

# Report



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## Glossary

Abbreviation	Description
EPS	European Project Semester
ISEP	Instituto Superior de Engenharia do Porto
USB	Universal Serial Bus
SWOT	Strenghts Weaknesses Opportunities Threats
ETC	Et cetera
PDCA	Plan Do Check Act

Abbreviation	Description
ISO	International organization for standardization
LCA	Life cycle analysis
R&D	Research and Development
PBI	Product Backlog Items
CE	Conformité Européenne (European Conformity)
EU	European Union
PESTEL	Political, Economic, Social, Technologies, Environmental and Legal
PLA	Polylactic Acid
ECG	Electrocardiogram
IoT	Internet of Things
PSRAM	Pseudo-Static Random Access Memory
LCD	Liquid Crystal Display
TTL	Transistor-Transistor Logic
TFT	Thin-Film Transistor
I2C	Inter-Integrated Circuit
IO	Input/Output
GPIO	General Purpose Input/Output
SPI	Serial Peripheral Interface
LED	Light Emitting Diode
EMCD	Electromagnetic Compatibility Directive
LVD	Low Voltage Directive
MD	Machinery Directive
RED	Radio Equipment Directive
ROHS	Restriction of Hazardous Substances in Electrical and Electronic Equipment Directive
NSPE	National Society of Professional Engineers

## 1. Introduction

Smart health and well being is the monitoring of health through the use of new technologies. This report describes the work carried out by a group of 6 students from different universities and countries who all took part in a European Project Semester (EPS) at Instituto Superior de Engenharia do Porto (ISEP). The aim of the EPS is to work on a project that responds to a real and topical problem and to develop a number of skills, such as teamwork, communication and improving our English.

Billy is a friendly, and also fun, pill dispenser for children suffering from long-term illnesses, allergies or epilepsy. Billy makes it easier for children to take their medicine, reassures parents and ensures that they never forget to take their medicine.

This document outlines the various stages and elements involved in the making of this project.

## 1.1 Presentation

The team is composed of 6 people from different parts of Europe working on the same project for a semester. The team members have different educational backgrounds and will use each other's knowledge to complete the project. Moreover, the project will be carried out entirely in English, which is not the native language of the team members. This will enable the team to gain a wide range of skills, whether technical, linguistic or soft skills. Table 1 below shows the home towns of the team members and their educational backgrounds.

Table 1: Team Camelia

Name	Studies	Location
Łukasz	Computer Science	Poland, Łódź
Tibo	IT and Electronics engineering	Belgium, Ghent
Lena	Media Technology	Austria, St Pölten
Tamara	Production and logistic engineering	Germany, Köln
Noé	General engineering	France, Tarbes
Stijn	Construction	Belgium, Ghent

## 1.2 Motivation

All the members of the team came to Porto with the aim of working on an innovative and collaborative project, contributing their own skills and knowledge. Below you will find the personal motivations of each team member and the reasons that led the team to choose this subject.

### Personal motivation :

- Łukasz : I think EPS is a great program that brings people together and prepares them for future work.
- Tibo : I wanted to do the EPS project to open myself up more. And too within my general knowledge and soft skills.
- Lena : My personal motivation for doing the European Project Semester is wanting to grow professionally as well as personally. Doing a project with people from different countries, cultures and academic background requires a lot of adaptability, understanding and structuring while also having to gain knowledge in the field of expertise. Aside from studying, moving abroad gives you a once-in-a-lifetime experience, forcing you to become more independent and gifts you with life long friends.
- Tamara : I choose the EPS to kind of challenge myself with living in a different country and working with an international team. I hope to get out of my comfort zone, and I hope to improve my English skills. Moreover, I am interested in gaining knowledge about other cultures!
- Noé : I wanted to do an EPS because I thought it would be more interesting to work on a multi-disciplinary and multi-cultural project than to do a 'classic' Erasmus. I also have friends who have already done an EPS and who have strongly recommended it to me. Moreover, I wanted to improve my English and meet new people. I think this will also be an interesting point to add on my resume.

- Stijn : Going abroad and explore new things. That was my main motivation why I choose EPS. Meeting and working with students from all over Europe, improve my English and soft/social skills, only benefits if you ask me!

