Loopbin Composter – An EPS@ISEP 2025 Project

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.

Keywords: Engineering Education · European Project Semester · Composting · Homecomposting · Foodwaste · Fertilizer · Homegardening.

1 Introduction

The European Project Semester at Instituto Superior de Engenharia do Porto (EPS@ISEP) is a capstone design programme for third-year engineering students focused on learning through real-world challenges, teamwork, and sustainability. Multinational teams of 6 students develop and implement solutions to current problems, culminating in proof-of-concept prototypes.

In spring 2025, the LeftLovers team with six engineering students from across Europe, chose to address urban food waste. Food waste holds potential as a source of biogas and compost [1] [2]. Yet in many cities, where private gardens are rare, composting remains impractical without municipal support. For example, in Poland only a third of survey respondents were initially willing to compost, though 80 % would consider it if it reduced waste fees by 15 % [11]. Similarly, a study in Shiraz, Iran, found that distributing 10,000 composters could cut landfill CO_2 emissions by 9 %, though managing humidity and temperature remained a key challenge [5].

To address this, the Loobpin composter was developed. It is a compact, odourless, energy-efficient indoor solution. The project combines product design with educational support to enable effective urban composting. It aims to make composting accessible, reduce composting time, improve compost quality, raise user awareness, and promote sustainable waste management.

The resulting prototype meets several key requirements: a 100 € budget, open-source software, EU compliance, suitable compost quality, a 4 to 6 week cycle, intuitive design, sustainable materials, and a mobile app for parameter monitoring, with the goal of producing a high-quality fertilizer.

This paper outlines the research (Section 2), proposed solution (Section 3), prototype development (Section 4), and the project's conclusions (Section 5).

2 Preliminary Studies

Compost bins already exist in different forms and shapes, designed with different advanced materials, innovative aeriaton systems and user-friendly features. As global interest in sustainability is increasing, these bins play a more important role in promoting environmentally friendly practices and reducing environmental impact. This section discusses already existing compost bins and projects or research programs related to household food waste composting, and related ethical, marketing and sustainability issues.

2.1 Related Work

Different smart compost bins were analyzed and compared to have an idea about what already exists on the market, which features they include and what should be included when making a new design for a smart compost bin.

Various food waste disposal solutions with different processes are already in place. Drying and heating are two different processes with a different goal. Drying the compost will prevent bad odors and prepare the compost for storage, while heating the compost will accelerate the breakdown of organic materials and kill off pathogens and weed seeds. Heat is generated naturally from the composting process or can be added by heating up the compost in an artificial way.

FoodCycler Eco 3 [3] recycles food waste 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 or backyard compost [7]. Different ratios of by-product to soil are recommended depending on the composition of the food waste. The product includes an application for the user to schedule and remotely monitor the composting process through humidity and temperature sensors. FoodCycler is self-cleaning, easy to use and does not emit methane.

Greenzy food waste bin [4] is a composter that relies on microorganisms. The whole process of composting takes 2 months to complete, during which the user continues to add food waste to the bin. It has a fly trap on the surface to prevent flies. This standalone product does not monitor the process and has no companion application.

Lomi Bloom compost bin [6] uses three different stages to process food waste, taking from 3 to 20 hours. With the heating, grinding and cooling stages, it mimics the natural composting process. The bin comes with an application for the user to track the food waste footprint, and receive notifications, rewards and tips. Lomi does not monitor the process.

Reencle home composter [9] transforms food waste in 24 hours by creating an optimal environment for the aerobic microbial decomposition of food scraps. It has a three-layered filtering system, with one mesh filter and two carbon filters, to prevent bad odours. Reencle offers a starter package containing activated carbon, wood pellets, glucose, and a trio of patented microbes to ignite the process. This is a standalone solution without process monitoring and companion application. The company claims to make real compost rather than dehydrated waste.

Soilkind compost bin [10] has two chambers. In the first chamber, the food leftovers are dried and cut into smaller pieces, while in the second chamber, the pieces are broken down with the help of microorganisms. The whole process takes 48 hours. The bin monitors the process with the help of humidity and temperature sensors and produces condensation water and compost, both for plants. Soilkind includes a heat exchanger, so that the heat from composting can be used to dry the food waste in the first chamber, and an app that shares information about compost and plants.

