the middle class, living in flats in big cities, without necessarily having access to green spaces or gardens.

To achieve this, a sustainable product needs to be offered, as discussed earlier, but also economical, so that it is accessible to everyone. The previous chapter explained how costs can be reduced.

What's more, the solution is interactive and fun. The user is a player in the process, acting directly on the process, using the compost mixing system for example. What's more, the application guides users through the process, enabling anyone with little or no knowledge of the subject to produce effective and healthy compost.

The system of mobile boxes to collect compost also adds a social dimension to the product. If too much compost is produced, it can be shared with a neighbor, a relative, etc.

LoopBin's ease of use, fun and low cost make it easy to recommend and affordable for anyone who wants to try it out. This way, someone who has tried it can easily tell their friends and family about it, encouraging them to act for the environment!

5.5 Life Cycle Analysis

In this section, issues relating to the manufacture of the product and the composting process will be examined.

As mentioned above, the materials used to create the prototype are the following. Firstly, PVC, which is the main material, will be used to make the outside of the bin, its structure. For the inside mechanism, the solution is stainless steel. It's not the most environmentally friendly solution, because its extraction and processing are not ideal. However, stainless steel is infinitely recyclable, and is a durable material, even when in contact with compost. This makes it a suitable alternative for the final product.

Finally, the LoopBin composting process is designed to be as economical as possible, both for the environment and for the user. The food waste is placed in the bin, then mixed and blended in the first stage. This operation is carried out by the user but only takes a minimal amount of time each week. The user will be alerted via the application, which uses various sensor data to detect a need for oxygen or a temperature that is too high.

By transferring to the lower level, you can store compost at different stages of maturation. In this second part, the user no longer needs to mix the waste, only to blend it, even less often than in the first stage.

Finally, when the compost is ready, it is sent to a recycling drawer. This drawer can be placed at the top of the bin to grow herbs, for example, or used on its own to be given away, or to produce other plants.

As mentioned above, the materials used are recyclable, and the electronic components reusable, so once LoopBin has reached the end of its life, it can be completely dismantled and recycled!

5.6 UN Sustainable Development Goals

The LeftLovers Compost Bin contributes to several Sustainable Development Goals, ranked from most impact to least impact, as shown in Figure 27



Figure 27: Sustainability Goals

First of all, goal 12: Responsible consumption and production. By offering a way of recycling organic waste at home and giving food waste a new purpose (compost), the bin helps to reduce food waste and encourages the transition to a circular economy.

Second, goal 11: Sustainable cities and communities. The product makes urban gardening and composting accessible for people without a garden, helping to create more sustainable and self-reliant cities.

Third, goal 13: Climate action. Composting organic waste instead of sending it to landfills significantly lowers methane emissions, which is a powerful greenhouse gas. Additionally, it reduces the need for the transportation of organic waste, which also minimizes environmental impact.

Fourth, goal 3: Good health and well-being. The integrated garden offers an affordable way to grow vegetables, promoting healthier food habits. Gardening could also be considered a fulfilling hobby, promoting mental and emotional well-being.

Fifth, goal 15: Life on land. On a small scale, LeftLovers supports healthier soils and biodiversity by promoting natural composting and reducing the use of chemical fertilizers.

Lastly, goal 2: Zero hunger. While the product is not directly aimed to fight hunger, it does raise awareness about food production and encourages people to grow their own food in the city.

5.7 Summary

This section looks at several concepts relating to the ecological aspect of the LoopBin project. The first step is to develop a product that offers users a solution for transforming their own food waste into something that is good for the environment.

The idea is to have a product that is popular, easily accessible because of its price, easily recommendable because it is sustainable and good for the environment, and finally simple to use. Its design makes it an interactive product, with the user as a real player in the composting process, while simplifying its mechanism to have a solution that is less expensive than products on the market.

Finally, the sustainability of the system is central to its development. It is designed to last a long time and be fully recycled at the end of its life cycle.

So it is an affordable way to do your bit for the planet, with a healthy and fun product!

6. Ethical and Deontological Concerns

6.1 Introduction

This chapter discusses the ethical and deontological concerns relevant to the project. Ethics are moral principles that govern an individual's behavior or the conduct of an activity. It is essential to apply ethical behavior in any profession. Deontology, on the other hand, is an ethical theory that evaluates actions as morally right or wrong based on a clear set of rules **[Eldo Frezza, 2017]**. Such rules help maintain a balance between chaos and order.

Engineers must apply ethical principles from the very beginning of the project. Throughout the product development process, it is essential to adhere to established regulations and transparently report test results. The environmental impact of the product must be taken into consideration. Once the product is fully developed, the product needs to enter the market. The focus shifts to marketing and sales. These areas also bring ethical concerns. Developers must follow ethical guidelines to ensure fairness and honesty in promotion and sales. In addition, the liability of the product is taken into account. A product must be safe, reliable and meet legal standards. If a product causes damage, the responsible party must address the consequences.

Addressing these concerns results in a responsible and sustainable product. Ethical and deontological principles help us maintain integrity and social responsibility throughout the project.

6.2 Engineering Ethics

In engineering ethics, each country's engineering board establishes its own code of ethics. The team observed significant similarities among these various codes and selected the most relevant principles for the project. Five fundamental principles of engineering ethics were identified to guide the team: integrity and honesty, competence, responsibility, impartiality, and confidentiality.

1. **Integrity and Honesty**
    - Engineers must accurately document all design specifications and test results and avoid misrepresenting the capabilities of the product.
    - Contributors and external sources must be properly cited to maintain intellectual honesty.
    - Engineers working in diverse teams must promote inclusive collaboration and respect cultural and professional differences, regardless of religion, gender and personal characteristics.
    - Corruption and bribery must be strictly rejected. Offering or accepting bribes, commissions or gifts to obtain contracts is prohibited.
    - Transparent communication regarding the product's performance and limitations is essential in all technical documentation and presentations
2. **Competence**
    - Engineers shall regularly update their knowledge and skills in line with developments in science and technology.
    - Engineers aim to achieve the best possible results by making the best possible use of the resources at their disposal, and by integrating human, economic, financial, social and environmental dimensions.

3. **Responsibility**
    - Engineers should base design decisions on verified scientific principles, particularly regarding composting mechanisms and material performance.
    - Continuous testing and refinement are necessary to optimize functionality and user safety.
    - Material selection should prioritize sustainability, durability and end-of-life recyclability to minimize environmental impact rather than quick wins.
    - Potential safety hazards, such as structural instability or material toxicity, should be identified and mitigated.
    - Engineers should also not sign documents for projects outside their expertise or without supervision.
4. **Impartiality**
    - Engineers should select materials and manufacturing processes based solely on technical quality, sustainability and project requirements.
    - Personal biases or external influences should not compromise objective decision making.
5. **Confidentiality**
    - Engineers shall not disclose, without consent, confidential information concerning the business affairs or technical processes of any present or former client or employer, or public body on which they serve.

6.3 Sales and Marketing Ethics

In today's competitive marketplace, businesses must focus not just on customer satisfaction but on building lasting trust and loyalty. Modern consumers evaluate products based on the complete value proposition - including benefits, services, and ethical considerations - rather than just physical attributes alone. Effective marketing serves as the crucial bridge between products and consumers. However, unethical practices can severely damage customer relationships and tarnish brand reputation. When implemented properly, ethical sales and marketing strategies positively influence all elements of the marketing mix of 4 P’s. The 4 P’s stands for product, pricing, place and promotion, as stated in 4.6.4 Marketing Mix.

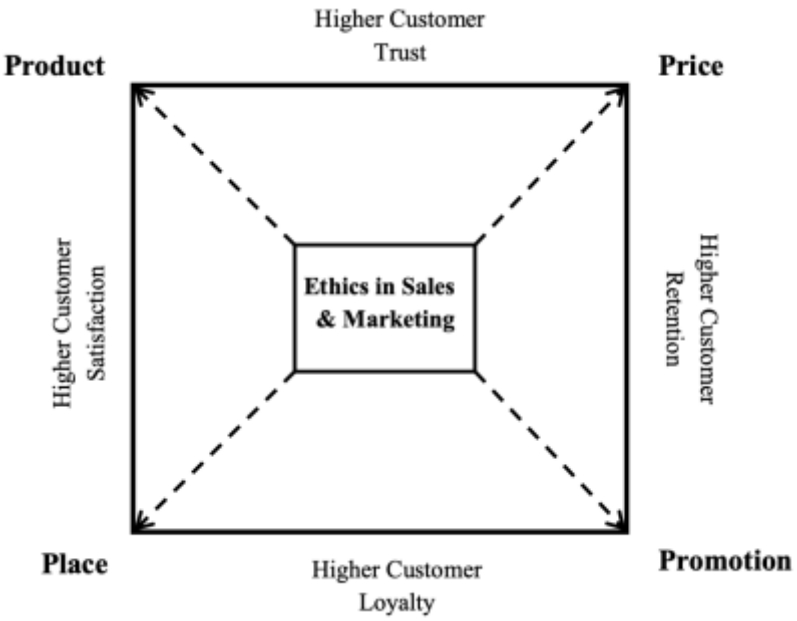


Figure 28: Ethics in Sales and Marketing: Customer Perspectives

As illustrated in Figure 28, this ethical approach ultimately strengthens the customer value

proposition. The following sections will explain how the 4 P's principles apply specifically to the ethical considerations for the project **[Pankaj M. Madhani, 2020]**.

1. **Product** development aligns with consumer needs.
    - The compost bin marketing must present accurate information, clearly stating decomposition timelines without exaggeration.
    - For odor control, precise language like "reduces odors" will be used rather than "eliminates odors."
    - Insect prevention features should be described as deterrents, not guarantees.
    - Data collection requires user consent. It is important to explain how collected data improves service quality and ensure that users understand their privacy rights.
2. **Pricing** must remain fair and transparent.
    - Premium features should have justified pricing. Any additional costs—such as ad-free app subscriptions—must be disclosed upfront.
    - Discounts should be true savings, not increased base prices.
3. **Place** should prioritize accessibility and environmentally friendly distribution.
    - The goal is to make Loopbin available through channels that are convenient for customers while minimizing environmental impact.
    - Marketers must not conceal product flaws or delivery issues.
    - Sales channels must operate ethically—no coercive or manipulative tactics should be used.
4. **Promotion** should be focused on honest and responsible communication.
    - Environmental claims must be realistic and verifiable. Phrases like "100% earth-friendly" should be avoided unless fully supported by evidence.
    - Proper disposal instructions must be included to promote sustainable use.
    - Warnings and instructions should be clearly translated for all target markets.
    - Marketers must never misrepresent product benefits or make false claims about performance.

6.4 Environmental Ethics

Environmental issues are a massive problem that humans need to solve. Depletion of natural resources, pollution and climate change are growing concerns. Products must always be sustainable and contribute to reducing waste in landfills. This is essential to minimize negative impact on the environment and promote a circular economy. Environmental ethics are crucial in the development of a product. This requires a careful balance between innovation, conservation of resources and ecological responsibility. This includes material selection, packaging and the final function of the product, ensuring minimal damage to the environment while maximizing benefits.

Engineers must work together to create products that are both functional and environmentally friendly. Ethical decision-making in engineering ensures that sustainability is prioritized over short-term convenience. It is important to find harmony between humans and nature. Products must not disrupt the habitats and the lives of other organisms. Biodiversity plays a crucial role in ecological stability and disruption can have long-term consequences. As part of the earth, there is a responsibility to protect it by making well-considered design choices. To support this, the team has created Loopbin. It transforms food waste into compost, which nourishes plants and reduces the carbon footprint of food waste. This aligns with environmental ethics by promoting waste reduction and sustainable living.

There are some environmental concerns regarding Loopbin's material. Firstly, PVC is selected as the

main material. It is a type of plastic. The main concerns with PVC are microplastic pollution, slow biodegradation and greenhouse gas emissions during production. However, since the compost bin is designed for indoor kitchen use and is not a single-use product, PVC is still considered safe. By using durable materials, the product lasts longer and the total waste production is reduced. In terms of design, users can grow plants on top of the compost bin, giving food waste a second life. This feature emphasizes the ethical principle of waste repurposing and supports the idea of closed-loop sustainability. Material selection is further explained in 7.4.1 Structure.

To reduce electricity consumption, the team integrates human power into the composting process. Instead of an electric grinder, the system works manually. This reduces energy dependency and encourages the participation of the user. In addition, carbon dioxide sensors record gas emissions, allowing users to monitor environmental impact in real time. Transparency in environmental impact is an important ethical consideration, so that users remain aware of their ecological footprint. The application guides users in composting efficiently, minimizing errors and reducing waste. This increases user involvement and encourages long-term use of the product, reinforcing ethical responsibility in daily routines. By fostering environmental awareness and ethical consumption, Loopbin contributes to a more sustainable future.

6.5 Liability

Manufacturers have legal responsibility to compensate users or consumers if a product or service is defective or malfunctions. This refers to liability. By ensuring product safety and compliance with industry regulations, risks can be minimised and consumer trust can be maintained.

Product Liability

The Loopbin contains mixers and sharp blades designed to mix and cut food waste into smaller pieces. To prevent injuries, the compost bin must be fully sealed to ensure that users cannot come into contact with the blades when rotating the mixer, especially if the compost bin is placed in kitchen, where child contact is possible. Additionally, a secure seal is necessary to prevent odors and remove pests or animals from being attracted to the food waste. Maintenance is another important aspect of product liability. Users must receive clear and detailed step-by-step instructions on how to safely remove and reassemble each component of the bin. Hence, our project has created a user manual to reduce the risk of improper handling, which could lead to injuries or product damage. The Loopbin integrates IoT functionality, including smart monitoring through a connected mobile application. To mitigate the cybersecurity risks, the app must follow industry best practices for cybersecurity, including data encryption, secure authentication protocols, and regular software updates. Users should also be informed about data privacy policies and how their information is collected, stored, and protected.

Warranty & Consumer Protection

Providing a comprehensive after-sales support system is necessary to maintaining consumer trust and ensuring compliance with consumer protection laws. The company must offer clear policies regarding product warranties, handling complaints, and addressing product recalls. If a product is found to be defective, customers should have access to refunds, replacements, or repair services. A well-defined customer support system should include multiple communication channels, such as email, phone, or FAQ section in the website and app.

Regulatory Compliance

To ensure that the Loopbin functions safely and effectively, it must comply with all relevant regulations and industry standards. Compliance with these standards not only prevents legal issues but also reinforces the credibility and reliability of the product. There are five directives are to be followed throughout the whole project.

- Electromagnetic Compatibility Directive (EMCD) discusses about the influence of electromagnetic distribution. Our product is integrating some sensors, microcontroller and a mobile app. These components emits electromagnetic signals. Hence, the directive is important to be followed to make sure when the product enters the market, it does not interfere with radio or telecommunication **[Entrepreneurship Industry Internal Market, SMEs, 2025]**.
- Low Voltage Directive (LVD) defines the acceptable range of voltage for the electrical equipments entering the market, which can protect the users from electrical hazards **[Entrepreneurship Industry Internal Market, SMEs, 2025]**.
- Machinery Directive (MD) ensures the safety requirements for machinery in terms of design, manufacture and operation, as well as regulates the machinery the EU's market for the first time **[Entrepreneurship Industry Internal Market, SMEs, 2025]**.
- Radio Equipment Directive (RED) describes the regulations for radio equipments for placing them into the market. This includes electromagnetic compatibility, the efficient use of radio spectrum and safety and health requirements **[Entrepreneurship Industry Internal Market, SMEs, 2025]**.
- Restriction of Hazardous Substances Directive (RoHS) restricts the use of certain hazardous substances in electrical and electronic devices, ensuring reduced impact for health and environment **[Entrepreneurship Industry Internal Market, SMEs, 2025]**.

6.6 Summary

By proactively addressing these ethical and deontogolical concerns, the Loopbin can deliver a safer and more reliable experience for consumers while minimizing legal and operational risks for the company. At the same time, consumer trust can be maintained.

Based on this ethical and deontological analysis, the team chose the bin's design with a growing space for plants, enclosed system for the bin, PVC as the main material for the compost bin, integrating human power on the mixing and grinding system, using reusable packaging solutions for generating a greener environment and protecting the users. Although PVC brings argumentative concerns for the environment, we believe that using the material in a smart way can reduce the impact to the environment.

The following chapter discusses the project development, starting from the early stage of ideation and designs until the final prototype.

7. Project Development

7.1 Introduction

This chapter describes the development of the Leftlovers Loopbin, detailing the entire process from initial concept to finished product. The first section explores the ideation phase, presenting the first design sketches of potential final products. This is followed by an in-depth look at the product concept and its functionality. Section four focuses on the design process, discussing the technical aspects

using a black box model and providing reasoning for material choices. The final part of the chapter covers the prototyping phase and the tests conducted to evaluate the product.

7.2 Ideation

The first brainstorms resulted in the idea to make a smart compost bin that monitors the quality and advices the user for improving the compost. The first drawings are shown in Figure 29.

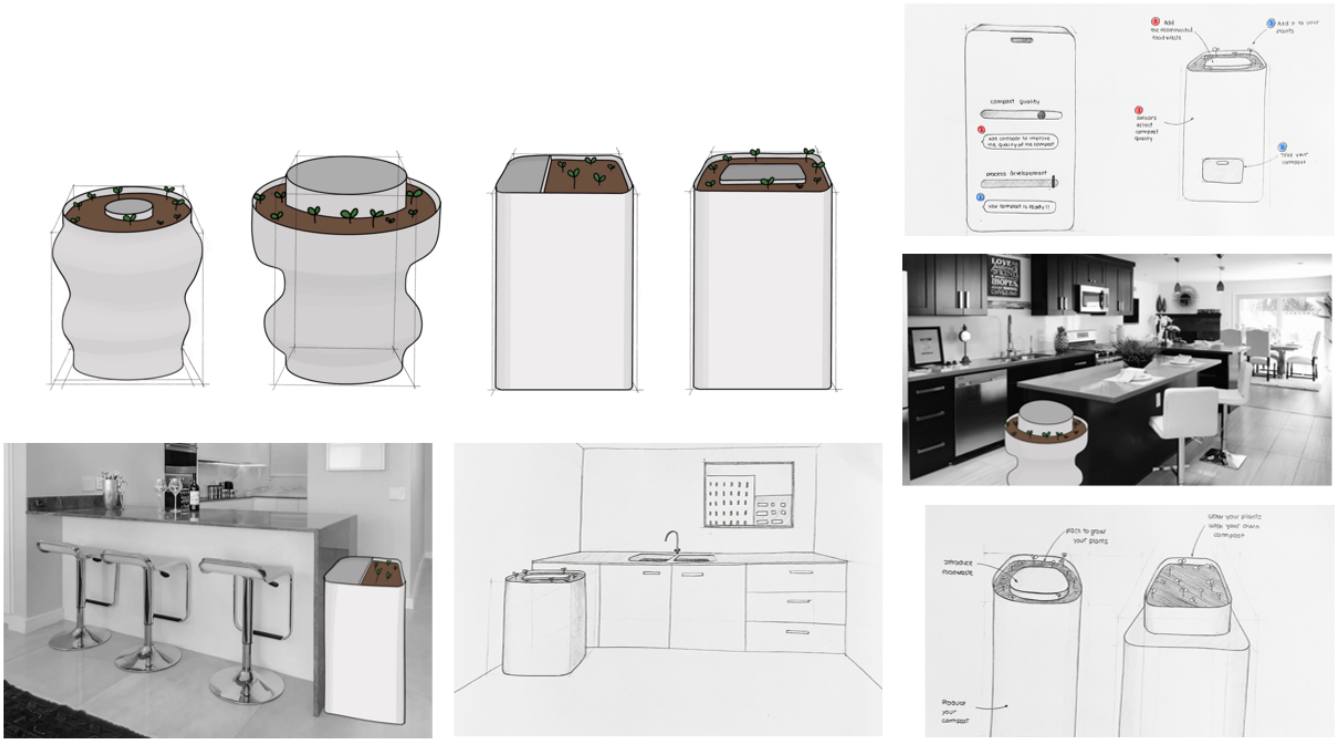


Figure 29: Composition First Ideas

7.3 Concept

After chapter 7.2 Ideation explains the basic idea of the Compost Bin, a detailed description of the concept follows, covering the key properties needed for an optimal composting process to create high-quality fertilizer. This concept is shown schematically in Figure 30 and is based on the theoretical foundations from chapter 2.2 Concepts. The input material for the Loopbin is food waste, which should ideally consist of a 50/50 mix of green and brown waste and should be added to the process continuously. Additionally, it is recommended to add mature compost at the beginning to start the composting process more effectively.

To speed up the composting process, a shredding step is carried out first. Then it must be checked wether the composting process is completely finished. This is done by checking soil parameters such as temperature and moisture and analyzing the gas composition. These values are displayed to the user via an app, which also provides instructions for further steps. These instructions may encourage the user to take active steps needed to properly manage the composting process. Since turning the compost only needs to be done twice a week, this task is performed manually by the operator. This ensures user involvement in the process and helps reduce costs. Additionally, an automated ventilation system ensures proper airflow, creating optimal conditions and preventing unpleasant odors. Through this optimized composting process, it becomes possible to produce high-quality fertilizer for plants, which will also serve as the base for a plant box on top of the Loopbin. The

Loopbin will cost 400 €, with a process time of 4 to 6 weeks. The odor will be controlled by maintaining a healthy compost mix by monitoring and controlling ventilation and formed gases. The daily capacity will be 0.350 kg and will have to be emptied around every 4 weeks.