### Project Choice motivation :

After brainstorming about the different topics that the team wanted to cover during this EPS, it was decided to put smart health and well-being at the top of the list. For the team, this was an opportunity to work on a subject that was close to their hearts. What's more, the team was very enthusiastic about the idea of working on a project that aimed to help people directly, in this case, their health. So the team chose 'Billy' for their project, a friendly pill dispenser for children suffering from long-term illnesses, allergies or epilepsy. Billy makes it easier for children to take their medicine, reassures parents and ensures that they never forget to take their medicine. By combining the knowledge of all team members, the team believes that it can develop a concept and propose a solution to address this problem.

## 1.3 Problem

A lot of people all over the world are struggling with health issues and have to take certain measurements in order to get better or not get sicker the very least. Taking pills is a big part of the way how medicine needs to be taken, depending on the region and country, these statistics may vary, but for example 51 % of American adults take two or more pills each day [\[Express Medical Supply, 2012\]](#). When thinking about a sick person taking their pills, in most cases an elderly person comes to mind which is not wrong since most people of an older generation have health issues. However, since it's a well-known problem, there are a lot of solutions to fight the problem.

Children are the target group of this project. These days, more and more children suffer from allergies, long-term illnesses or epilepsy. This necessitates the regular use of pills. More than 10 % of children suffer from asthma, 4-8 % of pre-school children have a food allergy, and 20 % of the general population suffer from allergic rhinitis [\[American Hospital of Paris, 2024\]](#). In France, 4,000 children under the age of 10 develop epilepsy every year, and around 40,000 children under the age of 15 are treated daily with an anti-epileptic drug [\[Hôpital Fondation Rothschild, 2024\]](#). All these data and statistics show that there are more sick children than someone might imagine and for them it's even harder to take their pills than for elderly people since in a lot of cases they associate it with a negative experience. That is what the team wants to change by developing a pill dispenser for children to take the right amount of medicine at the right time, the right dosage of it and to be monitored doing it at the same time. While doing all of that, the main goal of our project is to make the intake of medication fun and playful so it's something the children look forward doing to.

## 1.4 Objectives

The aim of this project is to create a playful way for children who have to take pills regularly. In order to achieve this goal, the team will develop a pill dispenser that stores the pills a child has to take throughout the week, also dividing it into different times a day. By a fingerprint sensor it is being controlled that only certain people have access to the dispenser. To make sure that the pills are actually being taken, a camera will be installed.

In addition, "Billy", the pill dispenser includes a reward system addressing the fun factor of the product. Those rewards are being put in by the person or the person taking care of the child,

therefore, the system can be adapted individually to the child. This makes it even more fun for the child since the dispenser only contains presents they like. The reward could be a sweet, an activity, a game, an outing like going to the cinema or playing in the park. The Billy team encourages parents to offer their children rewards that are both fun and educational. Billy's goal is to reduce the negative impact of children when having to take their medication.

## 1.5 Requirements

During the process of this project, the following requirements and limitations will be followed:

### Initial requirements:

1. Comply with the following EU Directives:
  1. Electromagnetic Compatibility Directive ([EMCD](#));
  2. Low Voltage Directive ([LVD](#));
  3. Machinery Directive ([MD](#));
  4. Radio Equipment Directive ([RED](#));
  5. Restriction of Hazardous Substances in Electrical and Electronic Equipment Directive ([ROHS](#));
2. Mandatory adoption and use of the International System of Units ([The NIST International Guide for the use of the International System of Units](#))
3. Use open source software and technologies.

### Budget requirements:

- 100 € max for the prototype.

### Product requirements:

- Easy to use
- Attractive to children
- Deliver the right dose of medicine at the right time
- Store medicines in a safe place
- Box for gifts
- Checks that children have taken their pills
- Sustainable

## 1.6 Functional Tests

The aim of the project is to produce a prototype at the end. To ensure that this prototype works properly, a number of tests need to be carried out. The tests are described below and will be developed in the project development section.