Table 1 compares the main features of the products listed above. Loopbin is inspired by all these products.

2.2 Ethics

The considered ethical concerns cover engineering, sales and marketing, environmental responsibility, and product liability. The team adheres to the code of ethics for engineers [8] throughout the development process, which includes integrity, honesty, competence, responsibility, impartiality, and confidentiality. In sales and marketing, ethical practices are applied to the four Ps: product, price, place, and promotion to build customer trust, satisfaction, loyalty, and long-term retention. In terms of environmental protection, the team focuses on the use of recyclable and durable polyvinyl chloride (PVC) to minimize environmental impact and avoid single-use materials. Incorporating manual mixing into the design also helps reduce energy dependence. In terms of product liability, safety is a key concern. As the compost bin contains moving parts and sharp blades, the design provides a fully sealed bin. Detailed operating instructions must be included in the user manual to help reduce the risk of accidents. The product also comes with a guarantee and complies with consumer protection legislation and European Union (EU) directives to ensure legal responsibility and maintain user confidence.

Table 1. Comparison of different home composters

	Foodcycler Eco 3	**Greenzy**	**Lomi Bloom**	**Reencle**[1]	**Soilkind**
Price	412 €	899 €	479 €	458 €	1490 €
Process	Drying, Grinding, Cooling	Aerobic Composting	Heating, Grinding, Cooling	Aerobic Composting	Grinding, Drying
Time	4 h to 9 h	2 months	3 h to 20 h	24 h	48 h
Odour Filtering	Carbon	Carbon[2]	Carbon	Carbon, Mesh[3]	Carbon
Noise Level	$\leq$ 36 dB	$\leq$ 42 dB	$\leq$ 60 dB	$\leq$ 28 dB	$\leq$39 dB
Daily Capacity	$\approx$ 1.5 kg	$\approx$ 2.0 kg	$\approx$ 1.3 kg	$\approx$ 1.0 kg	$\approx$ 1.0 kg
Emptying Frequency	2 d	2 months	1 week	1 months to 3 months	1 week
App	Yes	No	Yes	No	Yes
Sensors	Humidity, Temperature	–	–	–	Humidity, Temperature
Extra Features	Smart control[4]	–	–	–	Self-cleaning, Smart control[5]

[1] Includes a compost starter pack with organic additive;
[2] Filter replacement (25 €) recommended every year;
[3] Filter replacement (45 €) recommended every 3 months;
[4] Scheduling and monitoring of the process;
[5] Scheduling, monitoring and control (via ventilation) of the process.

2.3 Marketing

The target market for Loopbin consists of urban residents without access to a garden. What sets this product apart from other organic waste bins is the integrated garden on top. This gives the user the opportunity to use the compost they produce directly by growing new herbs or vegetables. Another distinguishing feature is the application, which provides real-time insight into the composting process and notifies the user when action is needed. The product is appealing to environmentally conscious consumers with modest incomes who are looking for practical ways to reduce their food waste. The main goal is to keep the price as affordable as possible while maintaining customer satisfaction and profitability. The Loopbin will be available through a dedicated website. Additionally, retail partnerships with gardening stores are being explored, as these locations attract customers that fit the target market. Promotion will mainly focus on social media platforms, supported by advertisements in places that are frequently visited by the target market, such as garden centers and urban areas.

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 logo of Leftlovers is shown in Figure 1 (left) and consists solely of the word “LeftLovers”, with a capitalized “L” in the center to continue highlighting the word “leftover". The “V” in the logo is represented by cutlery and a heart symbol placed above to represent “Lovers.” “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 to grow new herbs and vegetables from old waste. The logo of Loopbin is shown in Figure 1 (centre). In the 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, as depicted in Figure 1 (right).

Fig. 1. LeftLovers and Loopbin brand logos

2.4 Sustainability

The project promotes sustainable development by addressing environmental, economic and social aspects. Composting food waste gives it a second life by nourishing plants, which helps create a greener environment and reduces trips to the supermarket when growing common herbs at home. Designed for small spaces, this compact compost bin has a planting area on top. The main structure of the bin is made of recyclable PVC. The mixing assembly and blades are made from stainless steel, a material that prevents damage during the composting process. Moreover, its power consumption is extremely low (0.23 kWh/month) and it requires no additional maintenance such as changing carbon filters. To achieve these goals, the bin has built-in sensors that optimise composting conditions and prevent odours. The integrated manual mixing function not only saves on electricity costs, but also allows the user to participate in the composting process. The companion app supports user engagement by guiding beginners through the composting process step-by-step, encouraging sustainable habits at home and raising awareness of food waste.