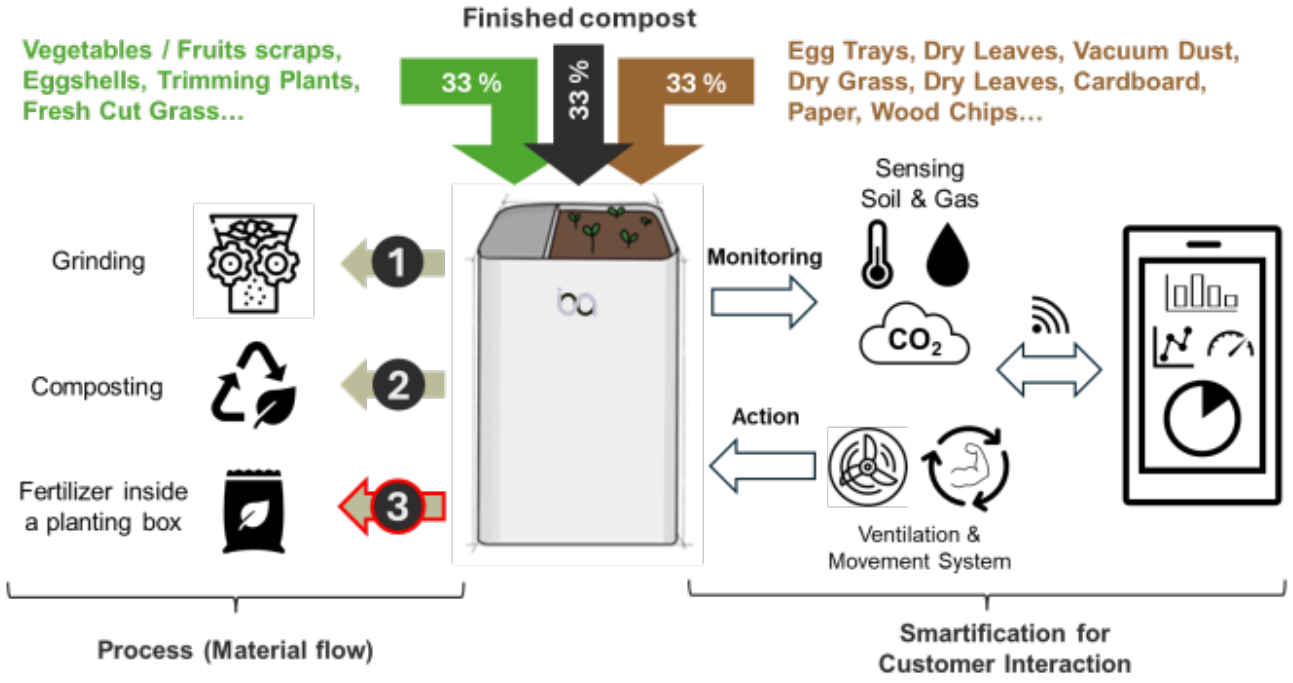


Figure 30: Concept of the LeftLovers Loopbin

7.4 Design

7.4.1 Structure

Initial Structural Drafts

By combining theoretical knowledge, initial conceptual sketches, and the developed concept, it was possible to create the first function-specific drawings of the Loopbin. Figure 31 presents a collection of different illustrations that highlight the various functions of the system.

The left diagram shows the basic structure of the Loopbin, including the functional areas and how the ventilation system is integrated. The middle diagram illustrates the key functions of the shredding and composting process.

At the top layer, food waste can be continuously added. This layer serves as a storage area, but the composting process begins here. A mixing system shreds the material and a soil sensor measures temperature and moisture to ensure optimal conditions for the composting layer below.

A manual lever mechanism moves the food waste to the composting layer, where the entire composting process takes place. A movement system keeps the compost in motion. This layer also contains another soil sensor and a gas sensor, which monitors the atmosphere. Based on theoretical findings, different gases (O_2, CO_2, MH_4) can be used for monitoring. A follow-up analysis will determine which specific gases should be measured to ensure optimal composting conditions.

Once the composting process is complete, a mechanical floor drop mechanism transfers the finished compost into a storage box, which also serves as a plant box for growing herbs on top of the Loopbin.

The app displays notifications to inform the user when to perform manual tasks such as turning the compost and emptying the chamber. While the turning process may vary based on sensor readings to create the optimal environment as outlined in the theoretical foundations, the emptying of the chambers occurs every three weeks. This duration, as indicated by the state of the art analysis, is considered ideal for composting shredded and pre-composted food waste, meeting the requirement for composting to be completed within a few weeks. The illustration on the right provides an isometric view of the entire system.



Figure 31: First Structure of the LeftLovers Loopbin

Material Selection

Material selection is a critical step in designing functional and durable products, as it directly influences performance, cost, and user experience. When choosing materials, engineers and designers must consider factors such as strength, weight, corrosion resistance, thermal properties, manufacturability, and environmental impact. For indoor compost bins, the material must withstand moisture, resist odors, and maintain structural integrity while remaining lightweight and easy to maintain. This report evaluates suitable materials based on their properties and suitability for composting applications.

Table 28: Plastic Comparison

Plastic type	Pros	Cons	Possibility of 3D-Printing	Price per m²*
Polyethylene (PP)	Lightweight, recyclable, resistant to moisture, can trap heat, can withstand bending without breaking	Have limitations when exposed to strong oxidizing acids and some chlorinated hydrocarbons	Yes, but poor adhesion	1.50-3 €

Plastic type	Pros	Cons	Possibility of 3D-Printing	Price per m²*
Polypropylene (PP)	Lightweight, stronger and more rigid than HDPE, lightweight, good heat retention	Highly flammable, susceptible to UV degradation and oxidation	Yes	1-3 €
Polyvinyl chloride (PVC)	More rigid than HDPE	Heavier than HDPE, Harder to recycle, Contains chlorine, which can release harmful dioxins during production and disposal, can degrade over time outdoors	Yes, but not common	2-4 €
Polylactic Acid (PLA)	Polyester made from renewable biomass, enviromental friendly, recyclable, industrially compostable	May absorb water	Yes	2.60 €
Acrylonitrile Butadiene Styrene	Strong and rigid, resistant to wide range of chemicals, surface furnish	Less eco friendly (harder to recycle), low resistance to fire, degrade when exposed to sunlight	Yes	1.80-4.30 €

After the team discussion, polyvinyl chloride (PVC) is chosen as the primary material for castings due to its suitability for indoor composting applications. As a widely used plastic, PVC offers several advantages: it is naturally moisture-resistant, which is essential for long-term exposure to compost liquids, and its rigid structure eliminates the need for elastic components. PVC also provides thermal insulation, which keeps the temperature inside the bin stable and reduces energy consumption for decomposition. Its light weight improves usability and makes cleaning and maintenance easier for household users. While PVC is technically feasible for 3D printing, its practicality is limited due to concerns about chlorine gas emissions during the printing process, as noted in several studies.

Table 29: Metal Comparison

Metal type	Composition	Pros	Cons	Price per metric ton*
Stainless steel	Composed of iron and carbon, with at least 10.5 % chromium by mass for its corrosion resistance	Highly durable, rust-resistant	Heavy, expensive	1730 €
Galvanized steel	A coating of zinc is applied to steel or iron to offer protection and prevent rusting	Durable, cheaper than other metals	Coating can wear off over time, it will eventually rust	230 €

Metal type	Composition	Pros	Cons	Price per metric ton*
Aluminium	/	Rustproof, lightweight, good heat retention	Can dent easily, soft metal, can react with acidic compost over time	1770 €

**Prices are subject to change based on market fluctuations and supplier pricing.*

For critical mechanical components such as the grinder and the mixers, stainless steel is chosen for its superior durability and corrosion resistance. Stainless steel is an iron-based alloy with a minimum of 10.5 % chromium, which prevents rusting even when exposed to moist food waste. This makes it ideal for high-stress, long-term applications where hygiene and structural integrity are priorities. The combination of PVC for the main bin structure and stainless steel for moving parts ensures a balanced approach, optimizing both performance and cost-effectiveness.

Mixing Part

After researching different kinds of mixers, the peddle blending mixer was chosen as the best choice for the product as it is used for mixing liquids and solids in food processing and pharmaceutical industry. An advantage of the paddle blending mixer is that it is still effective with a capacity of 20%. As the chambers of the product will not always be completely filled, this is an important factor.

Another option was an Archimedes screw. This mixer type is used in industrial applications such as on farms. A disadvantage of this type of mixer in a vertical use, is that the food waste has to be mixed multiple times to get small enough for an effective composting process. When used in an horizontal way, sharp edges were added to the Archimedes screw to cut the food waste. This application only worked on a high speed and would ask a powerful motor to make it function. The ribbon mixer is also an option but due to a difficult design the paddle blending mixer is a preferred choice.

An overview of the different mixers is seen in Figure 32.



Figure 32: Different Mixers: paddle blending mixer - Archimedes screw - ribbon mixer

To combine the mixing and cutting part, sharp cutting parts are added to the floor of the first chamber to avoid the need to clean a separate shredder. This cutting parts will be surrounded by compost that will avoid rotting of food waste that sticks to the parts as these will be broken down into

compost. As the cutting and mixing part are combined, these parts will be designed by the team.

Detailed Drawings

The current design and main functions of the Loopbin are shown in Figures 33 and 34. To create a strong and attractive market appearance, the Loopbin has been given a modern and appealing look. It will be available in different colors, as shown in Figure 33.



Figure 33: Design of the Loopbin

Figure 34 also shows the key functions of the stirring system and how each layer can be opened. Both layers use the same basic stirring mechanism, which is operated by a lever. However, the first (top) layer includes extra blades that are used to shred food waste.

The detailed views show how the layers can be opened: by pulling out a pin, one layer can be opened (see top image). Pushing the pin back in will close it again (see bottom image). After this interim report, the next step in the design process will be to improve this mechanism and add technical parts like bearings.

In addition, Figure 34 also shows that the plant box and the fertilizer storage box have the same construction. This helps to improve the functionality and flexibility of the Loopbin.

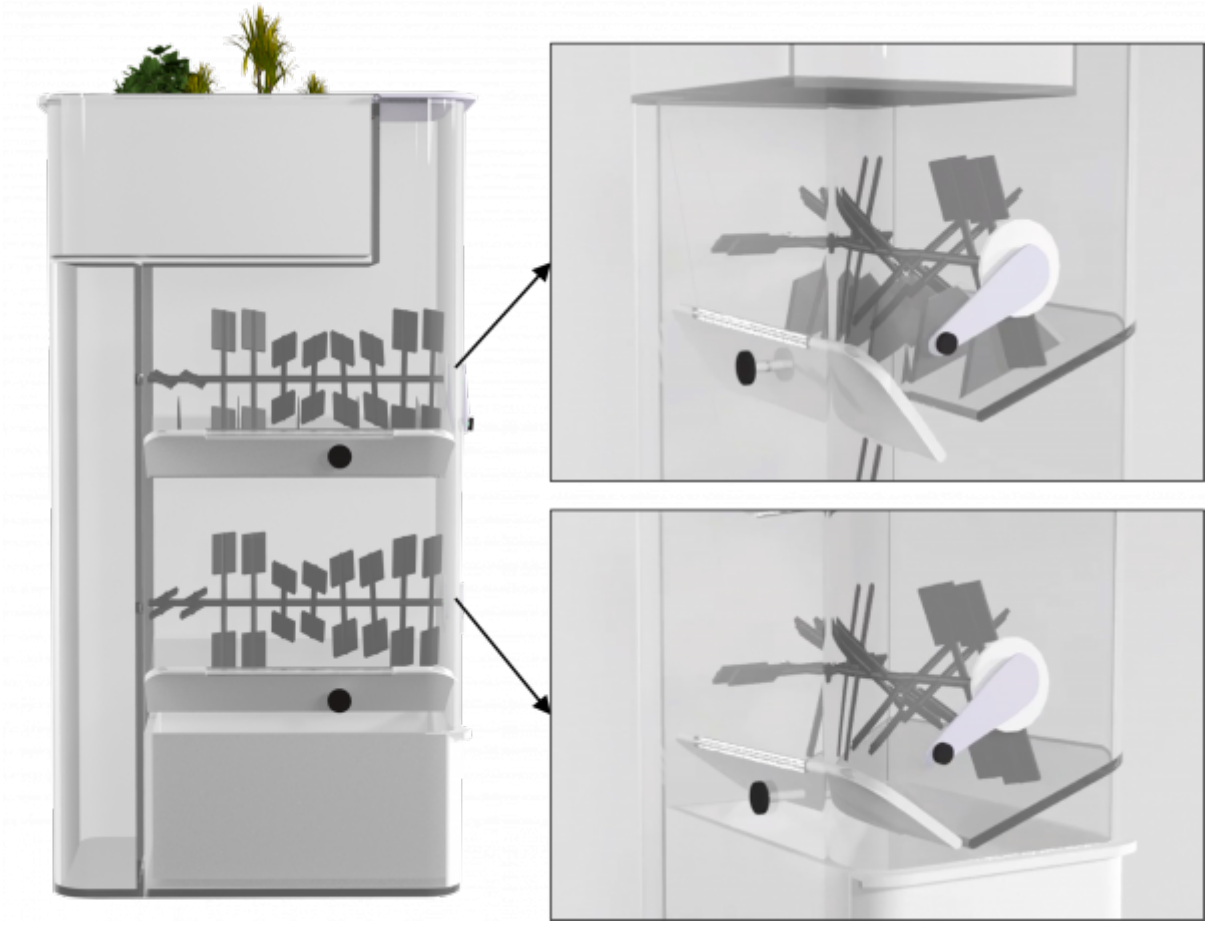


Figure 34: Functions of the Loopbin

In the following schematics, show in Figure 35, it is displayed how the components are placed inside the bin.

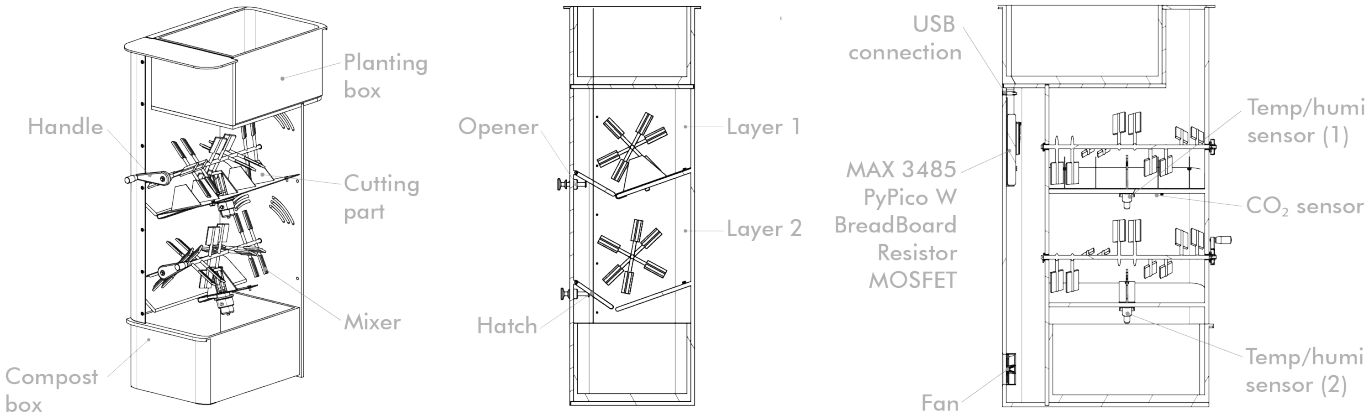
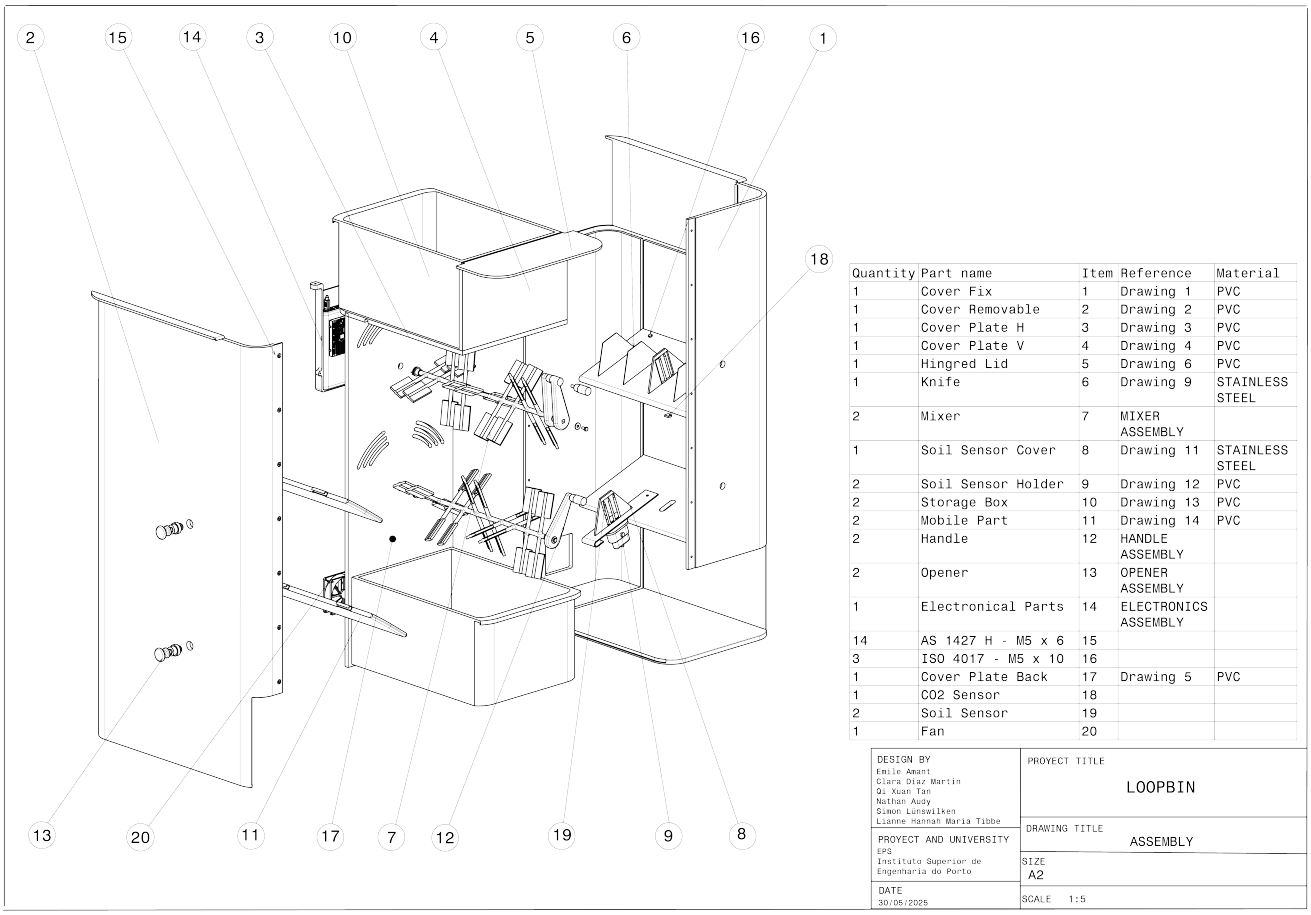


Figure 35: Loopbin schematics

The drawings of the product include the assembly of the components and the geometry of the different elements. In the Figures 36, 37, 38, 39, 40 the assembly drawings are presented.