### Functionality tests :

- When the buzzer vibrates and the child places their finger on the fingerprint sensor, a dose of medicine is dispensed.
- When the parent selects parent mode and places their finger on the fingerprint sensor, the various doors open.
- A picture of the child is taken while he is swallowing his medicine.

**Safety tests :** For safety, no doses are administered if the alarm has not sounded or if another person places their finger on the fingerprint sensor. These initial tests will enable the team to see whether the concept, the ideas and the elements used to realize them are sufficiently effective to produce the product.

## 1.7 Project Planning

In order to manage this project as effectively as possible, a software package called Jira is used, it uses the Scrum method [Scrum.org, 2021]. This is illustrated in Figure 1.

The aim of the scrum method is to divide a project into a number of small tasks that are more manageable and achievable. To define the work and tasks required to complete a project, you need to define the project scope. The backlog forms an overview of all the needed tasks. These tasks are then grouped into sprints, which correspond to a period of work during which we want to complete a certain number of tasks. For the project, the team has decided that a sprint will last 1 week (from Thursday to Wednesday). All team members are assigned to tasks in each sprint.

At the end of each sprint, the team carries out a review to see the progress made but also the problems encountered.

By applying these tools, the team will be able to manage its project properly by concentrating initially on the important and urgent tasks in order to meet the deadlines. This method enables the team to work efficiently and productively throughout the various sprints.



Figure 1: Scrum illustration [iam2mai, 2021]

## 1.8 Report Structure

The report is divided in eight chapters as can be seen in Table 2 below.

Table 2: Report Structure

Task	Description
Introduction	Team introduction, definition of the problem and the requirements of the project.
State of Art	Research of existing products.

Task	Description
Project Management	Overview of the management of the project.
Marketing Plan	Marketing research and analysis of our product.
Eco-efficiency measures for Sustainability	Structurally demonstrate sustainability through research.
Ethical and Deontological Concerns	Ethical analysis of possible concerns.
Project Development	Course and evolution of the project with the result.
Conclusions	Overall thoughts about the work.
Bibliography	A list of references of sources we used.

## 2. State of the Art

As the topic for this project, the team chose “Smart Health and Well-being.” But why? This topic was selected because the team wanted to invent a product that is not currently on the market and that can make a significant impact in improving health issues.

With the help of workshops, the team began brainstorming different problems and project ideas. Several project ideas related to the project's topic came to mind. This was done by picking types of products that were the most interesting for the chosen topic of the project. One issue that stood out to the team was the challenge of self-medication for the elderly, sick, mentally disabled etc...

In the sections that follow, the team researched existing products related to smart health and then focused on the different types of pill dispenser available on the market.

### 2.1 Smart Apps

Even though there are various products and accessories, we spend most of our time with our smartphones. This device is with us almost constantly and it is also a very smart device. By using smart software we can get a lot of information from our smartphone. The standard installed apps such as Health from Apple [Apple Health, 2024] are able to provide insight into the number of steps and stairs you take daily, the number of hours you sleep, send reminders for taking medication and much more (see Figure 2).



Figure 2: Health app Apple [Apple Health, 2024]

There are also many other apps that monitor your well-being and maintain your fitness. For even more accurate data, this app can be combined with the Apple Watch, more on such devices in the next section 2.2 Smart Wearables. In addition, there are many other apps that often focus on a specific part of your health. There are apps, for example, Calorie and Nutrition Tracker from Virtuagym, which provide an overview of the amount of calories you take in per day [Virtuagym, 2024] (see Figure 3).



Figure 3: Virtuagym Food [Virtuagym, 2024]

Keeping track of your calories makes it easier to stick to a particular diet or goal. When you grab next to your goals, the app gives a notification about this to encourage you to stick to the plan. There are also apps that allow you to use your smartphone to measure your heart rate and blood pressure. This is done using a sensor in your smartphone and is measured by the software in the app and displayed in the app [Aiby, 2024]. This does not replace a doctor's examination when in doubt, but it can give an insight into your state of health.

The development costs for specialized applications and the programming knowledge required for them are far beyond the reach of this course.



## 2.2 Smart Wearables

Smart wearables, like watches and fitness trackers, have become really popular. They're everywhere and mix technology with our daily routines smoothly. Right now, there are many of them available, each designed for different purposes and styles. This shows that more and more people want gadgets that help them stay healthy and feel good.