3 Proposed Solution

This chapter discusses the theoretical solution proposed by the team. Both the concept and the design (strucural and electronics) are explained.

3.1 Concept

The concept of this compost bin is to divide the bin into three rooms: two for the composting process and one at the bottom to store the ready to use compost. Figure 2 illustrates how the process works. The input of the compost bin is compost and green and brown food waste. To speed up the composting process, a shredding step is carried out first. Then it must be checked whether 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 compost turning 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. In addition, 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.

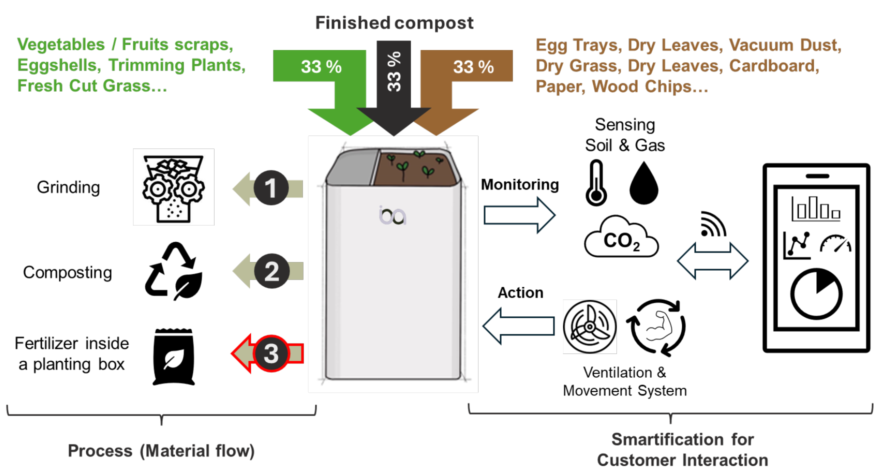


Fig. 2. Loopbin concept

3.2 Design

Structure By combining theoretical knowledge, initial conceptual sketches, and the developed concept, the Loopbin was created. As illustrated in Figure 3, the case is segmented into different parts to allow the assembly.

The composing area is divided into layer 1 and layer 2. While in the first layer the mixer is combined with a cutting part to allow the shredding of the leftovers, in the second its function is to aereate and turn the compost. Regarding the system placed between the layers, it consists of a fixed structure and a hatch, which movement is controlled by an opener. The main part of the electronic system is placed on the backside, while the sensors are located inside the composting chambers.

Concerning material selection, after evaluating different options for their suitability in composting applications, PVC was chosen as the primary material for the castings. The cutting part and the mixer, which require durability and corrosion resistance, are constructed from stainless steel.

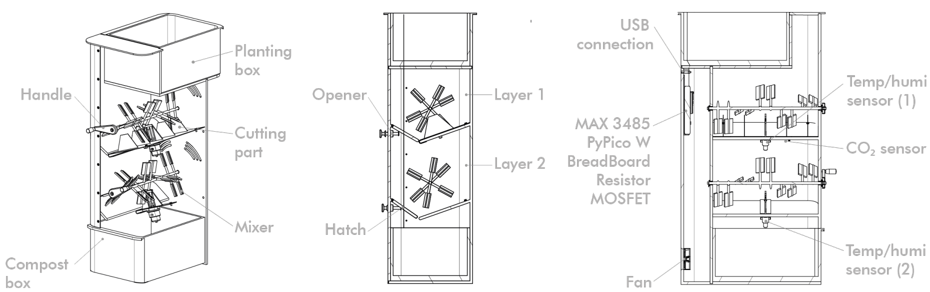


Fig. 3. Loopbin structure

Smart Monitoring Smart monitoring refers to the use of sensors, connected to an app, to monitor the state of the compost. The measured characteristics are the temperature and humidity of the compost, as well as the level of CO_2 in the bin. To do this, the various sensors are connected to an ESP32/Pi Pico W microcontroller board equipped with Wi-Fi. This board also includes a fan to aerate the compost.