Quantity	Part name	Item	Reference	Material
1	Cover Fix	1	Drawing 1	PVC
1	Cover Removable	2	Drawing 2	PVC
1	Cover Plate H	3	Drawing 3	PVC
1	Cover Plate V	4	Drawing 4	PVC
1	Hingred Lid	5	Drawing 6	PVC
1	Knife	6	Drawing 9	STAINLESS STEEL
2	Mixer	7	MIXER ASSEMBLY	
1	Soil Sensor Cover	8	Drawing 11	STAINLESS STEEL
2	Soil Sensor Holder	9	Drawing 12	PVC
2	Storage Box	10	Drawing 13	PVC
2	Mobile Part	11	Drawing 14	PVC
2	Handle	12	HANDLE ASSEMBLY	
2	Opener	13	OPENER ASSEMBLY	
1	Electronical Parts	14	ELECTRONICS ASSEMBLY	
14	AS 1427 H - M5 x 6	15		
3	ISO 4017 - M5 x 10	16		
1	Cover Plate Back	17	Drawing 5	PVC
1	CO2 Sensor	18		
2	Soil Sensor	19		
1	Fan	20		

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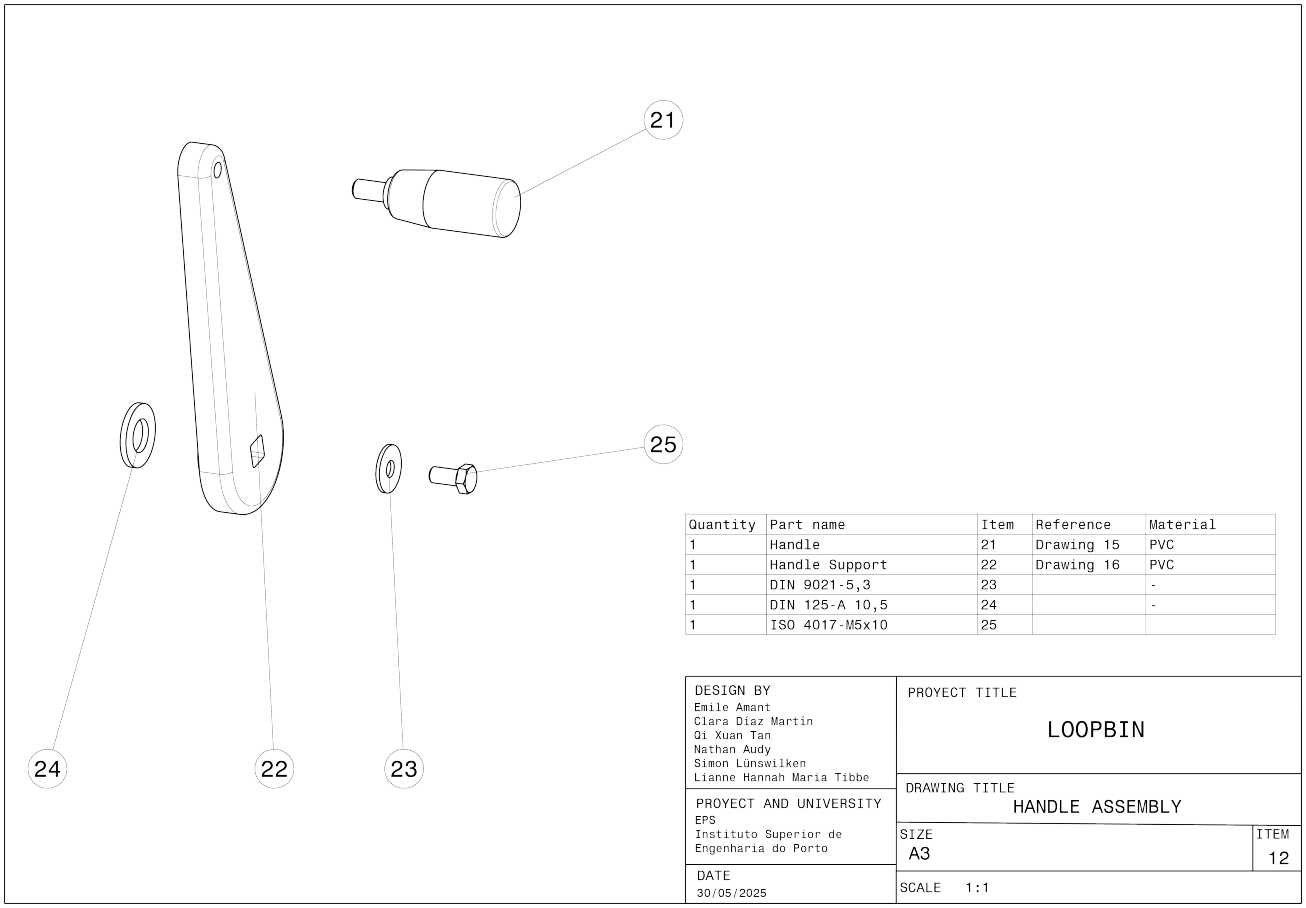
PROYECT TITLE
LOOPBIN

DRAWING TITLE
ASSEMBLY

SIZE
A2

SCALE 1:5

Figure 36: Assembly



Quantity	Part name	Item	Reference	Material
1	Handle	21	Drawing 15	PVC
1	Handle Support	22	Drawing 16	PVC
1	DIN 9021-5,3	23		-
1	DIN 125-A 10,5	24		-
1	ISO 4017-M5x10	25		

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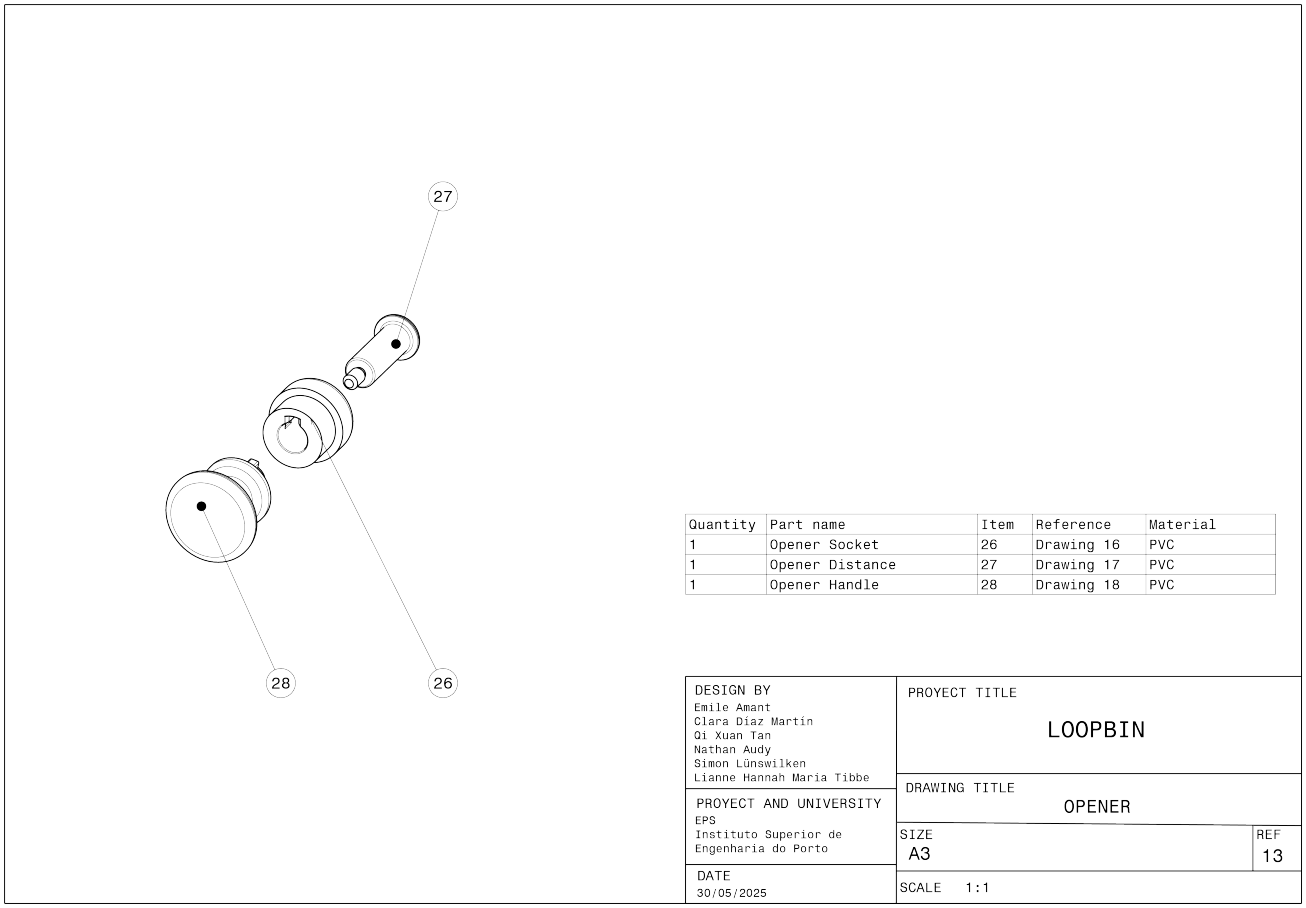
DRAWING TITLE
HANDLE ASSEMBLY

SIZE
A3

ITEM
12

SCALE 1:1

Figure 37: Handle Assembly



Quantity	Part name	Item	Reference	Material
1	Opener Socket	26	Drawing 16	PVC
1	Opener Distance	27	Drawing 17	PVC
1	Opener Handle	28	Drawing 18	PVC

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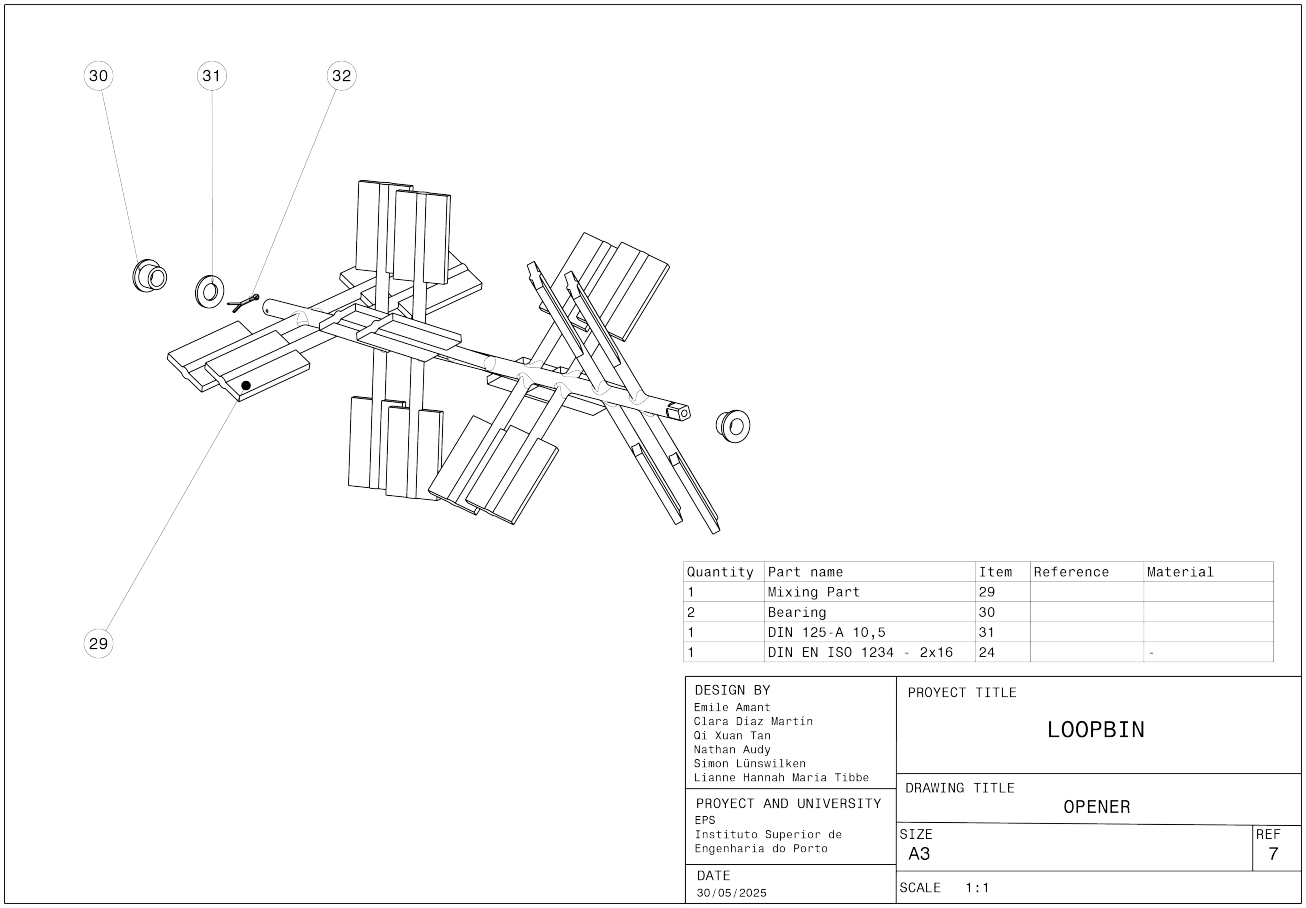
DRAWING TITLE
OPENER

SIZE
A3

REF
13

SCALE 1:1

Figure 38: Opener Assembly



Quantity	Part name	Item	Reference	Material
1	Mixing Part	29		
2	Bearing	30		
1	DIN 125-A 10,5	31		
1	DIN EN ISO 1234 - 2x16	24		-

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PROYECT TITLE
LOOPBIN

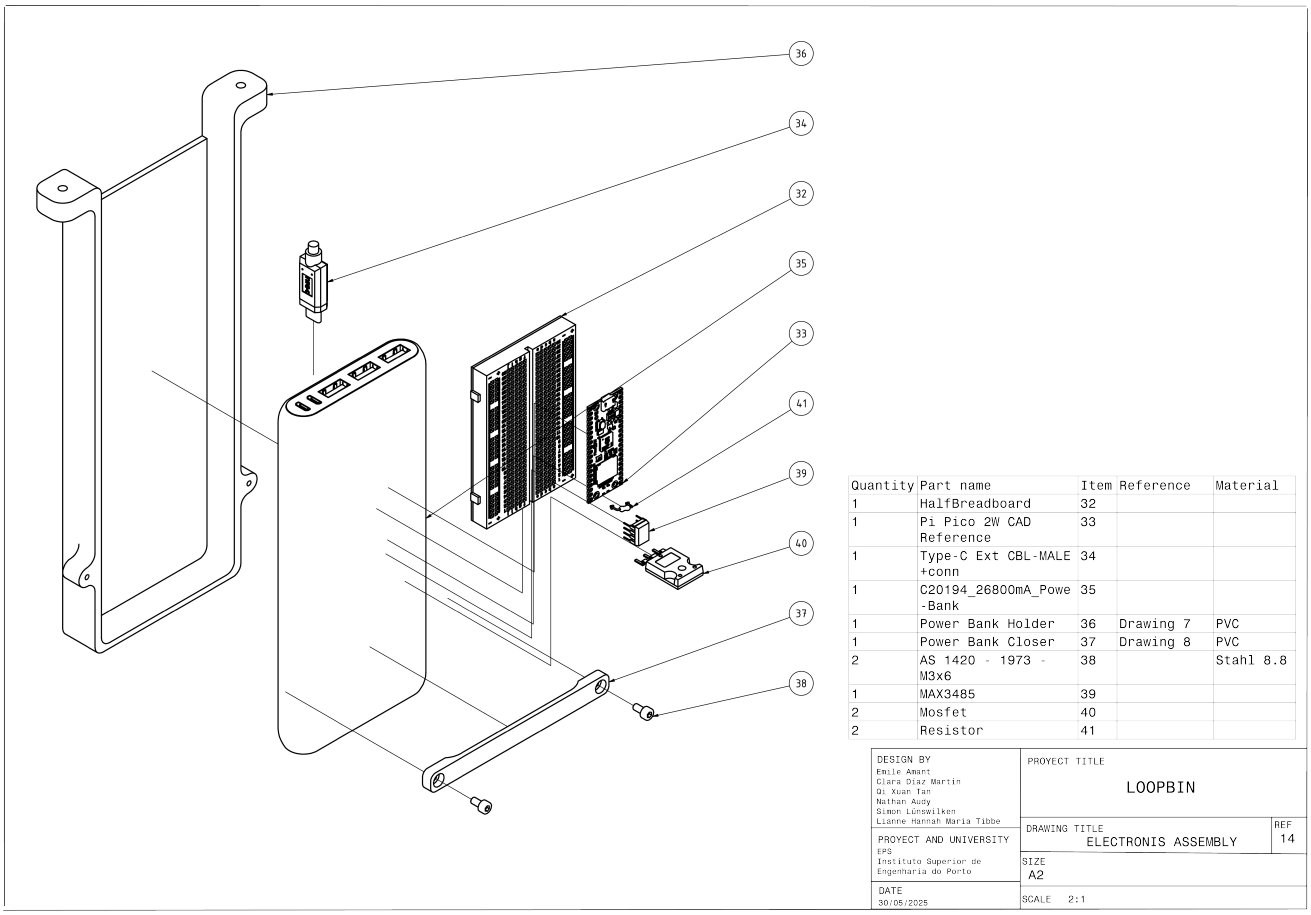
DRAWING TITLE
OPENER

SIZE
A3

REF
7

SCALE 1:1

Figure 39: Mixer Assembly



Quantity	Part name	Item	Reference	Material
1	HalfBreadboard	32		
1	Pi Pico 2W CAD Reference	33		
1	Type-C Ext CBL-MALE +conn	34		
1	C20194_26800mA_Powe -Bank	35		
1	Power Bank Holder	36	Drawing 7	PVC
1	Power Bank Closer	37	Drawing 8	PVC
2	AS 1420 - 1973 - M3x6	38		Stahl 8.8
1	MAX3485	39		
2	Mosfet	40		
2	Resistor	41		

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DATE
30/05/2025

PROYECT TITLE
LOOPBIN

DRAWING TITLE
ELECTRONIS ASSEMBLY

REF
14

SIZE
A2

SCALE 2:1

Figure 40: Electronics Assembly

The following attached document includes all the part drawings developed.

Drawings

Link

3D model with load and stress analysis

To make sure the final product is strong enough, a strength analysis was done. Each part of the Loopbin needed clear boundary conditions. To make the analysis more efficient, the Loopbin was divided into several logical sections, as shown in Figure 41. It made sense to study the moving parts like the mixer and the handle separately from the solid, non-moving parts of the structure, which is divided in the housing, lid, knife and locker.

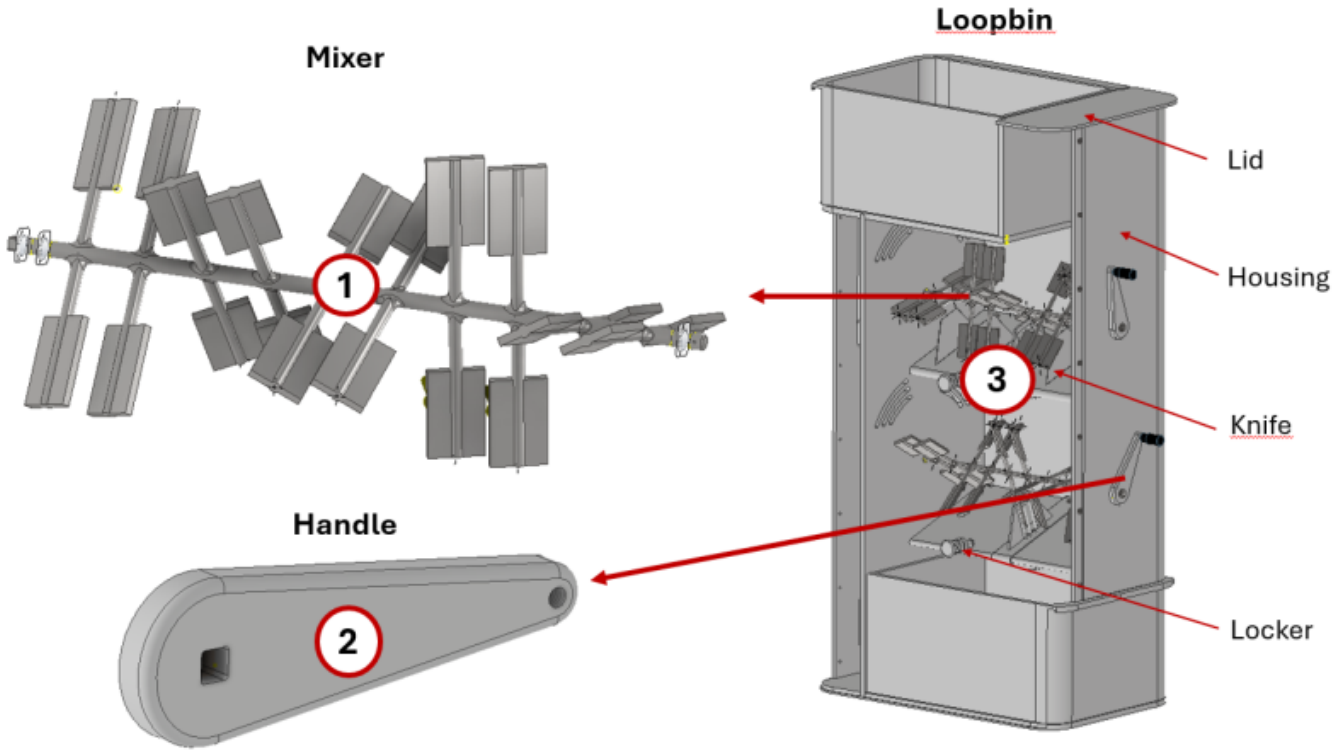


Figure 41: Procedure for strength analysis

All parts were analyzed in Autodesk Inventor using the material properties of each component. The parts discussed in the following sections are based on the material data listed in Table 30. The goal was to design all parts so that the stress levels would stay below the material's yield strength. The results of the analysis are shown in Table 30, and they confirm that all parts are strong enough.

The next sections explain the analysis in more detail.

Table 30: Results stress analysis

Part	Material	Yield Strength	Max. Stress	Result
Mixer	X5CrNi18-10	225 MPa	213 MPa	Pass
Knife	X5CrNi18-10	225 MPa	80 MPa	Pass
Handle	PVC	40 MPa	22.4 MPa	Pass
Lid	PVC	40 MPa	10.1 MPa	Pass
Locker	PVC	40 MPa	24.2 MPa	Pass
Housing	PVC	40 MPa	11 MPa	Pass

1. Mixer

The setup for the mixer is shown in Figure 42. It is made of stainless steel that is safe for food contact. Because the blades are placed at different angles, only one pair of blades cuts at a time. The other blades just help with mixing. For a maximum load of ten kilograms, only about two kilograms are active during cutting, which leads to a force of around twenty newtons per blade pair in the analysis.

To estimate the cutting force, tests were done using hard food items like apples and potatoes on a scale. These tests helped define a worst-case scenario. Based on this, a maximum cutting force of two hundred newtons was chosen, including a safety margin.