### Types of Smart Wearables

**Smartwatches** have become much more than just watches. They now do lots of things like tracking fitness, giving you notifications, and even letting you pay with your phone, an example can be seen in Figure 4. The Apple Watch is the top choice for health features because it's the best-selling connected watch in the world [Apple Watch, 2024]. However, other brands like Samsung, Garmin, and Huawei also have some great options.

**Fitness trackers** are still really important in the world of smart gadgets. They're affordable and do a great job of keeping an eye on how active you are. Brands like Fitbit [Fitbit, 2024], Garmin [Garmin Watch, 2024], and Xiaomi [Xiaomi, 2024] are the big players here. They make devices with fancy sensors that can track things like steps, calories burned, sleep, and your heart rate, an example can be seen in Figure 4.

**Smart clothing**, although not super common yet, is becoming more popular with fitness lovers and tech fans. Brands like Athos [Smart Clothing Lab, 2024] and Sensoria [Sensoria Fitness, 2024] make clothes with special sensors built-in, as you can see in Figure 4. These sensors keep track of things like your heart rate, how your muscles are working, and even how you're standing or moving. This info can help you perform better and avoid injuries.



Apple Watch Ultra 2



Garmin Venu 3



Sensoria textile sensor infused sock and balance data heat map

Figure 4: Types of smart wearables

### Functions and Features

**Keeping an eye on your health** is a big deal for all types of smart wearables. They come with sensors that can monitor important things like your heart rate, how you sleep, and how active you are. This helps you understand more about your health and gives you advice on how to stay well.

**Tracking your activities** has gotten much better, thanks to better sensors and smarter ways of analysing data. Now, you can keep an eye on lots of different things like running, biking, swimming, and even yoga. The details you get are more accurate and precise than before.

**Coaching:** Nowadays, lots of smart gadgets offer personalized coaching to help you reach your fitness goals. They might suggest workouts, give you tips on how to do exercises correctly, or even cheer you on when things get tough. These features are meant to keep you motivated and accountable on your fitness journey.

## 2.3 Smart products

Another example of smart health are all the everyday objects that have become connected, most of them are objects that contain a large number of electronic components such as sensors or micro-controllers. The field of health objects has been expanding rapidly for several years now. This category can include all the different types of equipment that are used daily in hospitals, such as blood pressure monitor, scanner, ultrasound, etc... But our research were mainly focused on objects that can be used by everyone, not just healthcare professionals. The aim of these smart products is to make it easier to monitor a patient's health or take a treatment, in order to improve the quality of life and preserve the long-term health of all users. Connected devices and technologies enable remote monitoring of patients, allowing healthcare professionals to provide high-quality healthcare that truly matches the patient's needs.

There are many products in this category. One of the best known is undoubtedly the connected scale Withings Body Scan that delivers precise weight, segmental body composition and heart health with 6-lead electrocardiogram (ECG), Vascular Age and Nerve tracking for better health. This scale is even able to locate your fat and muscle mass to get you in shape. All this data is then stored on an application to help you improve your health by suggesting sports programmes, for example [\[WithingsBodyScan, 2023\]](#).

Another example of a smart product is the Dyson PH04, an air purifier. An object like this is considered smart because it has sensors, can deal with a problem on its own and is connected to an application. It captures dust, fine particles, viruses and allergens, or humidifies a room. All this to improve the quality of the air in your home, for a cleaner, more comfortable environment. It's a smart health product because it can help allergy sufferers live better at home by creating a healthy environment [\[DysonPH04, 2021\]](#).

The Pillo pill dispenser is a good example of a smart product. It reminds patients to take their medication at the right time of day. Pillo Health devices use camera and biometric technology to ensure that information and medication are provided to the correct user. This dispenser allows patients to take their treatment independently and also allows carers or family members to monitor it remotely [\[PilloHealth, 2020\]](#).

Moreover, the world of sport includes a lot of equipment that falls into the smart product category, such as the jump rope from Crossrope. It's capable of tracking your workouts via a mobile application, giving you feedback in real time and monitoring your progress [\[Crossrope, 2024\]](#). For each example there is a picture of them in Figure 5.