Web/Mobile Application The microcontroler Wi-Fi functions enable measured data to be transmitted in real time. This makes it possible to set up an application that provides the user with an interface on which to display these values. This application also provides user tips for improving the state of the compost, by suggesting actions such as mixing the compost or activating the fan. This helps to optimize the microorganisms, resulting in healthy and fast compost. On the technical side, the microcontroller transmits information in

JSON format, over Wi-Fi, to a Linux server. On this server, the back-end processes the values and sends the information to a mobile application developed in JavaScript via ReactNative. A front-end is also present on the server to display the values of the various sensors, using an HTML interface.

Packaging The brand aims to reduce waste by designing a packaging box that serves a second purpose once it is unpacked. To protect the bin during transport, it is enclosed in a box made of cork. Cork is lightweight, durable, biodegradable and commonly found in Portugal. This box can be transformed into a window planter, creating more space for growing plants. To add strength to the box, a cardboard box is placed around the cork box. After unpacking, this box can be composted directly in the bin, eliminating waste. An instruction manual and additional accessories (such as a hook or rope) helps users easily convert the box into a planter.

4 Prototype Development

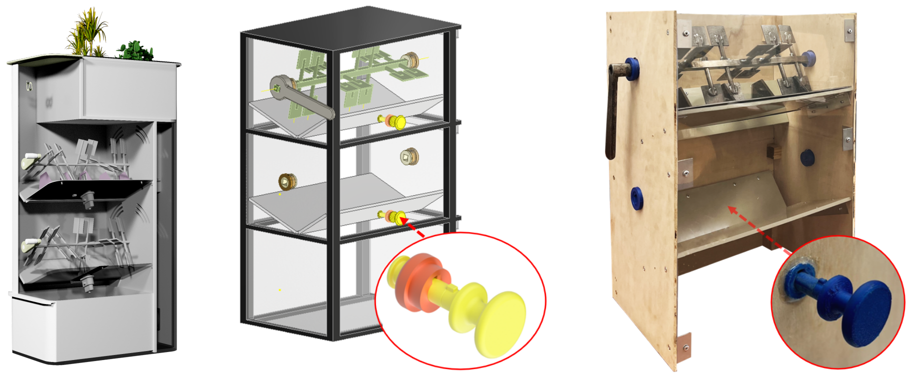
The prototype was developed in three separate areas: structure, smart control, and application. This made it possible for experts from different fields to test the mechanical, electronic and computing functions independently. First, the development of the prototype is described, followed by the test results.

4.1 Assembly

Structure Figure 4 shows the development process of the final prototype. Starting from the final product shown in Figure 4a, a 3D model was created (Figure 4b). The three essential layers of the system are also visible in this model. The main difference is that only a single mixing part was produced, allowing both the shredding and mixing functions to be tested within one unit.

The different layers were replicated as closely as possible to the original design, and the opening mechanism was implemented using 3D-printed components. This prototype was then manufactured (Figure 4c). However, since the original plastic containers were not available, a closed wooden structure was built instead. This alternative construction allowed all functions to be tested effectively.

Smart Monitoring For this prototype, only the humidity sensor is available. To ensure consistent operation, the other sensors will be simulated. To do this, a “Random” function is integrated into the C++ code. Thus, when the server is called to request a measurement, a request is made to the sensor. The other two values are defined randomly. Initially, the fan will operate slower than expected because there is no suitable power supply available: it requires 12 V, while all other components run on 5 V. However, everything is coded for optimal comportment, with requests on the server side and the associated MOSFET triggered on the microcontroller side.



(a) Final concept (b) Prototype concept (c) Manufactured prototype

Fig. 4. Loopbin downsizing process

Web/Mobile Application The application is developed in React Native, using Expo (in JavaScript). It includes user management (Sign In/Log In), sensor value display, composting process time tracking, and advice display. It is organized as follows: A login page, which allows users to enter their credentials or access the account creation page. Accounts are stored on the Linux server, with a hash for password security. Once logged in, users are taken to the home page, which features buttons for accessing the various sensors, as well as a visual display for monitoring the status of the compost. There is also a message display banner at the bottom of this page.

4.2 Tests & Results

It is important to know the weaknesses of the product in order to be able to make improvements. This is why structural, functional, performance and usability tests were performed or simulated, by using software, on the product and the prototype. The software Inventor is used for the stress analysis (structural tests). For the functional, performance and usability tests, the different components (electronics and mechanical parts) were tested.