The mixer is supported by a sliding bearing. One side is fixed both in the radial and axial directions. The other side is fixed only in the radial direction. The ability to rotate around the main axis was blocked at the handle position.

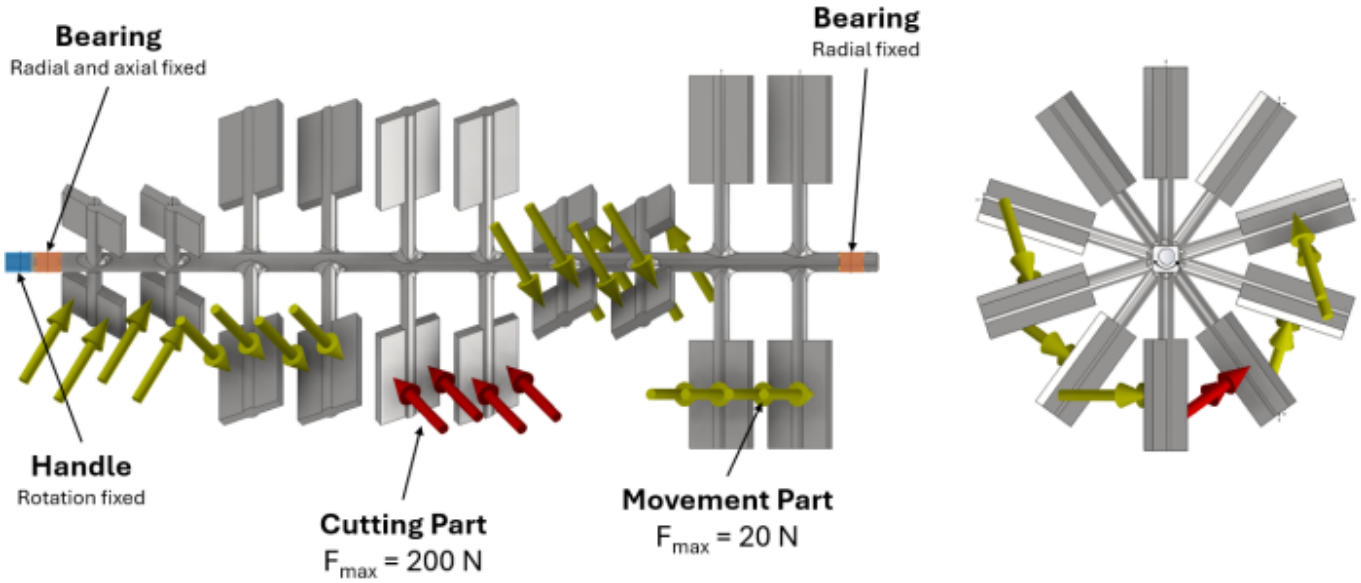


Figure 42: Boundry conditions mixer

The model was built using tetrahedral elements with square shapes. The mesh was made finer in critical areas where high stress was expected, such as the corners between the mixer and the shaft. In those zones, at least eight elements were placed around a ninety degree angle to ensure accurate results. Convergence studies were also carried out to check that the results are reliable. The results of the strength analysis are shown in Figure 43. They show that all stresses are well below the allowed material limits. This confirms that the mixer is strong enough for use. The reaction forces at the support points from the previous analysis are also used as boundary conditions for the following analyses.

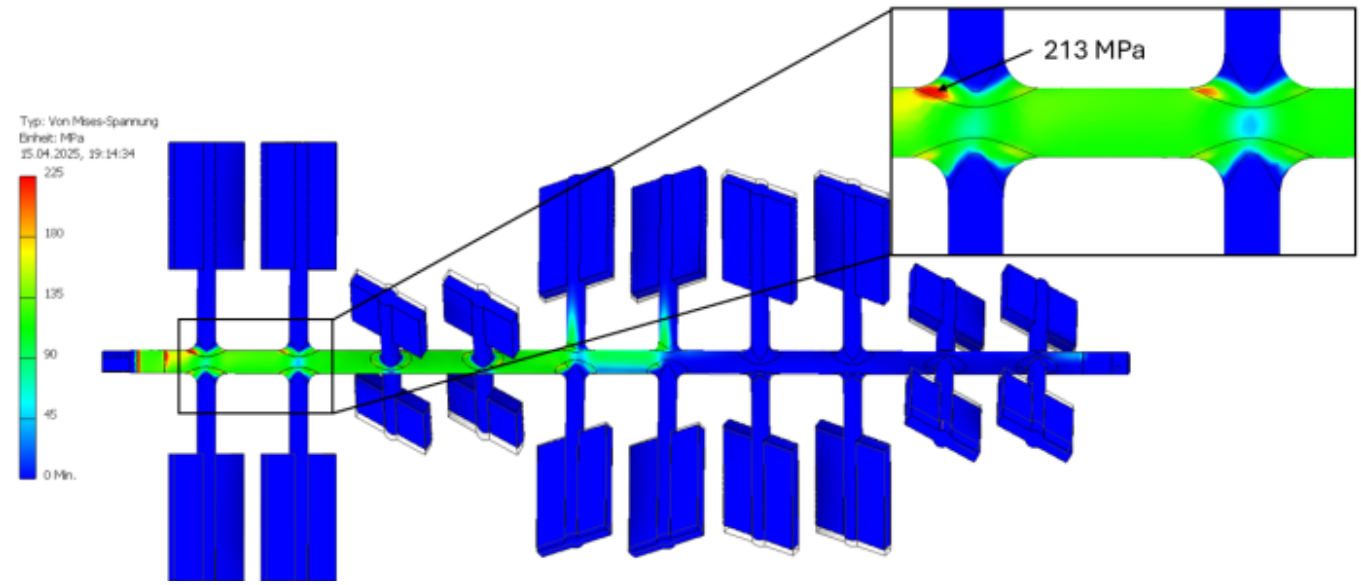


Figure 43: Stress analysis mixer

2. Handle

The boundary conditions and the analysis results for the handle are shown in Figure 44. At the

connection point to the mixer, a fixed support was applied that blocks all degrees of freedom. Based on the reaction forces at this point from the previous mixer analysis, a force of about 200 newtons acts at the crank point. This value corresponds roughly to the reaction force identified in the mixer results. The strength analysis of the handle shows a maximum equivalent stress of 22.4 megapascals.

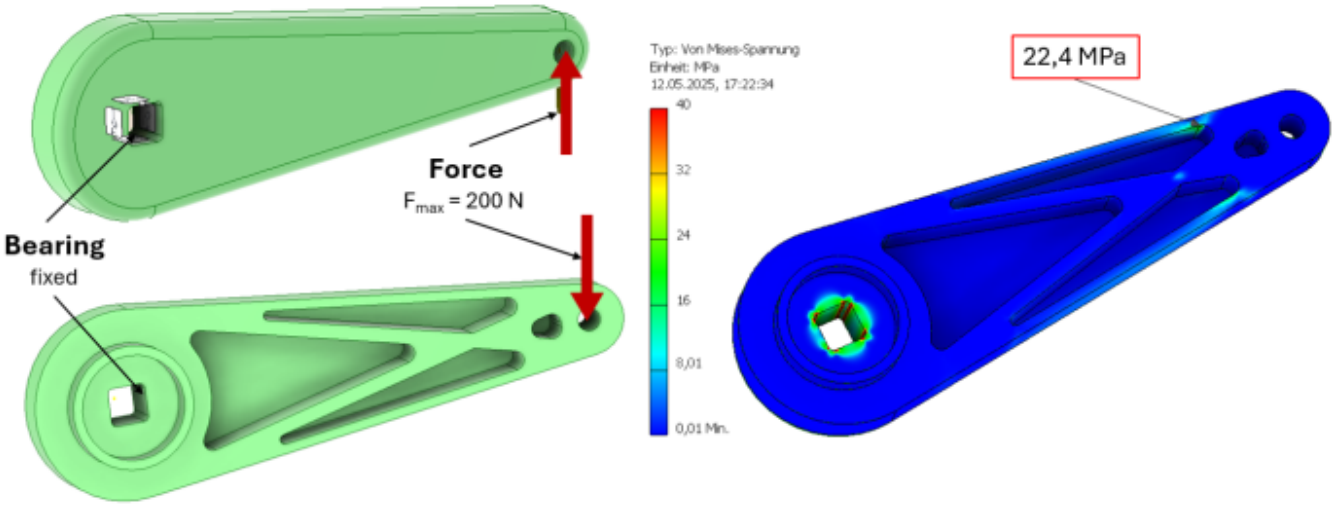


Figure 44: Stress analysis handle

3. Structure

Finally, the remaining structure of the Loopbin was analyzed. For this purpose, appropriate boundary conditions were defined. As shown in Figure 45, the support reactions from the mixer analysis were included. In addition, the following loads were taken into account:

- A maximum food waste load of 10 kg per layer,
- An equivalent cutting force of 200 N, as used in the mixer analysis,
- The gravitational force acting on all components,
- Two misuse cases: placing heavy objects on the structure and applying a sideways kick.

These scenarios were considered to ensure the structure remains strong even under unintended use.

The structure was fixed at the base to simulate full support. Tetrahedral elements with square shape were used again, and the mesh was refined according to expected stress concentrations. Convergence studies confirmed that the mesh quality was sufficient for reliable results.

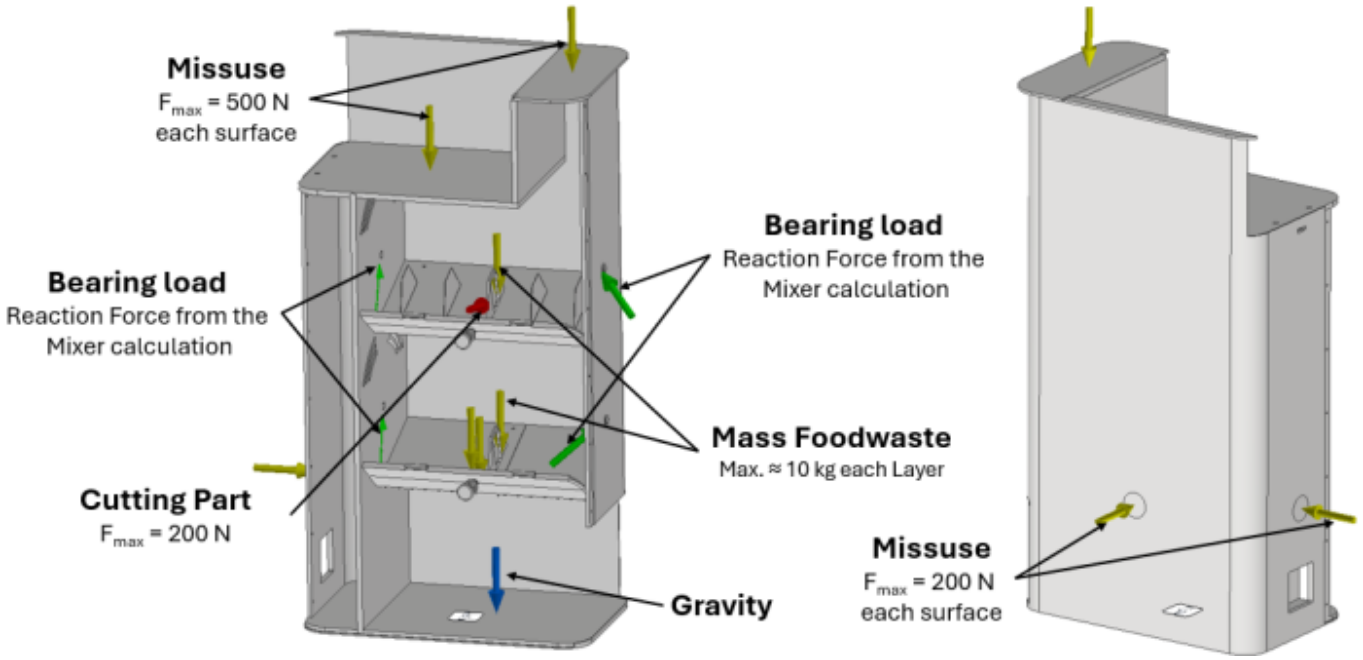


Figure 45: Boundry conditions of the Loopbin structure

The first part of the analysis focused on the housing, as shown in Figure 46. The highest stress was found at the notch near the movable lid, reaching eleven megapascals. Compared to the yield strength of PVC (40 MPa), this indicates sufficient strength. The remaining parts of the housing showed very low stress values, suggesting possible overdimensioning. This insight can be used in future design updates to reduce material use and improve sustainability.

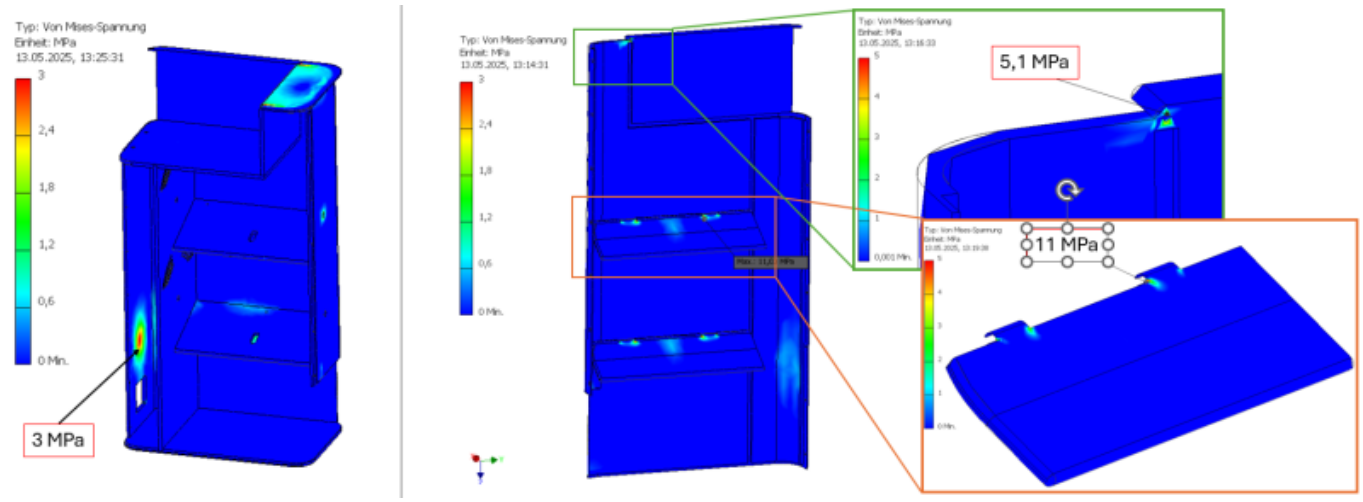


Figure 46: Stress analysis Loopbin Housing

Figure 47 shows the analysis results for the lid and the locking mechanism. These components are also intended to be made of PVC. Both the lid and the lock showed maximum stresses well below the material limits, confirming that the design is strong enough.

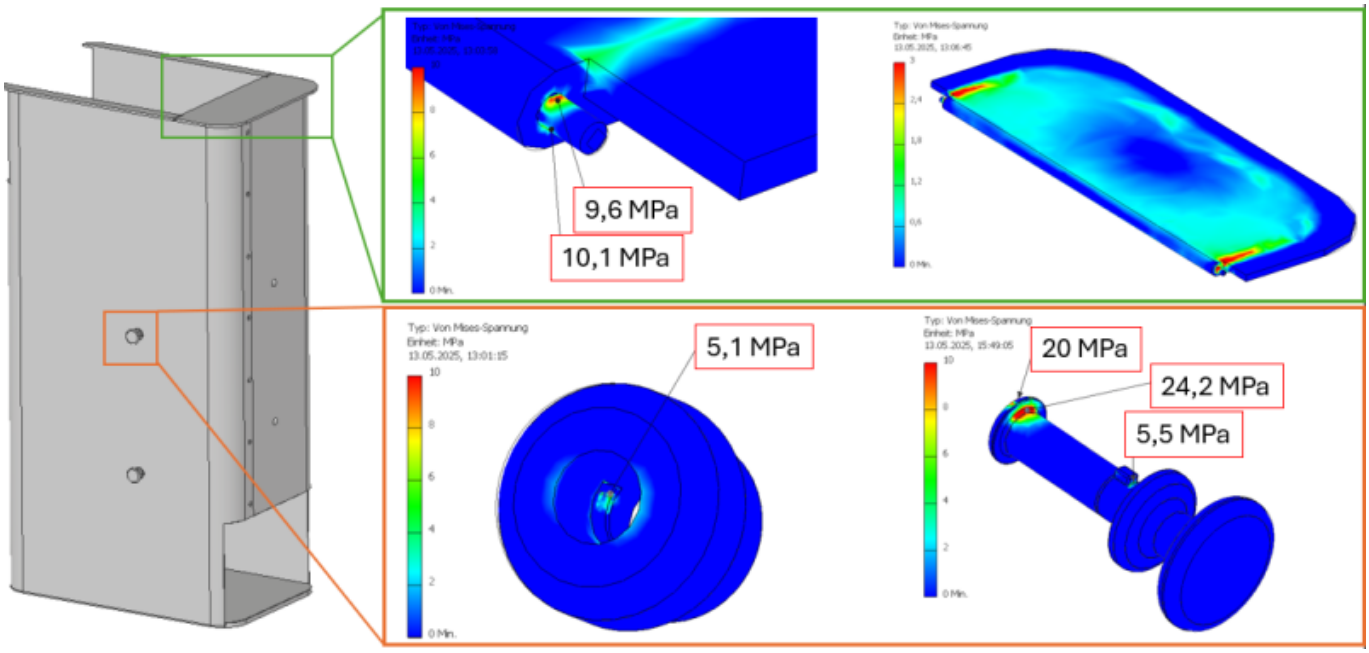


Figure 47: Stress analysis Loopbin lid and locker

Finally, the stress distribution on the knife was analyzed, as shown in Figure 48. Two different loading scenarios were considered to reflect all possible operating conditions. The maximum equivalent stress reached eighty megapascals. Since this part is made of stainless steel, the stress is well below the material's yield strength, confirming that the design is safe and reliable.

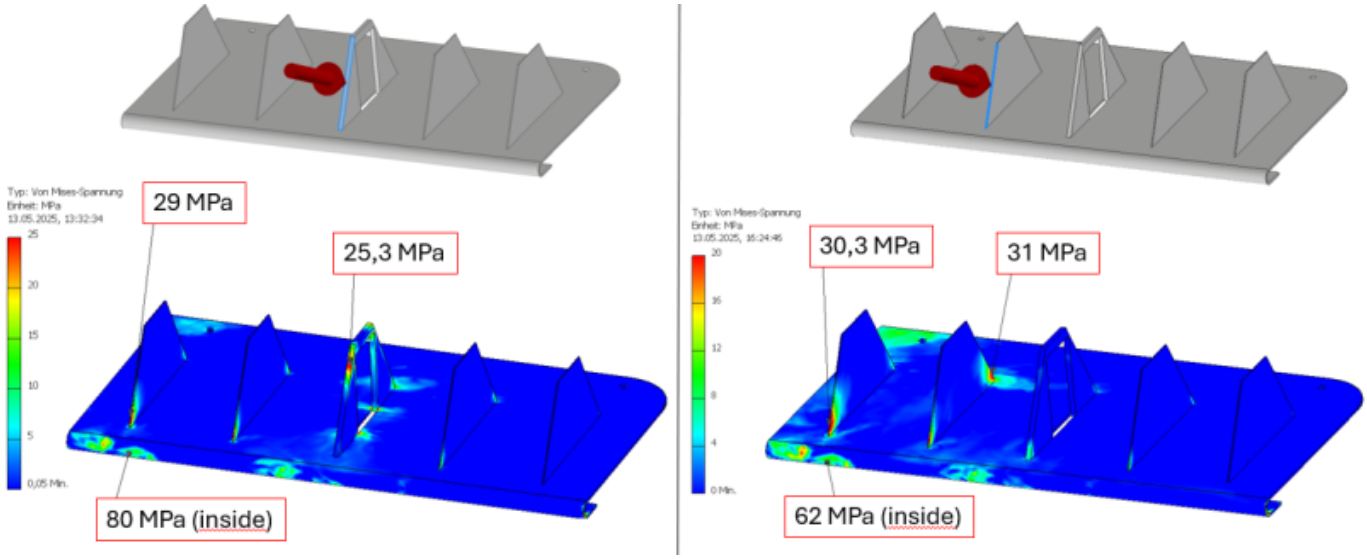


Figure 48: Stress analysis Loopbin knife

Colour Palette

Providing the product with a colour palette, is a strategic decision, as it affects to public perception, brand identity and user behaviour. In order to select a proper chromatic scheme, it is important to consider different aspects like colour psychology and brand values.

Taking that into account, it has been defined a palette composed of four hues. The first one, a soft lavender provides the user with a calm feeling and innovation. The soft green is related to freshness and nature. The combination of these two colours creates a balance between the physical and emotional. Using them together, it is given an image of growth, renewal and fresh elegance. The grey and the dark brown are the elections for the neutral hues, acting as a foundation for the colour

palette. In consequence they do not boldly or grab attention. The grey, which feels stable and reliable, is often used by tech companies. On the other hand, the dark brown is related with the earth, reinforcing the connection between Loopbin and nature.

As a result, the palette shown in Figure 49 has been obtained. These colours will be used for the branding and the product aesthetics.



Figure 49: Colour palette

7.4.2 Smart System

7.4.2.1 Hardware

Black box diagram

The Black-Box model of the Loopbin, shown in Figure 50, illustrates how the system works and its key functions. The LeftLovers Loopbin processes food waste and turns it into nutrient-rich fertilizer. With an integrated garden for plants, this fertilizer can be used directly for plant growth. The system therefore produces not only fertilizer but also fresh herbs—and optionally vegetables— that are grown with the help of the compost. Additionally, an external energy source is needed to power various functions.

Each time food waste is added to the Loopbin, it is first chopped into smaller pieces and stored in the upper section. A movement system helps with both chopping and mixing the waste. At the same time, a ventilation system provides enough oxygen to start the composting process. Sensors in this section measure key factors such as temperature, humidity and air quality to ensure optimal conditions.

In the second, enclosed composting space, the monitoring process continues. Sensors continue to monitor environmental conditions, while a movement system and an additional ventilation system help regulate the composting process.

A central controller manages the entire system and sends the collected data to a connected app. This app shows the current composting conditions and provides guidance for the user to optimize the process.

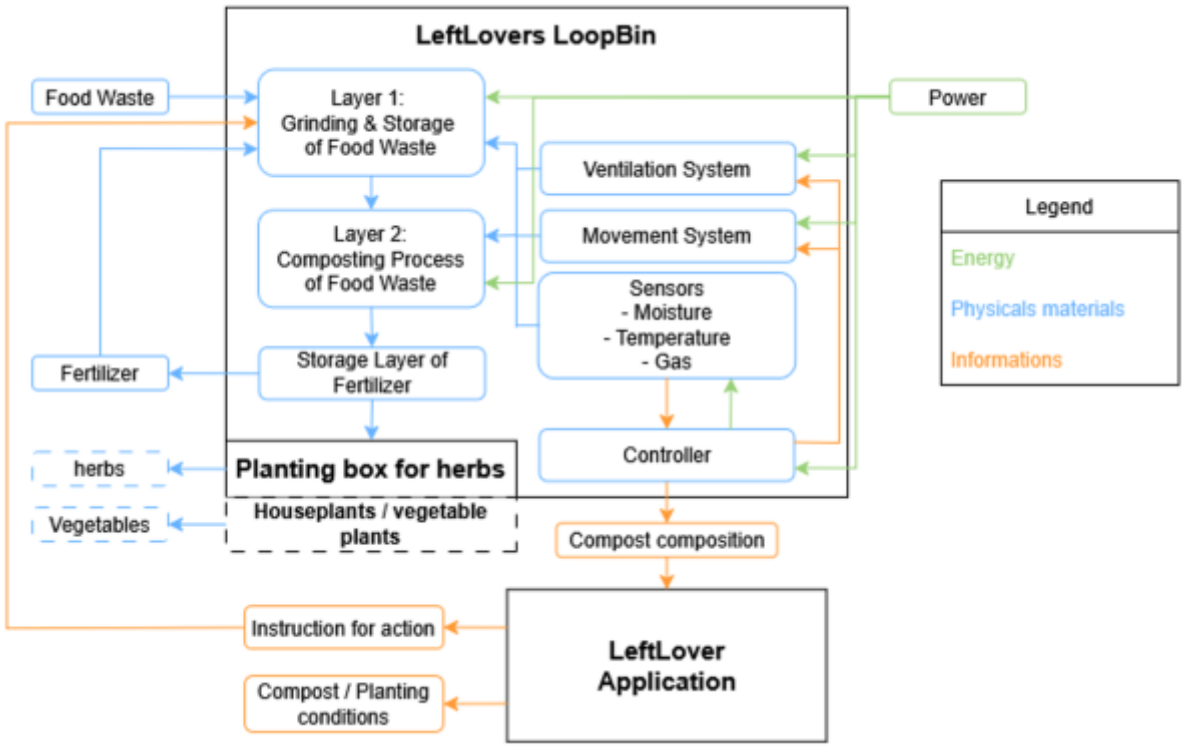


Figure 50: Black Box Model

Hardware component selection

Since all movements only need to be performed a few times per week, they are operated manually and determined by the design of the system. The components used for the monitoring process are standard purchased parts, meaning suitable components must be selected.

The table 31 presents various sensor options for monitoring compost composition. It is advisable to select a sensor that measures both temperature and moisture. Low-cost options like the STEMMA Soil Sensor lack detailed accuracy specifications and require calibration for accurate moisture readings, making them less suitable. Considering price and performance, the SEN0600 sensor is particularly appropriate for this application and has been selected accordingly.

Table 31: Soil Sensor Comparison

Name	**STEMMA Soil Sensor**	**SEN0308**	**S-Soil MT-02A**	**SEN0600**	**SEN0602**	**DS18B20**	**Decagon EC-5**
Supplier	Adafruit	DFRobot	Seeed Technology	DFRobot	DFRobot	Dallas Semiconductor / Maxim Integrated	Meter Group
Price	7.15 €	14.07 €	75.32 €	27.65 €	56,05 €	~ 4 €	~ 200 €
Measurement	Moisture & Temperature	Moisture	Moisture & Temperature	Temperature, Moisture	Temperature, Moisture, and pH	Temperature	Moisture
Power supply	3 - 5 V	3.3 - 5.5 V	3.6 - 30 V	5 - 30 V	5 - 30 V	3 - 5 V	2.5 - 3.6 V
Dimensions	76.2 mm x 14.0 mm x 7.0 mm	175 mm x 30 mm	123 mm x 45 mm x 15 mm	123 mm x 45 mm x 15 mm	123 mm x 45 mm x 15 mm	Cable length usually 1 m or more	89 mm x 18 mm x 8 mm

Name	STEMMA Soil Sensor	SEN0308	S-Soil MT-02A	SEN0600	SEN0602	DS18B20	Decagon EC-5
Communication	I2C	Analog	RS-485	RS-485	RS-485	Digital	Analog
Range Temp.	Temperature not mentioned	-	-40 °C to +80 °C	-40 °C to +80 °C	-40 °C to +80 °C	-55 °C to + 125 °C	-
Range Moisture	200 (very dry) to 2000 (very wet)	540 (very dry) to 0 (very wet)	0 % - 100 %	0 % - 100 %	0 % - 100 %	-	0 % - 100 %
Accuracy Temp.	± 2 °C	-	± 0.5 °C	± 0.5 °C	± 0.5 °C	± 0.5 °C	-
Accuracy Moisture	Humidity not mentioned in datasheet	Humidity not mentioned in datasheet	±3 % (0 % - 50 %); ±5 % (50 % -100 %)	±2 % (0 % - 50 %); ±3 % (50 % -100 %)	±2 % (0 % - 50 %); ±3 % (50 % -100 %)	-	±3 %

In addition to the soil conditions, the composition of the compost atmosphere provides key indicators for a successful composting process. Particularly important are the O_2 and CO_2 levels near the compost. Table 32 shows suitable sensors for monitoring these values. It turns out that monitoring the CO_2 level is more cost-effective than monitoring the O_2 level. For this reason, it was decided to monitor the CO_2 level. The SCD41-D-R1 sensor offers the best value for money with acceptable accuracy and was therefore selected for the project.

Table 32: Gas Sensor Comparison

Name	SCD40-D-R1	STC31-C	SCD30	T6793-5K	PS1-O2-25%	EZO-O2
Supplier	Sensirion	Sensirion	Sensirion AG	Amphenol Advanced Sensors	Amphenol SGX Sensortech	Atlas Scientific
Price	16.50 €	29,46 €	29,87 €	24.52 €	70,21 €	212,75€
Measurement	CO_2	CO_2, Temperature	CO_2, Humidity, Temperature	CO_2	O_2	O_2
Power supply	3.3 to 5 V	3.3 V (2.7 V - 5.5 V)	3.3 V - 5.5 V	4.5 V - 5.5 V	400-600 mV	3.3 V - 5 V
Dimensions	(10 x 10 x 6.5) mm³	(3 x 3.5 x 1) mm³	(35 x 23 x 7) mm³	(30 x 15.6 x 8.6) mm³	(11.5 x 11.5 x 5.5) mm³	(63 x 27 x 27) mm³
Communication	I2C	I2C	I2C, Modbus, PWM	I2C, PWM	Analog	I2C, UART
Range	0 - 40 000 ppm	0 - 100 000 ppm	0 – 40 000 ppm	0 - 5 000 ppm	0 - 25 %	0 - 42 %
Accuracy	± 5 %	± 0.5 %	± 3 %	± 3 %	-	± 0.01 %
Response time	60 s	< 0.5 S	20 s	180 s	4 s	1 s

Table 33 presents different ventilation system options. In addition to cost-effective variants, particularly quiet fans were also considered. However, these come with significantly higher costs, so the focus remains on affordable options.

It proved advantageous to design the system for 24 volts, as this voltage is compatible with the soil

sensor. For these reasons, the EF80252S2-1000U-A99 fan was chosen for the Loopbin. Compared to the existing market solutions from Table 2, the noise level of this solution is also within an acceptable range, which further supports the selection.

For the prototype, everything is powered by 5 V, so must the fan. That why the better fan seems to be the one from the school.

Table 33: Vent System Comparison

Name	**EF80251S1-1000U-A99**	**9S0812L401**	**EF80252S2-1000U-A99**
Supplier	Sunon Fans	Sanyo Denki America Inc.	Sunon Fans
Voltage	12 VDC	12 VDC	24 VDC
Power	1.44 W	0.6 W	1.01 W
Airflow	41.0 CFM	23.3 CFM	37.0 CFM
Noise	33.0 dB	16.0 dB	30.0 dB
Costs	4,75 €	19,70 €	3.00 €
Dimension	80 mm x 80 mm	80 mm x 80 mm	80 mm x 80 mm
Width	25.00 mm	25.00 mm	25.00 mm

The elements presented in Table 34 show the various available microcontrollers considered during the study. First, the ESP32 from Espressif Systems seemed the ideal candidate, as it is less expensive than its competitors, and has 2 cores, enabling tasks to be carried out simultaneously (retrieving information from two sensors, for example). This component has Bluetooth as well as a Wi-Fi connection, so it's not restrictive for future solution choices. However, during a meeting with the teachers, it was suggested that a Pi-Pico W be used. The W series from Rasberry Pi offers a Wi-Fi connection, enabling the bin to be connected to the application. This board has the various pins required for the project, and is available immediately, which will reduce the prototype's costs. What's more, this board can be powered at 5 V and can supply components at 3.3 V as well as 5 V, as long as a maximum current is respected.

Table 34: Controller Comparison

Name	**ESP32 VROOM 32**	**Arduino Uno**	**Raspberry Pi**
Supplier	Espressif Systems	Arduino LLC	Arduino LLC
Language	Arduino / µPython	Arduino	C/C++ / Arduino / µPython
Protocol	I2C(2)/I2S(2)/SPI(4)/UART(3)/USBOTG(1)	I2C(2)/SPI(4)/UART(2)/CAN(2)/1-Wire(1)	I2C(2)/SPI(2)/UART(2)/PWM(16)
Com/App	Wi-Fi / BLE / Cable	USB	Wi-Fi / USB
Dimensions	18 mm × 25.5 mm × 3.10 mm	68 mm x 53.4 mm x 15 mm (equipped)	21 mm x 51 mm x 1 mm
Price	5 / 8 €	30 €	10 €
Heart	2	1	2
RAM/ROM/Flash	520 KB / 448 KB / 4 ⇒ 16 KB	512 KB / 512 KB / 16 KB	264 KB / 16 KB / 2 KB
OP Voltage	3.3 / 5 V	5 V	3.3 V
OP Current	80 mA (Average)	50 mA	100 - 200 mA

Detailed schematics

Figure 51 presents the electronic schematic of the Loopbin. The protocol for connecting the humidity and temperature sensors is not supported by the microcontroller. To remedy this, a device must be installed to enable communication between the sensors and the board. This element also allows two sensors to be placed in parallel, so as to avoid having to duplicate the entire installation. The transceiver used is a MAX3485. It allows you to switch from RS845 to UART, and requires only 3.3 V of power. It can therefore be powered by the board. As explained above, it allows two sensors to be connected to a single board, even if it uses the UART protocol, which supports only one connection. Once connected in parallel, communication with a sensor will take place via its IP. Since they share

the same wires, you'll need to specify the IP of the sensor concerned when sending a request. This protocol works on the Master/Slave principle, the master being the Arduino and the slaves the sensors. The only problem is that you can only communicate with one sensor at a time.

The final sensor in the prototype is a gas sensor. Unlike temperature sensors, only one is needed, as it measures directly in the air. For economic reasons, the selected sensor is a CO_2 sensor. Too much CO_2 means too little oxygen. This makes it possible to define when it is necessary to mix and ventilate the compost. This kind of sensor works with the I2C protocol, supported by the Arduino, so there's no difficulty in connecting it. Its power supply is 5 V, also possible with the board. The final elements in the compost bin can are the fans. They are necessary for good ventilation of the compost, which is essential for an optimal process, and to avoid odors. The simplest solution for controlling these fans is to use MOSFETs. These are switches that can be controlled by the Arduino board. The gate is connected to an Arduino pin, the drain to the fan, and the source to GND. However, a resistor must be placed between the gate and the pin to avoid voltage spikes on the board. Fans require an excessive power supply, which the board cannot provide. For this reason, a battery must also be fitted, to power the temperature sensors.

To finish with the electronic schematic, it's important to connect all the GNDs together, to ensure circuit consistency. The red zone indicated on the schematic is the zone grouping the components that can be assembled together on a Shield, in the dedicated zone on the prototype. The other components are strategically positioned according to their role in the installation.

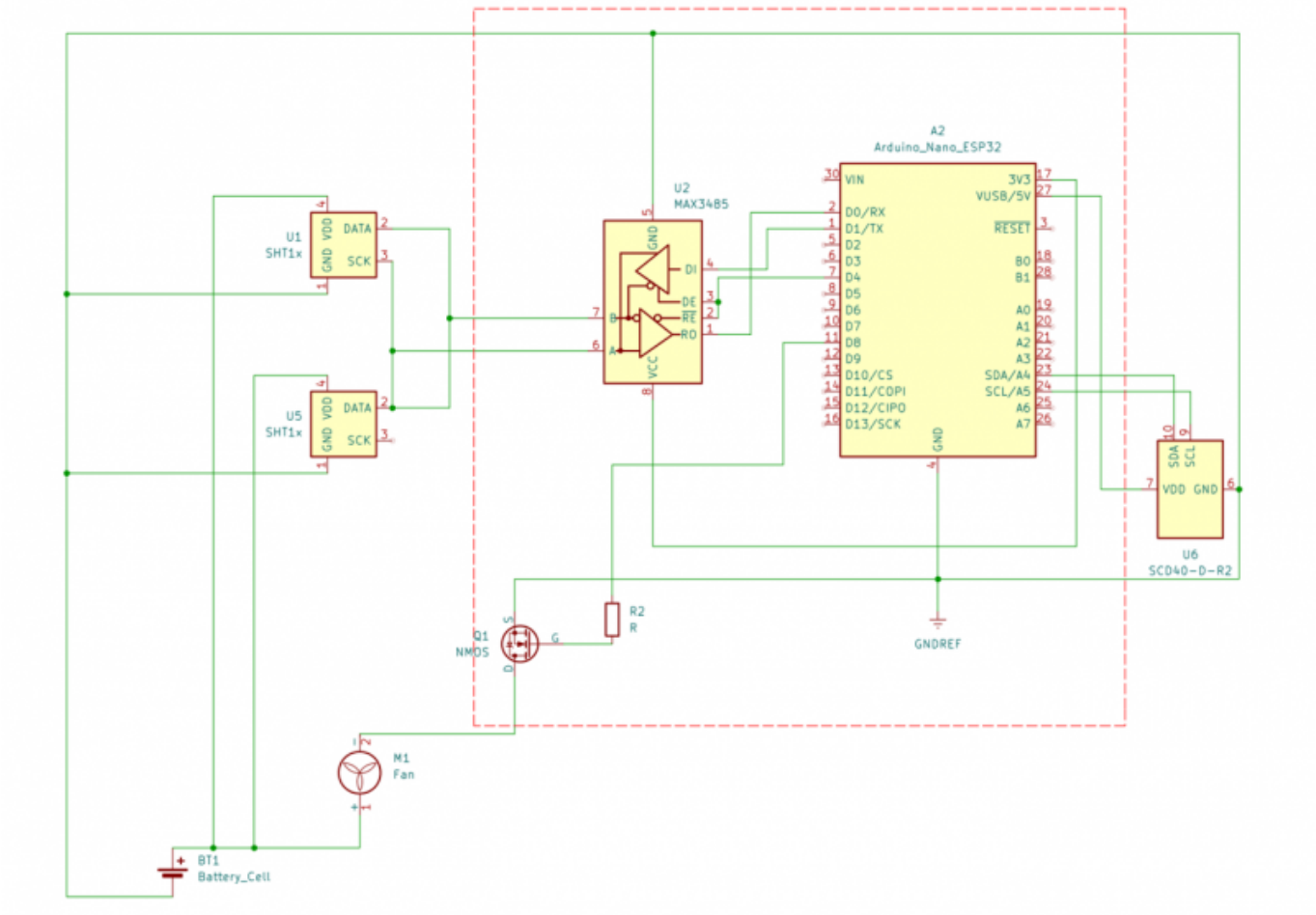


Figure 51: Electronical Schema

Figure 52 presents the electronical schema of the prototype. He's simpler, to fit the budget allowed by the school. All the elements are powered by the Pi Pico card, using the 3.3 V output and the Vbus output pin but there are two main points to keep in mind. First, the Vbus output needs that the card is powered by USB. Then, it's also important to keep an eye on the current, to not exceed 500 mA. The components used in the prototype are one temperature sensor, the MAX card to make the sensor and the Pi Pico talk together, and a fan, with 2 mosfet to control the power in the schema. The Vbus gives energy to the fan and the sensor, and the MAX card is powered by the 3.3 V output.

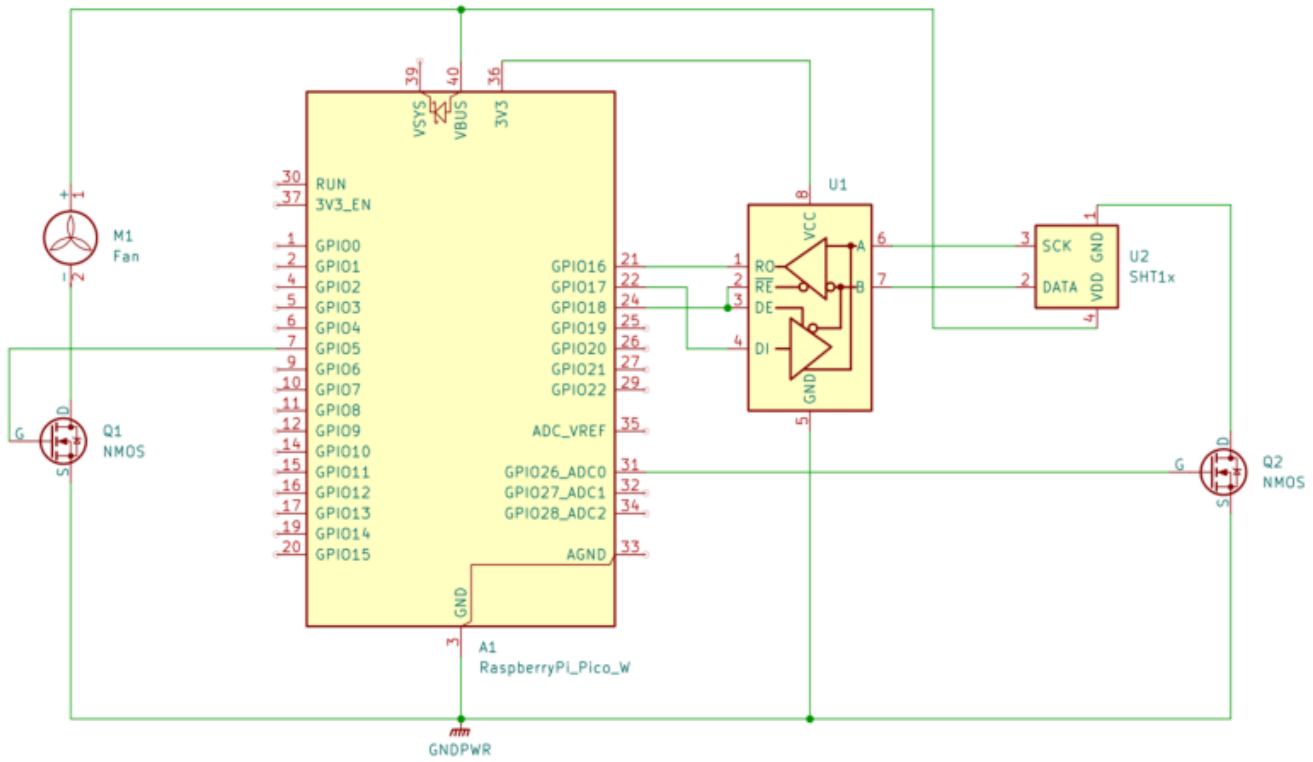


Figure 52: Final prototype schema

Power budget

The power budget of the product is calculated by summing the power consumption of all the electronic components. The product includes two temperature sensors, one carbon dioxide sensor, a fan, and a Raspberry Pi Pico microcontroller. Each component operates at 5 V, but their peak currents vary as specified in their respective datasheets.