Structure To ensure sufficient structural strength, stress analyses were performed on the final product. Boundary conditions were defined for the mixer, blades, opening mechanisms of both layers, and the housing structure, representing worst-case scenarios. These were evaluated based on the material properties of each component.

The goal was to design all parts in such a way that the resulting stresses remained below the material yield strength. The results of these analyses are summarized in Table 2. This confirmed that all components possess sufficient structural integrity.

Table 2: Results of the stress and strength analysis

Part	**Material**	**Yield Strength** (MPa)	**Results** (MPa)
Mixer	X5CrNi18-10	225	213
Knife	X5CrNi18-10	225	80
Handle	PVC	40	22.4
Lid	PVC	40	10.1
Opener	PVC	40	24.2
Housing	PVC	40	11

Smart Control Table 3 presents the functional test results of the smart control system, confirming that all components operate as intended.

Table 3: Device: functional results

Use Case	**Result**
Receive sensor information	Pass
Send information in JSON	Pass
Retrieve the state of the "state" variable	Pass
Receive a measurement	Pass
Display in HTML	Pass
Timing	Pass
Measurement button	Pass

Web/Mobile Software Application Table 4 summarizes the functional and performance evaluation of the back-end Application Programming Interface (API), which showed an average standard deviation of 4.23 % for its latency. This indicates that the system behaves consistently and is generally stable.

Table 4: API: functional and performance results

Operation	**Method**	**Result**	**Size** (B)	**Latency** (ms)	
				μ	σ
Get data	GET	Pass	264	309	12
State variable	GET	Pass	187	341	15
HTML display	POST	Pass	409	328	13
Trigger	GET	Pass	168	317	14
Sign up	POST	Pass	409	345	17
Log in	POST	Pass	409	318	12

Although it is not the endpoint with the highest latency, the most frequently used operation was tested to ensure reliable performance. As shown in Table 5, a slightly higher standard deviation was observed at low request volumes. However, as the number of requests increased, the standard deviation decreased, indicating stable system behavior under load.

Table 5: API: load test for "Get data"

Requests	**Operation**	**Method**	**Results**	**Size** (B)	**Latency** (ms)	
					μ	σ
10	Get data	GET	10	265	100	7
100			100		100	5
1000			1000		102	4

Furthermore, the "Sign up" operation, identified as the one with the highest latency, was tested separately as shown in Table 6. While its latency increased more noticeably, the standard deviation again decreased with larger sample sizes, indicating consistent system behavior.

Table 6: API: load test for "Sign up"

Requests	**Operation**	**Method**	**Results**	**Size** (B)	**Latency** (ms)	
					μ	σ
10	Sign up	POST	10	409	345	14
100			100		349	11
1000			1000		355	9

Based on feedback from 10 users, the app received a System Usability Scale (SUS) score of 85/100.

5 Conclusion

5.1 Project Outcomes

The team successfully developed a fully functional prototype, supported by structural drawings and through documentation. A comprehensive analysis of existing market products was conducted to support the ideation of the product and to identify key features for the product to be taken into account. The project achieved its primary goal of reducing food waste by enabling users to compost and garden within limited spaces. In addition, the integrated app allows users to monitor the composting process in real time, helping to establish composting as a sustainable daily habit.

5.2 Personal Outcomes

Working in a multicultural team was a valuable challenge for all members. Throughout the project, the strengths and weaknesses of each team member were identified and considered when distributing the tasks. The project also highlighted the importance of clear and precise communication between team members, which contributed to better collaboration and helped prevent conflicts.

5.3 Future Development

Future development of the product should focus on improving ergonomic design to make handling easier and more user-friendly. One key area for future improvement is the smarter selection and use of materials in the prototype, aiming to further reduce production waste and enhance environmental impact. Incorporating transparent materials into the design would allow users to observe the composting process, particularly in cases where the mixing mechanism becomes blocked. In addition, integrating retractable handles could help reduce the risk of falling or injury near the product. Improvements in the installation layout of electronic components would contribute to a greater ease of assembly and maintenance. Lastly, strengthening the cybersecurity features of the application is essential, including the implementation of data protection measures to prevent potential leaks.

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