Power is calculated using the formula:**P = V × I**

Power consumption over time is determined as:**Power consumption (kWh) = (P × t) / 1000**

According to Euractiv: "In the residential sector, the average price in Portugal was €0.2539 per kilowatt-hour **[Maria Joao Pereira, 2024]**."

Therefore, the electricity cost is calculated by:**Electricity cost = Power consumption × €0.2539 / kWh**

The table 35 shows an example of the power budget calculation over a 30-day period (one month):

Table 35: Power budget calculation of 30 days

Item	Voltage (V)	Peak Current (mA)	Power (W)	Time (h)	Power Consumption (kWh)
1st Temperature sensor	5	100	0.500	72.000	0.036000
2nd Temperature sensor	5	100	0.500	72.000	0.036000
Carbon dioxide sensor	5	137	0.685	72.000	0.049320
Fan	5	120	0.600	10.080	0.006048
Pico microcontroller	5	300	1.500	72.000	0.108000
					Total: 0.235368 kWh
					Electricity cost: 0.06 €

With an electricity cost of just €0.06 per month, the product is highly energy efficient.

7.4.3 Software

The figure 53 show the different possibilities to use the application. She will include a log in system, with an option to create an account for the new users.
Once he is logged, the user access to the homepage. In this page, it's possible to monitor the different layers of the bin. Based on the sensors values, a fan can be activated. It's also possible to follow the process of composting through the progression bar. When the bar is fully charged, a special message is displayed to the user, so he knows that it is the moment to transfer the leftovers. Finally, it's possible to go back to log in page via the disconnect button.

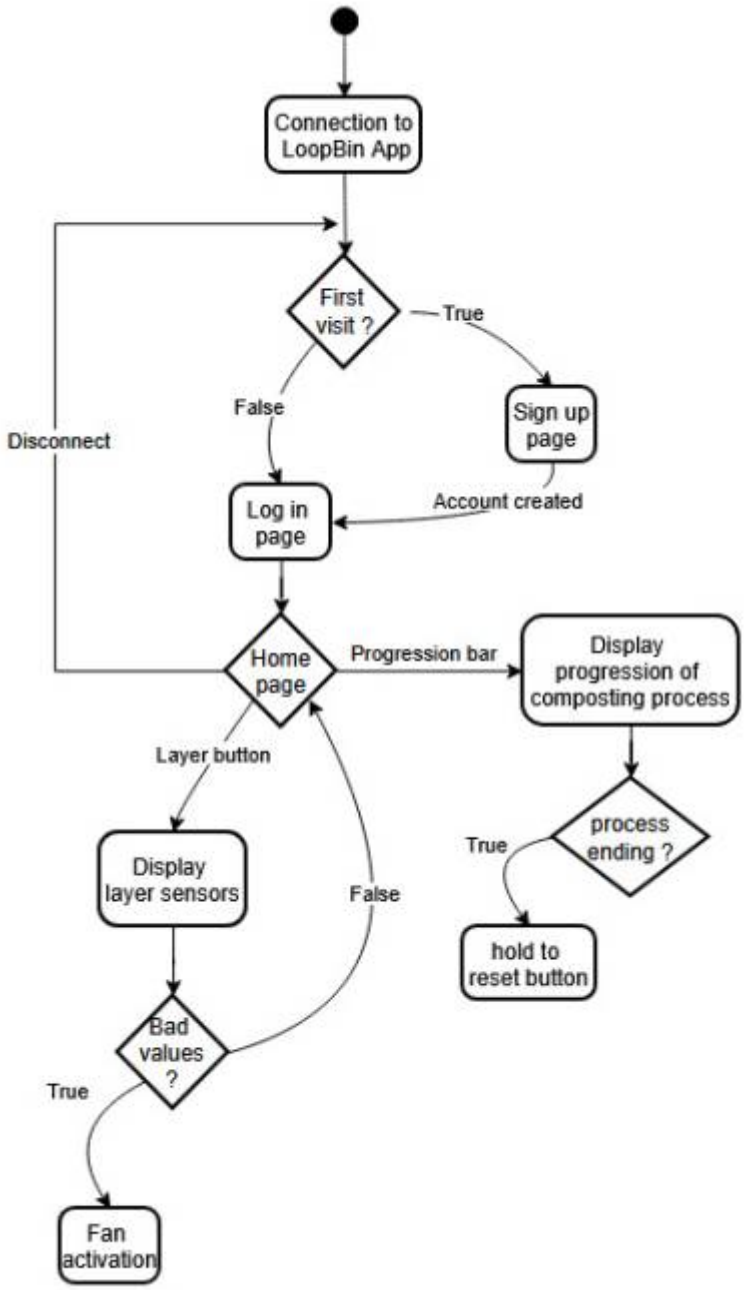


Figure 53: Use cases

7.4.4 Packaging

Initial packaging drafts

In this chapter, the concept of product packaging will be discussed. The different ideas presented make it possible to prioritize different notions, such as marketing or ecology. At the end of the presentation, a conclusion drawn up with the help of a table will make it possible to decide on the ideal solution.

Introduction

Before talking about the packaging, it is important to define what elements are provided with the bin.

Since the product is fully assembled beforehand, there are only a few additional elements. For the

garbage can, it comes with a charging cable, and two boxes, allowing you to collect the compost, and grow the plants at the top of the garbage bin.

The composting process requires help to get started. This is why a starter pack is also being considered. It would include ready-made compost, as well as seedlings.

Generally, this type of product is also accompanied by a leaflet. It is possible to consider making it dematerialized, accessible from a QR code, or from the application provided with the device. This prevents unnecessary printing of paper, which often ends up in the trash. A paragraph will be devoted to this element for each of the solutions.

First idea - Classic

This trash bin is a household appliance like there are already many on the market. In this first solution, it will be considered to apply the same packaging as these existing devices.

They consist of a cardboard box in which all the elements of the product are found, with an expanded polystyrene (EPS) to hold all the elements in place and protect them. It is generally used because it is very cheap, cardboard and EPS are easy to produce and inexpensive. In addition, they are very lightweight, which makes the device easy to carry. Finally, EPS provides optimal protection, because by giving it a shape adapted to all the elements, it is possible to protect everything from shocks.

However, this solution has several trade-offs, such as space and ecological impact. EPS is not reusable when the product is unpacked. It is difficult to recycle, because it is very light for a large volume, so it is not interesting to recycle it. The storage of the packaging also requires a lot of space, and EPS is difficult to reuse as it is, because of its shape, which is specific to the product.

In summary, this solution is the most economical, and easily adaptable to the bin and its components. However, its environmental impact is very bad, which makes this solution difficult to consider.

Second idea - Adapted classic

The main problem with the previous solution is the PSE. It is possible to keep the cardboard as the outer packaging, while adapting the interior with healthier material for the environment:

- The “Honeycomb” cardboard provides good protection for the elements of the bin. It is lightweight, is 100% recyclable.
- Kraft paper is also very light, more modular than “honeycomb” cardboard, and less expensive. The protection is weaker, less rigid.

A mix of these two elements keeps the elements inside the overall carton. With this solution, all the packaging can be recycled or reused (especially kraft paper, which is not shaped specifically for this product). The unit cost may be a little higher than with EPS, but does not require investment in mold, as is the case with the first solution.

As explained above, the leaflet is also an element of the packaging. It is possible to make it dematerialized, via a QR code on the cardboard. Thus, no additional paper in the packaging, the QR code will allow the application to be set up, connected to the bin. Within the application you will find the instructions, which will be accessible at any time.

Figure 54 shows how this idea will look.

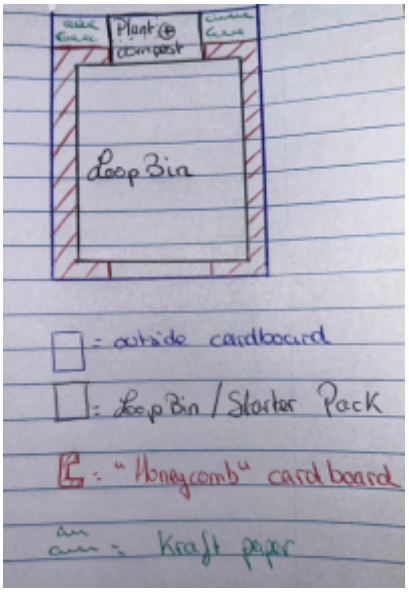


Figure 54: Packaging Idea

Third idea - Compostable

The image of Leftlovers is to offer an accessible, easy-to-use, but above all ecological solution for managing food waste. The idea of the latter solution is to apply this to packaging by offering 100% compostable packaging.

For this, the packaging must be made of cardboard, but there are several points to consider. First of all, resistance. Indeed, the cardboard will be less solid, therefore more sensitive to crushing or shocks. It also does not have to be treated in order to be composted. It will therefore also be sensitive to humidity. This poses logistical problems, the bins will have to be stored in a dry place, without risk of shock.

It is also necessary to limit the use of glue, and ink on the cardboard, for a healthier compost. The glue can be minimized with a well-thought-out folding, which allows for a solid structure. For ink, there are biodegradable inks, such as soy ink for example.

The main problem with this solution is the complexity of the model to be set up, the cardboard, which must have well-thought-out ribs/folds to have a rigid structure. It is also a more expensive solution than the two presented previously, due to the complexity of the cardboard once again, and the biodegradable ink.

Fourth idea - Second life

Leftlovers is a sustainable brand dedicated to reducing food waste. However, the focus extends beyond food — minimizing all forms of waste, including packaging, is equally important. To address this, a packaging solution has been developed that allows the packaging to serve a second purpose instead of being discarded.The primary goal of the packaging is to ensure safe delivery of the composting bin to the consumer. The second goal is to give the packaging a second life once the bin is unpacked.

To protect the bin from shocks during transport, it is enclosed in a box made of cork. After unpacking, this cork box can be transformed into a window planter. This directly supports the brand’s goal of enabling gardening for urban residents without access to outdoor space. In this way, the packaging becomes an extension of the product itself. The product already has a garden on top, but the cork box creates more space for growing new plants.

The box is made from agglomerated cork — a lightweight, durable, and biodegradable material that is commonly found in Portugal. Agglomerated cork is more cost-effective and easier to shape than solid cork, making it a practical material for this application. To extend the life of the cork box and prevent leaks while gardening, a protective inner layer can be added.

Because cork alone is not sturdy enough, a cardboard box is placed around the cork box. This adds strength and protects the bin during transport. After unpacking, the cardboard can be composted directly in the bin, eliminating waste.

To make the transformation from the box into a planter easy for the user, an instruction manual is included, featuring a QR code linking to a video tutorial. There is also extra space in the cardboard box for a bag with additional accessories, such as a hook or rope to mount the planter on a window.

Comparison

The purpose of the following table is to determine the most interesting option for the project. To do this, four criteria are taken into account:

- The price
- Feasibility
- Ecological impact
- Repurpose

Price is an important criterion, as the objective is to offer an affordable product, to stand out from the solutions already on the market. Feasibility takes into account the simplicity of the process, as well as its implementation. The ecological impact is a priority for this project. As explained earlier, the idea of the project is to offer a product that allows you to act for the environment. It would be counterproductive to have highly polluting packaging. Finally, repurpose means that the packaging has a second life after it is unpacked.

Table 36: Comparison packaging

Idea	Price	Feasibility	Ecological impact	Repurpose	Total
Classic	5	5	1	1	12
Adapted classic	4	4	3	2	13
Compostable	2	3	5	3	13
Second life	3	3	5	5	16

In table 36 is a score assigned to each criterion, 5 for the most advantageous solution, 1 for the least. Thus, the total indicates the most appropriate solution, considering the different criteria.

Looking at the results, it appears that the classic solution is the most affordable and the easiest, but it also has the worst impact on the climate.

The adapted classic has a high score on price and feasibility. It also does not damage the climate.

However, the fact that it has no repurpose makes it less attractive for this project.

The compostable solution is very sustainable and its ecological impact is in line with the direction of the project. However, its price and complexity make it difficult to implement. It may be interesting to keep this idea for a future product, a more luxurious range for example.

Lastly, the second life solution scores the highest in general. It has a second life and therefore it has a positive ecological impact. The only thing that needs to be considered is that it might be expensive and harder to accomplish.

Detailed drawings

The comparison revealed that the Second Life- idea is the best fit for this project. So detailed drawings have been created for this concept.

The outer cardboard box will be made from double-wall corrugated cardboard (BC flute), as shown in Figure 55 . This provides protection during transport and can later be composted as brown waste directly in the bin.

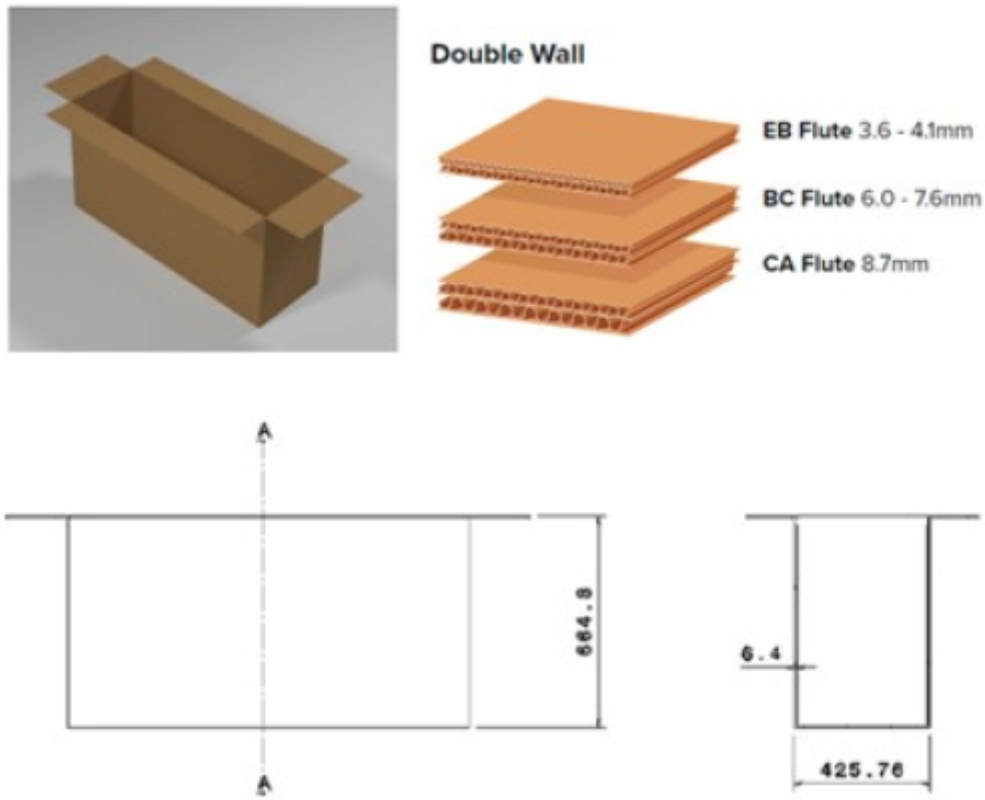


Figure 55: Drawings cardboard box

For the cork box, agglomerated cork will be used. This material has a natural cellular structure that cushions impacts and protects the bin. It can compress and then return to its original shape, providing flexible protection in tight spaces. After unpacking, the box can be reused as a window planter.

As seen in Figure 56, the cork box consists of two parts to securely protect the compost bin. Both parts have two drainage holes, which are essential for a planter to prevent water from pooling and drowning the plants. The holes in the top part of the cork box have an additional function: it fits precisely over the handles of the compost bin, preventing them from breaking during transport.

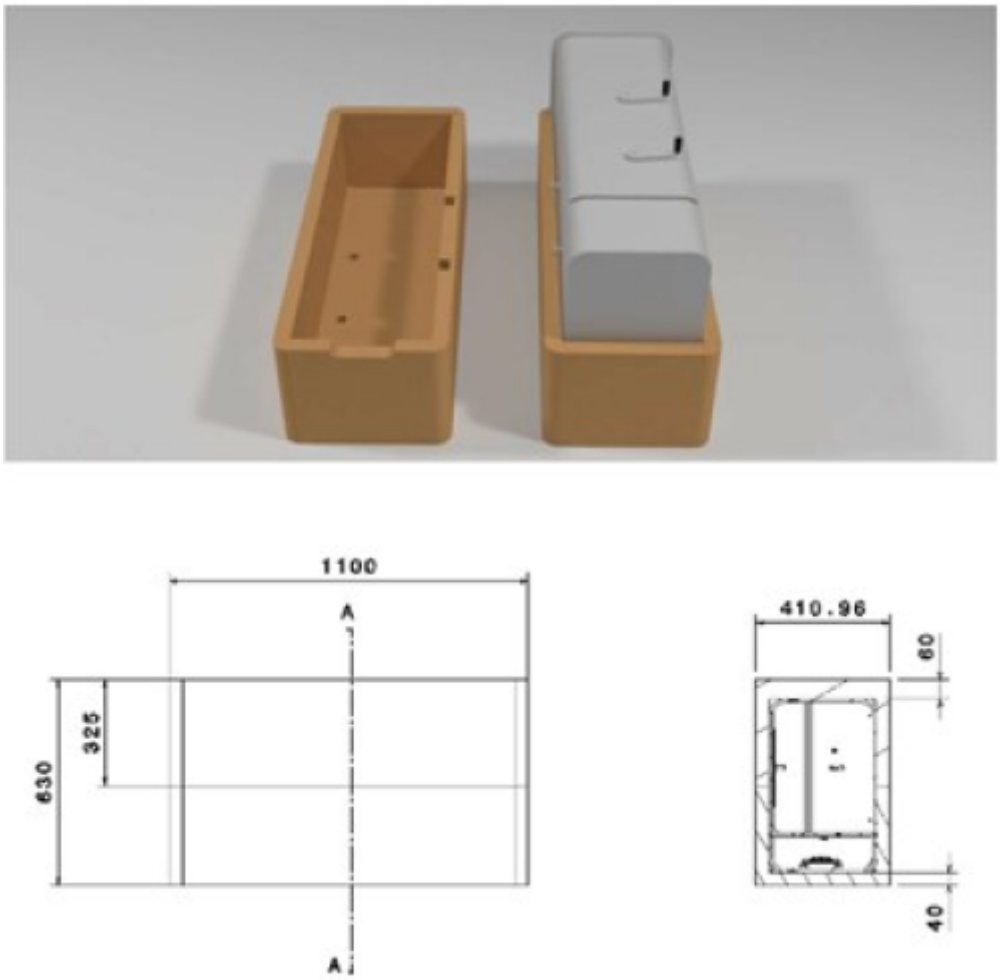


Figure 56: Drawings Cork Box

As seen in Figure 57, there is extra space inside the box for a bag with the instruction manual and additional accessories, such as a hook or rope to hang the planter on a window, and possibly a compost starter to help initiate the composting process inside the bin.

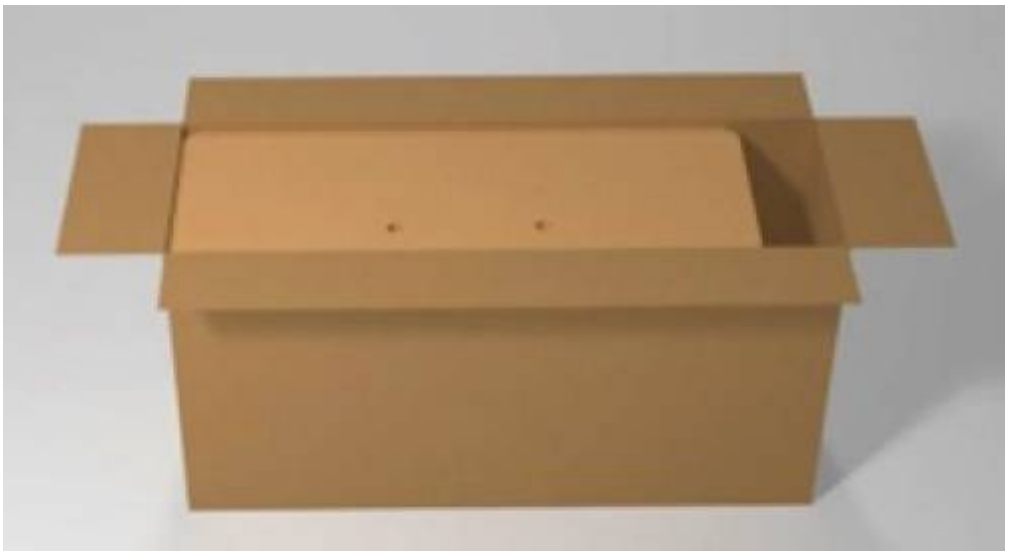


Figure 57: Cork box inside cardboard box

7.5 Prototype

Before manufacturing the prototype, the design of the actual product was analyzed and changed. This

was necessary so the team could build the prototype in a more easy way and to stay within budget. The structure of the prototype is very similar to the original product. It is downsized by 10 % due to the size of the plastic boxes used.

7.5.1 Structure

As shown in Figure 58, a 3D model of the prototype was made based on the final product. The original plan for the prototype was to use a drawer of boxes as a structure. The bottom of these boxes would be cut out and replaced by PVC sheets which would be used to place the blades on and to construct the drop-down system. Next to that, the planting box and storage box are left out of the design as they are not necessary for tests and make it more expensive to build. No separate room for electronics is provided in the prototype, these will be placed on the outside of the bin.

Due to delivering problems, the drawer of boxes couldn't be provided. This is why the team decided to change the structure and to make a box out of plywood. To keep the inside of the bin visible, one wall of the bin was made out of plexiglass.

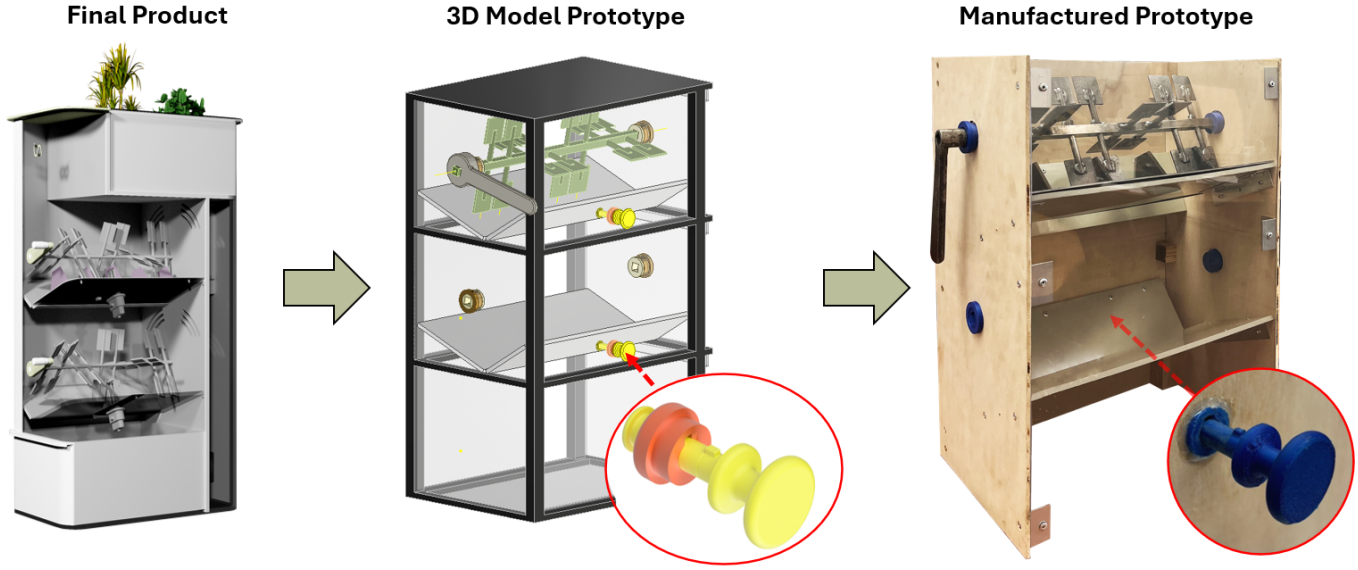


Figure 58: Differences between final product and prototype

7.5.2 Hardware

To keep the building process shorter and more affordable, only one mixing part was made for the prototype. Next to that, only one mixing part was needed for the functional tests. The mixing part was made out of construction steel (S235JR) instead of stainless steel as this was cheaper and available in the workshop. Also, the mixing blades are placed straight on the mixer instead of with an angle to keep it easier to make. The design of the locks was changed to the dimensions of the prototype but the locking system stayed the same.

7.5.3 Software

The LoopBin smart bin is linked to an app, to allow monitoring of different parameters, temperature, humidity, and CO_2 level, and the progression in the composting process. To do this, sensors are set up

in the bin and connected to a microcontroller. This microcontroller is equipped with a Wi-Fi chip, which allows it to communicate measurements to a Linux server. On this remote server, there is a Flask server serving as an API, which will retrieve the measurements, and process them, before sending them to a mobile application. This chapter will deal with the different steps presented above in more detail, but first in Figure 59 illustrations about how it works.

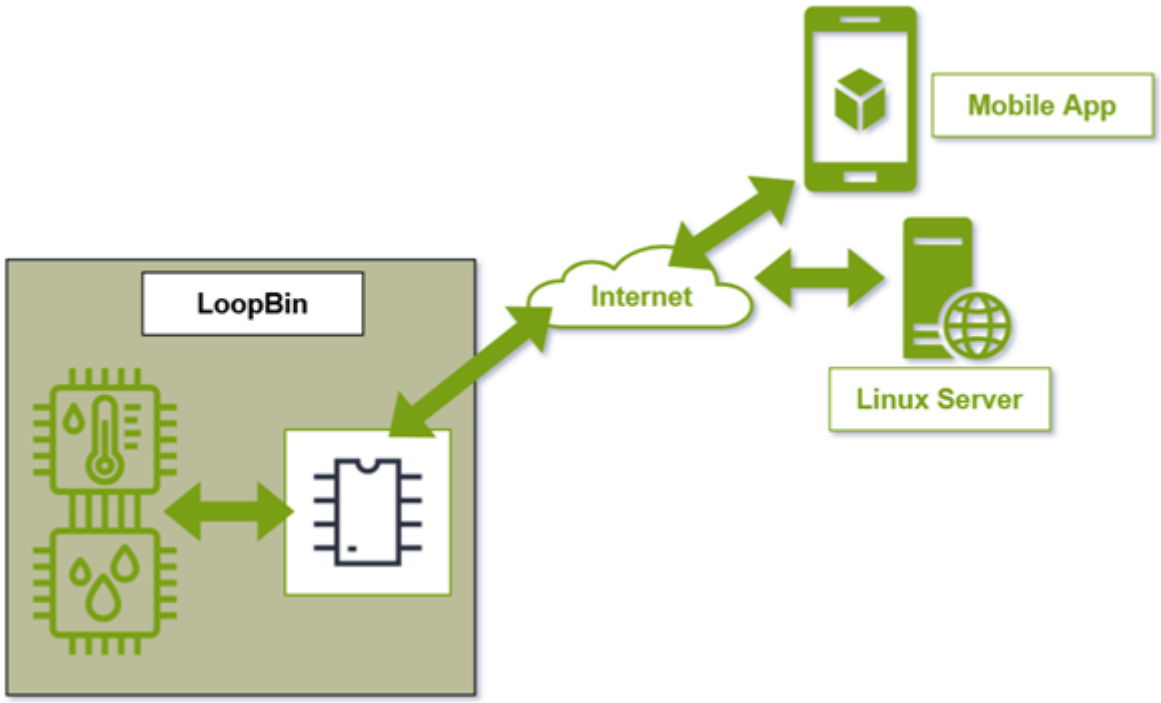


Figure 59: Organization of connected elements

Sensors/ Microcontroller

Hardware

The first part is the hardware layer, with the sensors, and the microcontroller. For budgetary reasons, the prototype only includes a humidity sensor and a microcontroller (ESP32 DevKit). Also for budgetary reasons, the microcontroller will be powered by USB-C using a computer, to avoid adding a battery to the prototype. The sensor is powered by the microcontroller. This is because it operates between 3 V and 30 V, and the ESP32 DevKit has two power pins, 3.3 V and 5 V. The sensor uses the first of these two pins. The last physical element is a fan. For the prototype, a 12 V fan will be used. For material reasons, it will be powered by the ESP32 with 5 V, which will result in a slower, but sufficiently efficient rotation. It will be controlled using a MOSFET, so that it can be controlled by the application.

Code

The different physicals elements must be controlled; that's the software layer. For this first part, everything is coded in C++, using the Arduino IDE. This paragraph presents the main functions of the code. The purpose of the microcontroller is to provide measurements to the API. Its programming must make it possible to establish the connection between these two elements. The advantage of an ESP32 microcontroller is the presence of an ESP-VROOM-32 chip, which allows it to connect via Wi-Fi. Once connected to Wi-Fi, it is possible to reach the server using its IP address. To ensure that the microcontroller and the server can communicate properly, they need to understand each other. For this purpose, the information is transmitted in JSON format. This is the second function present in the code, to put the measurements in the format expected by the server. Once formatted, the measurements are sent, using the POST method. To streamline the operation of this measurement part, the microcontroller will only be called upon when the server needs a measurement. This avoids

the need to send continuous measurements and thus overloads the API with unnecessary values. This also allows for the addition of a “Force Measurement” feature, which is useful for the user to request measurements as needed. To enable this call, the microcontroller will read the state of a “State” variable, on a dedicated endpoint in the API, using the GET method. Possible values are as follows:

- “Request”: The API requests a value. Use the measurement functions, then format in JSON before sending the values to the API.
- “Pause”: no need for measurement, delay of a few seconds before going to read the status of the variable again.
- “Fan”: a state independent of the previous two, it can be sent at the same time as one of them. If it is present in one of the requests, the pin associated with the fan is activated. If it is not present, the pine will turn off, which stops the fan.

The last part of the code is about sensors and measurement. As explained at the beginning of the chapter, only the humidity sensor is present in the prototype. To keep the overall operation consistent, the other values will be simulated, using random values. To avoid inconsistent values, they are coded to have “ideal” values that vary randomly little by little, depending on the other data. For example, too low humidity slows down the activity of microorganisms, which will lower the temperature in the bin. This function integrates many interactions between the different values, resulting in sensor values that are close to reality. The code is designed to detect if a sensor is present, on certain pins, associated with the desired quantities. If not, a simulated value will be used instead. This allows for value to be provided to the API in all cases.

Areas for improvement

In the future, it may be interesting to add a Wi-Fi connection page to the code. Indeed, for the moment, ID and passwords are integrated directly into the code. It is possible to create a small local server, which deploys when the microcontroller is powered but does not have access to a Wi-Fi connection. This creates an interface that can be accessed from a phone, where the user enters the username and password of the network the ESP32 is supposed to connect to. These values are stored in variables that can then be used by the code, to allow the operation presented above. This only requires preparing an HTML interface that will be used by the local server deployed by the microcontroller, and coding the connection process presented above. For a prototype, adding the login information directly into the code is sufficient.

Application

The app is the visual interface, the user's tool to visualize the important data in their LoopBin. For the prototype, the application is developed in Java Script (JS), using the React Native library. React Native is a framework that helps simplify mobile app development in JS, and facilitates IOS and Android development at the same time. To view the code, Expo is also used. It is a tool that allows you to view and publish code without going through traditional IOS/Android tools. It also allows changes to be viewed without recompiling, making development easier. A React Native application works with the help of “Stack”, different pages that can be accessed via different buttons or functions. In this part, the main pages will be presented, and the associated features that have been developed.

Log In / Sign Up

The app opens on a login page (Figure 60 left), like many other apps, you must first log in before accessing its interface. In case of first connection, a registration page is accessible, as you can see in Figure 60 (right). The information is stored on the Linux server, which associates a username with its password. An endpoint is requested when a user tries to log in, to verify their credentials. Once logged in, the user is taken to the home page.

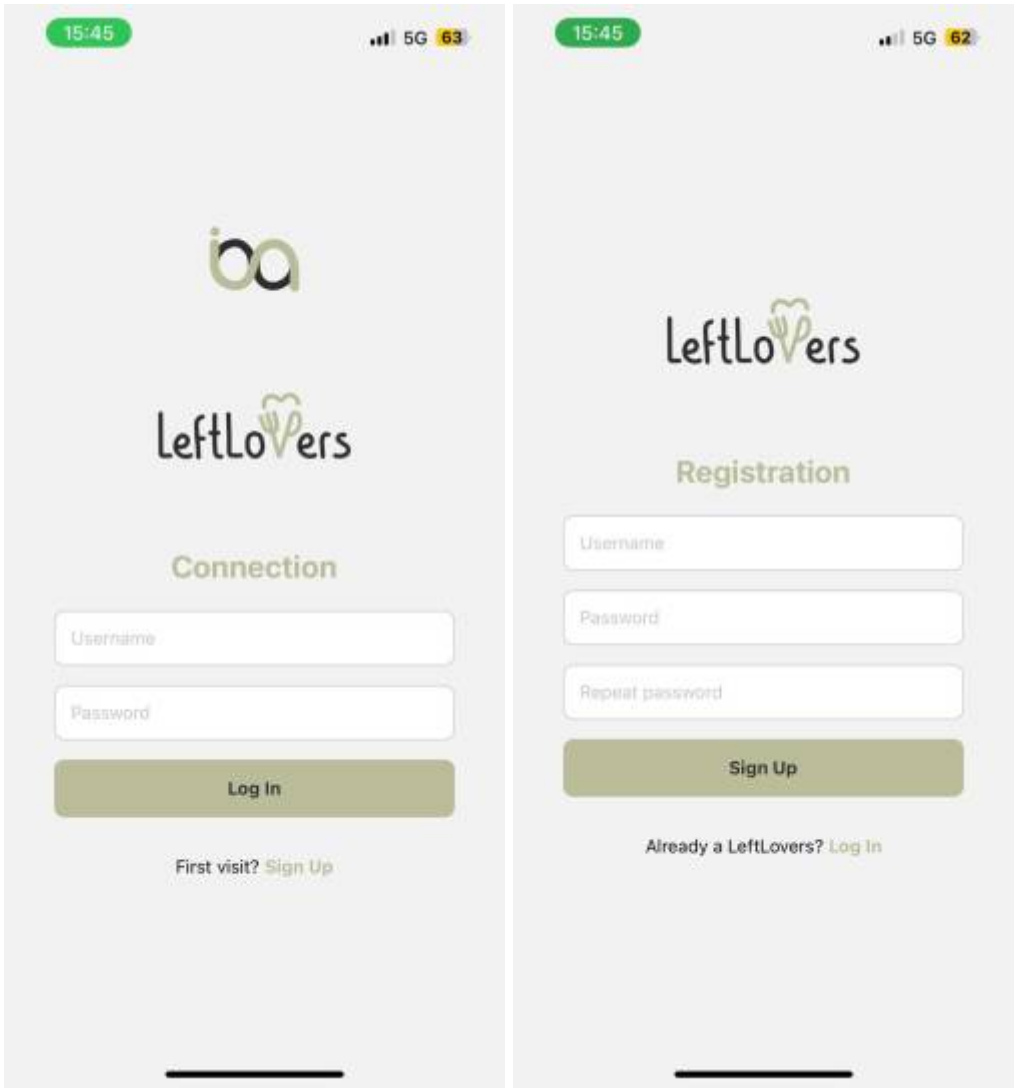


Figure 60: Design of the Loopbin application: Log in (left) and sign up page (right)

Home page

The main components of this page are the three buttons in the center, as you can see in Figure 61 (right). There is a button for each layer of the bin, and a bar representing the progress of the compost process. The two layers buttons are used to display important messages, in case of a sensor value outside the desired range. Behind these buttons, we find the precise values of the various sensors. The main challenge of these elements was to display the values provided by the ESP32, and to succeed in analyzing them using the API to return a message. There is also the compost progress bar on the homescreen in Figure 61 (right). The idea behind this bar is to represent the remaining compost time, before having to transfer the waste from one layer to the next. The challenge with this button was to make it interactive, “alive”. Indeed, it is a progress bar, from 0 to 100%. The problem was that with 14 days for the composting process, this bar was led to increase by 1% after 3 hours and 30 minutes, which made it a “dead” element on the interface. To do this, animations of leaves reminiscent of compost animate this element. A bar reset system with a long press of the button is also implemented. On this home page, there is also a fan button. It allows you to activate the fan in the LoopBin, when necessary. It was important to consider that there is only one fan for several users, as part of this prototype. To do this, an animation is set up to signify that the fan is working. The important thing was to inform all users, to make sure that this element was common to all. For this, a special endpoint is set up in the API. This makes it possible to track the fan status at any time, for all users. Other elements are present on this page, a bar allowing you to scroll through messages, a disconnect button that links to the “Log In” page, and a last button to display other elements (Survey,

user manual, etc...).

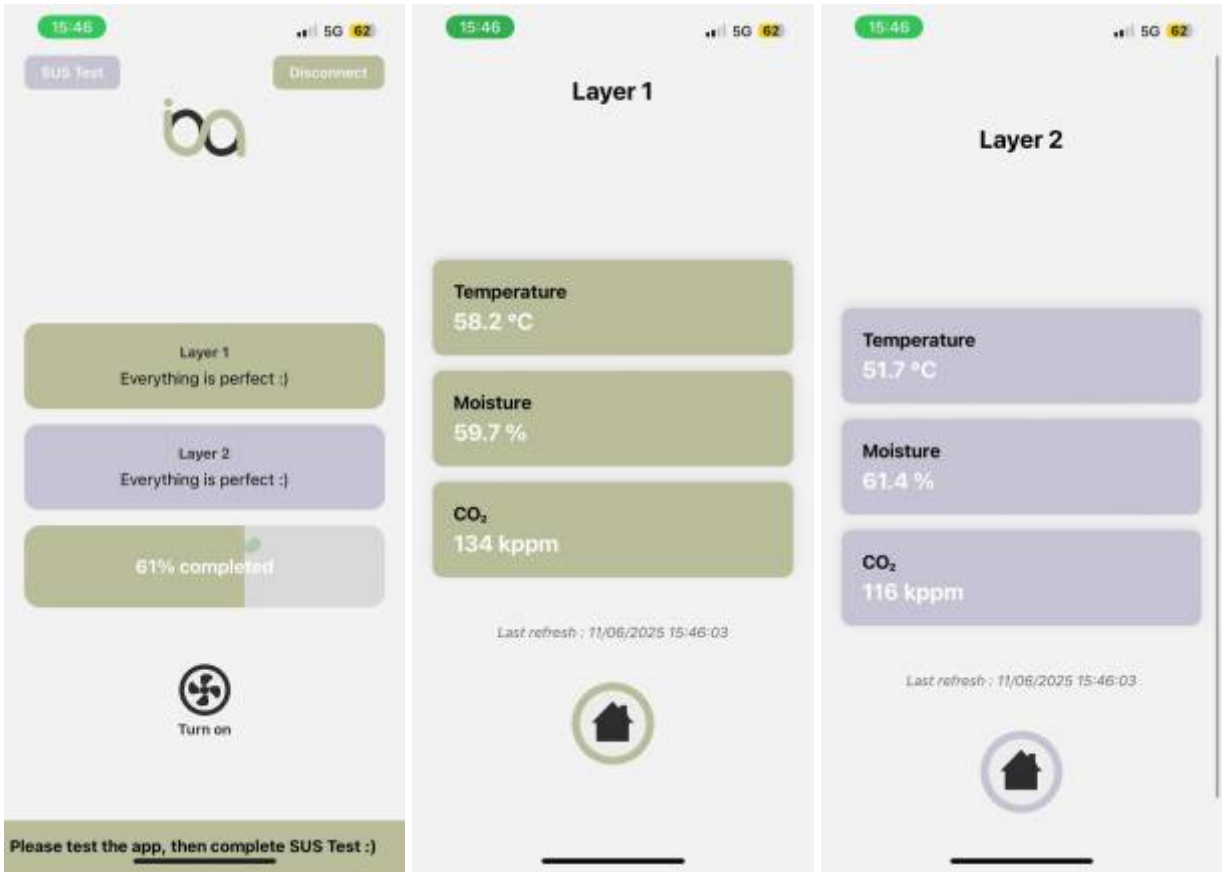


Figure 61: Design of the Loopbin application: Home Page (left), Layer 1 monitoring (middle) Layer 2 monitoring (right)

Areas for improvement

The application is functional as part of this prototype. The points of improvement are rather at the visual level, with for example the integration of alert messages, which would have to be reviewed at the level of the buttons on the different layers, or the loading time of certain images which is sometimes long (a few seconds). The main improvement lies in the deployment of the application. Indeed, going through Expo Go is a good development solution, but is not practical for the user. To do this, you must pay a license to deploy the application in the various IOS/Android stores. Sending notifications to the user is also possible, to warn them of worrying values, or at the end of the composting process for example.

API

The API is the heart of LoopBin's electronic system. He makes the link between the material part and the application. It is a Flask server, hosted on a Linux server, and coded in python. The advantage of this mode of operation is that the API is accessible to anyone connected to the Internet, without the need to be connected to the same network as the bin. All you must do is access the IP address of the server, at the port provided on the server. An API works using Endpoint, routes specific to certain requests. The main ones will be presented in this chapter.

Log In / Sign Up

As presented earlier, the app starts on a login/registration page. To manage this, the API saves the associated usernames and passwords. For security, a hash system is set up. This way, someone accessing the login file would be unable to recover a password.

Processing of measurements
The API is the link between the sensors and the application. The microcontroller only returns a JSON in which all the information can be found. One of the functions of the API is to separate the information and distribute it according to the floor concerned. They are also processed, to return a consistent message according to the value displayed.

Fan
Using the fan also requires good API management. Indeed, there is only one fan for several users, potentially simultaneously. An endpoint is set up to return the state of the fan, in order to show the user whether it is on or not. There is also feedback in the API command, so an administrator can track which user operates it, and when.

Microcontroller
Finally, as explained at the beginning of the chapter, it is the API that imposes the measurement rhythm on the microcontroller. To do this, two endpoints are set up, the first being used to request a measure, the second to receive them. The measurement request is coded to send one request per minute, unless otherwise specified (the user forces a measurement, thanks to a trigger button). As the bin is intended for compost, more frequent measurements are not of major interest. It is even possible to reduce the number of measurements, to preserve the battery of the bin for example.

Areas for improvement
As explained earlier, a hash system is in place to secure users passwords. This poses a problem if you forget your password. Adding a function to recover forgotten passwords is one way to improve. It is also possible to store the recorded values, to offer monitoring using graphs.

7.5.4 Tests & Results

Functional tests mechanics

To make sure that the mechanical parts work, they were tested during the assembly of the prototype. The parts that were tested are shown in the image 62 underneath:

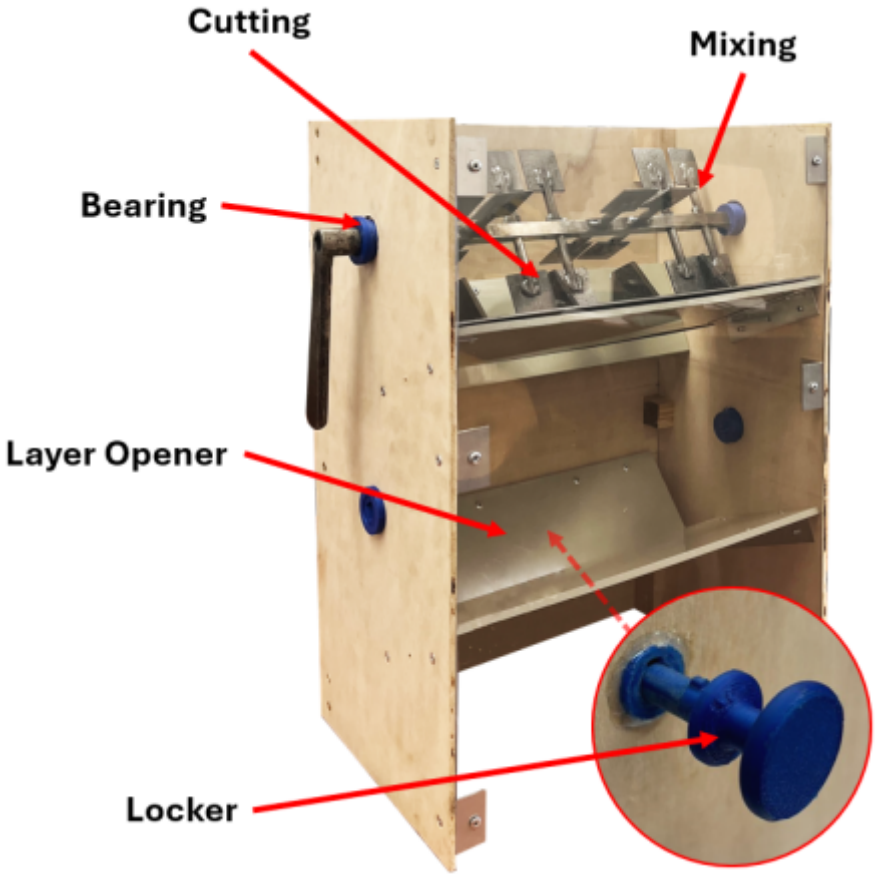


Figure 62: Prototype with the tested mechanical parts

The parts were tested by using it and analyze if it fulfills the function it was designed for.

Bearing: The 3D printed bearing makes sure that the mixing part can move while being hold in place in the wall of the compost bin.

Knives: The knives need to cut the leftovers that are added to the bin into smaller pieces. Smaller pieces of food waste will break down into compost faster. To test this function, paper (by hand) and cardboard (in mixer) were cut by using the knives. After testing, the paper got cut easily, the cardboard didn’t cut very well. To solve this, the knives should be more sharp and the mixing part should be improved.

Mixing part: The mixing part needs to make sure that the freshly added food waste gets mixed with the compost and older food waste that are already in the bin. This to speed up the composting process. During a first test trial, pieces of cardboard were added into the first room of the compost bin and mixed by using the mixing part. The pieces got mixed up in the chamber which shows that the mixing part works in a proper way. During a second testing trial, the same was tried but this time using water beads. This showed that the form of the layer sheet is not ideal. The mixing only works when there is enough material in the chamber. To improve this, the shape of the layer sheets should be reconsidered.

Layer Opener: The layer opener has to drop down so the compost in the bin can fall through to the room below. While testing this, the layer opened without weight added on top. It works in a proper way.

Lock button: The lock button has to keep the layer locked most of the time and to hold the weight of the compost that is added to the room. While testing, the lock worked but the cylinder part collapsed when pushing softly on the layer. The design needs to be improved by adding a metal screw in or 3D

print in in a different way. For the locking of the system it passes the test.

In the following table 37 a summary is given of the tests:

Part - function	**Pass/Fail**
Bearing - turn	PASS
Knives - cut	FAIL
Mixing part – mix cardboard	PASS
Mixing part – mix water beads	FAIL
Layer opener - open	PASS
Lock button - lock	PASS

Table 37: Functional test results - Mechanical parts

Functional tests electronics and software

Setting up the prototype's electronics is fairly simple. The components to be connected are a sensor, a board, and the server. To test this functionality, it is necessary to ensure that the sensor is capable of transmitting a measurement to the board, which will then be transmitted to the server. Next, it may be useful to test the overall operation, sending a request from the server to request a measurement, then the response from the board. Once connected, the sensor is tested first. To do this, it must be calibrated, then tested with a simple code, presented in Figure 63 .

```
1   #define capteur 33
2
3   void setup() {
4     // put your setup code here, to run once:
5   Serial.begin(9600);
6   }
7
8   void loop() {
9     // put your main code here, to run repeatedly:
10  int valeur = analogRead(capteur);
11  int humidite = map(valeur, 3669,768,0,100);
12  Serial.println(valeur);
13  Serial.println(humidite);
14  delay (5000);
15  }
```

Figure 63: C++ Testing code

This code simply reads the value returned by the sensor and converts it into a percentage, which is easier for the application to use. The limits of the “map” function are defined by calibration. This made it possible to test the sensor in very humid and dry environments to verify its proper functioning and wiring. Once the data has been acquired, it must be communicated to the server. To do this, the card is connected via Wi-Fi, which allows it to access the server. To check this step alone, the sensor values will all be simulated (random). The aim here is to check that the data is transmitted in JSON format on the requested port. It is then displayed on a web page using simple HTML code to provide visual feedback on the transmitted data. To go a step further, it was also interesting to test the overall functioning of the system. To do this, we need to ensure that the server sends a request to

the board. Upon receiving this request, the board analyzes it and acts accordingly. To monitor the different stages of this process, “Serial.Print()” commands have been added. This makes it possible to read in the “Serial Monitor” which elements are received by the card and how it interprets them. Below is a table summarizing the different steps tested.

Board Function	**Status**
Receive sensor information	OK
Send it in JSON format	OK
Retrieve the state of the “status” variable	OK
Operation in “measurement” mode	OK
Operation in “pause” mode	OK
Operation in “fan” mode	OK

Table 38: Board functions test

Server Function	**Status**
Retrieve a measurement	OK
Display it in HTML	OK
Timing	OK
Measurement button	OK

Table 39: Server functions test

The last two functions are those that allow you to start a measurement cycle. A timer is present on the server to request a measurement one minute after receiving the previous one. It is possible to test this by checking that the HTML page displays new values one minute after the previous ones, or by checking the time between two requests in the “Serial Monitor.” Finally, there is also a button on the HTML page that allows you to request a measurement without waiting for the timer. This allows us to anticipate how this feature will work in the application. It can be tested in the same way as the previous function.

Request	**Use Case**	**Method**	**Result**	**Size (B)**	**Latency (ms)**
10	Get Data	GET	10	265	100
100	Get Data	GET	100	266	100
1000	Get Data	GET	1000	266	102

Table 40: Load Results

Operation	**Method**	**Result**	**Size (B)**	**Latency (ms)**
Get data	GET	PASS	264	309
State variable	GET	PASS	187	341
HTML display	POST	PASS	409	328
Trigger	GET	PASS	168	317
Sign Up	POST	PASS	409	345
Log In	POST	PASS	409	318

Table 41: API: Functional and performance results

Another way to evaluate the application was by submitting a survey to the users. For that, SUS survey was implemented directly in the application, with the possibility for the users to submit a result after trying the different functionality of the app. After 10 results, the average score was 85 / 100.

Compost testing

This experiment is researching the duration of the composting process and the factors that influence it. Three different containers were used: a completely closed bin, a bin without a lid and a bin with holes in the side. This setup allows for observation of the impact of oxygen flow on the composting process. The three bins were all kept inside a big box, so that the environment could also be measured. The process started on April 30th, as seen in Figure 64 (left). It started with a big batch of food scraps, brown waste and some already finished compost. This was mixed thoroughly and divided into the three bins, this way all the bins have the same contents. After six weeks, decomposition was visible in all three containers: the material resembles compost, as seen in Figure 64 (right). Which means that it could be used as fertilizer for growing plants.



Figure 64: Composting result (bin with holes in the side): Comparison between starting material from April 30th (left) and final compost from June 11th (right)

Temperature

Temperature serves as an important indicator of microbial activity during composting. Higher temperatures are expected in containers where the composting process is most active, as increased microbial activity generates heat and causes the compost to warm up.

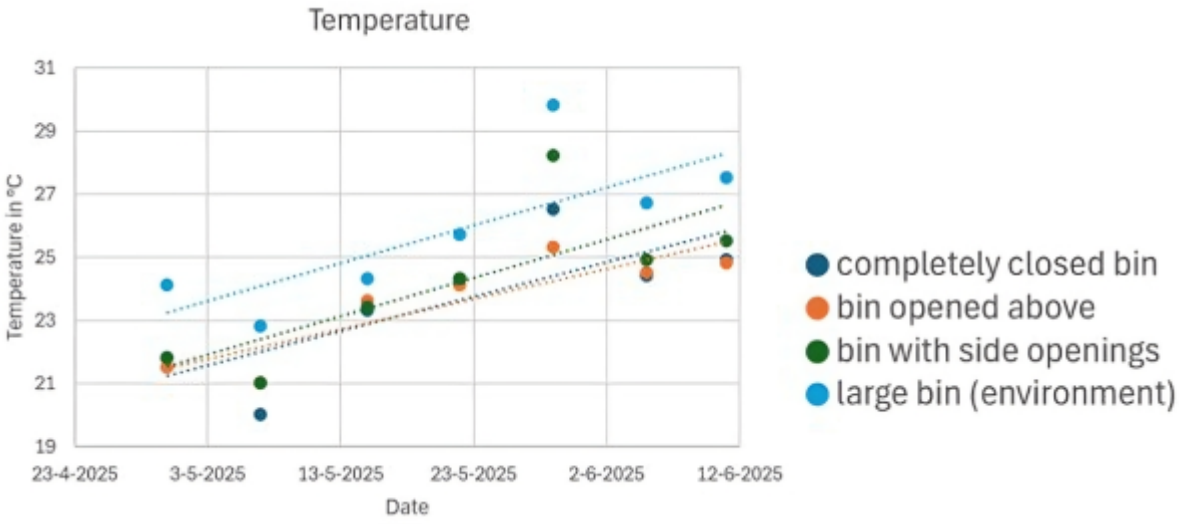


Figure 65: Results temperature

Figure 65 shows the recorded temperature results. The light blue line represents the temperature inside of the big box where the bins are stored, providing context for the measurements. The highest temperature was observed in the container with side openings. This suggests the highest level of microbial activity occurred in this container. A partially ventilated environment may therefore be optimal for microbial growth because it provides sufficient oxygen for aerobic organisms while preventing rapid drying.

Normally, you would expect the temperature of compost to be higher (around 50 – 60 °C), but in this experiment it remained significantly lower (around 25 °C). This is probably because it is on a much smaller scale. Because in a small container, the heat that is released cannot be retained well.

Moisture

Moisture is also an important parameter in the composting process. This factor influence which organisms are active and the efficiency of organic matter breakdown. For the first three weeks, two different types of meters were used to measure the moisture. These meters did not give a concrete percentage but the user had to read it off of an indicator. However they did work the same way, by putting the tool into the compost. Both meters showed results around 15 %, as seen in Figure 66 and Figure 67. The environment was measured by a different tool, made for measuring the humidity. These results provide context for the measurements.

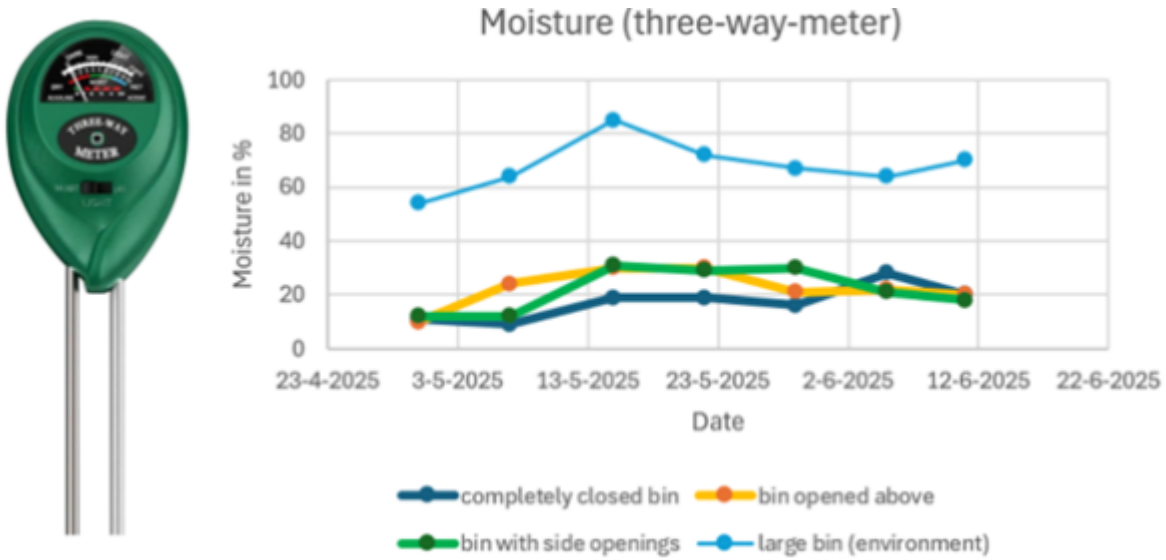


Figure 66: Results moisture three-way-meter

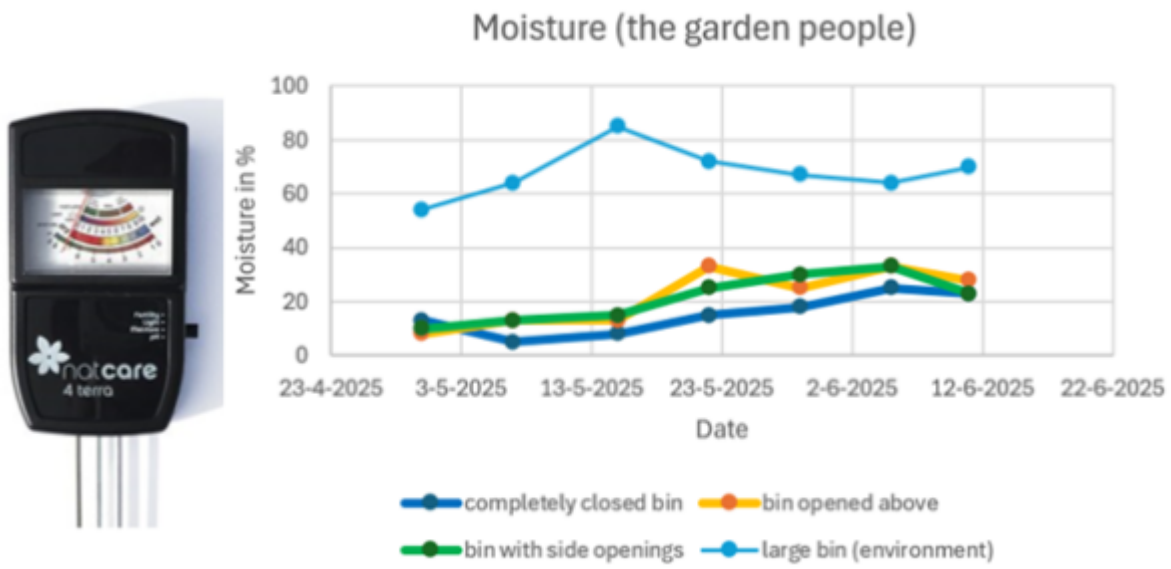


Figure 67: Results moisture three-way-meter

This was much lower than expected (55 – 65 %). However, the compost looked moister, suggesting that the measurement tools were not accurate. So, in the fourth week a new meter was used, which can be seen in Figure 68.

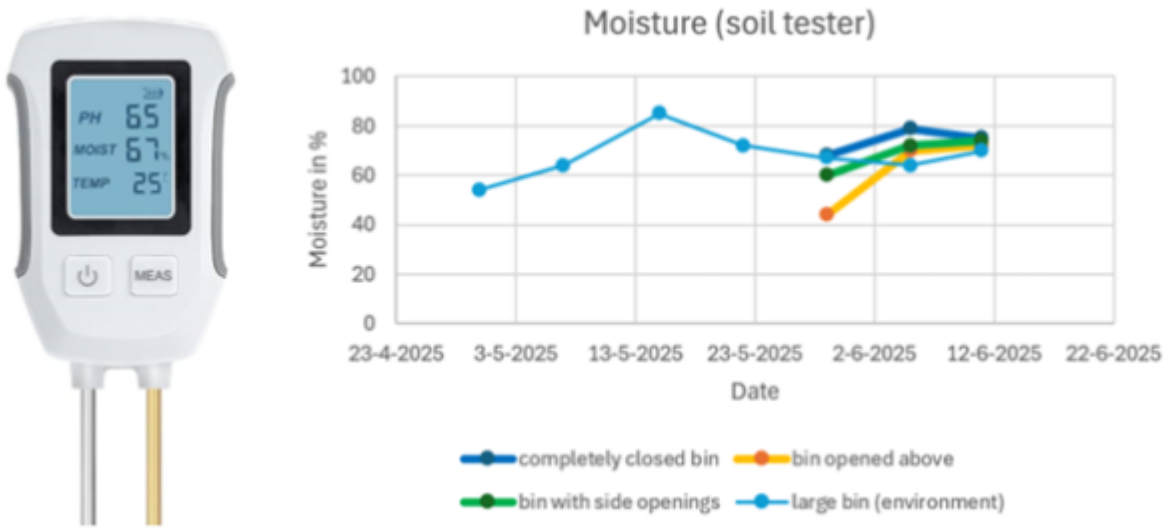


Figure 68: Results moisture three-way-meter

This tool was giving readings closer to the expected values. Since there was not much time left, only three measurements were taken with this device. This is not enough to determine the exact moisture levels of the compost.

However, it can be concluded that there is no clear difference between the different compost bins, suggesting that the amount of airflow does not have a major effect on moisture levels.

Odor

The smell of the compost was also evaluated throughout the composting process. All three containers gave off a typical “earthy” smell, which was not considered unpleasant. The odor remained largely

contained within the boxes and was barely noticeable in the environment.

7.6 Summary

This chapter described the development of the Leftlovers Loopbin, from initial concept to the final product.

The second section covers the ideation phase and the creation of initial sketches. Important considerations during this process were ensuring an attractive appearance, suitability for use in a kitchen and ease of production.

The third part explains the underlying concept of the product, focusing on the composting process and the key factors involved. The aim was to maximize functionality whilst keeping costs as low as possible.

The fourth section provides a more detailed analysis of the design. Using theoretical knowledge and the initial sketches, functional and detailed drawings of the Loopbin were created. These illustrated the structure of the product and the way it worked. The choice of materials was based on a comparison of several options to determine the most suitable choice. In addition, a 3D model of the product was developed and subjected to a stress analysis, which the product successfully passed. In addition to the mechanical aspects, the hardware and software components were also developed. Furthermore, the packaging was designed with a possible second life in mind, which promotes sustainability.

The fifth part describes the development of the prototype and the app that is coming with the product. Both were tested and evaluated, as well as the testing of the composting process itself. All tests delivered positive results.

Each of these steps, from development to final product and prototype, played a crucial role in this project and was successfully completed. The next chapter provides a reflection on the product and the overall process, with attention to the goals achieved and possible future developments.

8. Conclusions

8.1 Achievements

The team successfully overcame the challenges of working in a multicultural environment. Team members communicated effectively and ensured that all tasks were completed in each sprint. All required documents were submitted as part of the deliverables.

The project achieved its main goal of reducing food waste by enabling users to compost and garden in small spaces. A detailed analysis of similar products on the market was carried out to support the development of new ideas and to identify key features for the product. The optimal conditions for compost production were identified, and tests were successfully conducted to produce high-quality compost.

A working prototype of the compost bin was developed, along with a companion app. The app allows users to monitor the composting process in real time, helping to make composting a regular and

sustainable habit. By manufacturing more compost bins in the future, the team believes that more users will contribute to sustainable resource management and help reduce the environmental impact of food waste.

8.2 Future Development

Future improvements could focus on making the product easier and more comfortable to handle by enhancing its ergonomic design. Offering multiple sizes would give clients more flexibility in choosing what suits their needs.

The product design could be refined, with continuous updates to materials using state-of-the-art options. Adding transparent elements would allow users to view the composting process inside. Making the handles retractable could also reduce the risk of tripping or injury near the device.

Improving the installation of electronic components could make the product easier to assemble and maintain. Strengthening the app's cybersecurity features, such as enhanced data protection would help prevent information leaks. Additionally, future versions could explore features that allow users to share their composting activity through the app.

Lastly, new markets and target audiences could be expanded to increase the commercial potential.

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