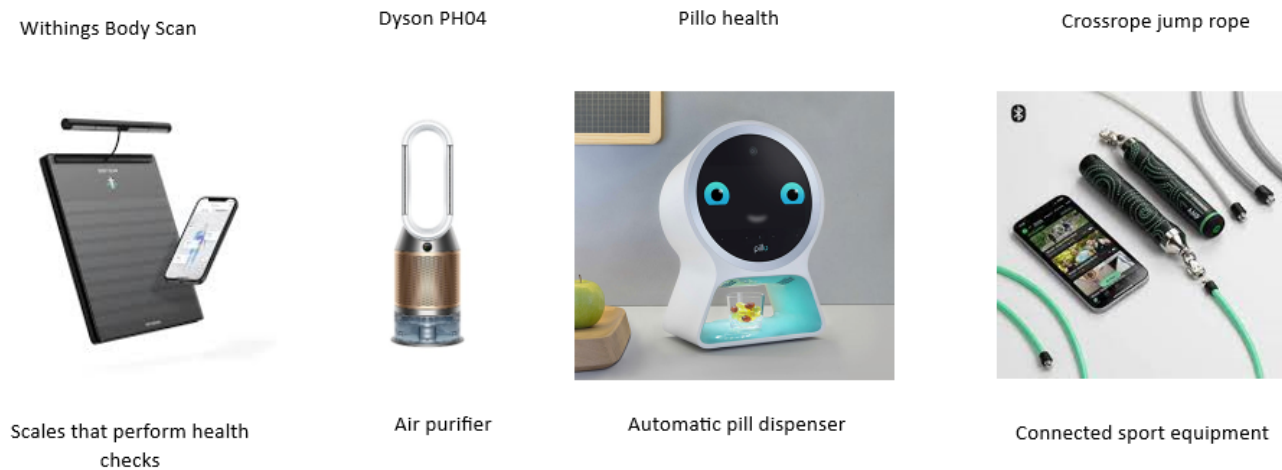


Figure 5: Different type of already existing smart health products

In conclusion, smart products are becoming increasingly popular and more and more present in our daily lives thanks to their benefits in terms of managing and monitoring our health. The use of this kind of technology in our homes allows users to monitor their own health independently, therefore improving their well-being.

## 2.4 Smart Medication Dispenser

After looking at the different types of smart apps, wearables and products, the team focused on refining their research into the different pill dispensing systems that already exist nowadays. Already existing products on the market aimed at addressing this issue of helping people to take their medication. Research has shown that there are many different types of medicine dispenser on the market today. There are very basic models, others that are much more modern and full of technology, and above all they come at all prices.

One of the most common types of medicine dispenser in the world is the simple plastic box on which the days and times when the medicine should be taken are usually written. They are on the market in different shapes and colours. Products in this category include Gogooda and LiveFine, which are very affordable, less than 100 € [LiveFine, 2024], [Gogooda, 2024]. These products are easy to use, but if you're not careful, you could make a mistake by taking the wrong medicine on a different day because there is no security system. Given the price, these products are rather fragile and therefore risk being replaced often, which is not sustainable.

Another example of an intelligent medicine dispenser on the market is Karie, a personal health companion. It is filled and configured by a pharmacist every month. It is secured by a pin code and facial recognition system. Patients are alerted at the right time to take their medication. In the event of forgetfulness, Karie helps with medication adherence by notifying select caregivers and family members when a dose is taken too early, too late or missed [Karie, 2024]. This service is more expensive than the previous examples, costing several hundred euros, as a monthly subscription (in addition to the purchase of the product) is required to benefit from the pharmacist's services.

Pillo, described above, is an intelligent medicine dispenser that differs from Karie in that a caregiver, not a pharmacist, must refill the dispenser from time to time. And its interface is much friendlier than Karie's, making it a health companion [PilloHealth, 2020]. However, its price is higher. It costs around 300 €.

There is one final type of medicine dispenser. These dispensers are much more expensive but much more effective. This is the case with Hero and Medacube. They can both be configured using an application and can hold up to 90 days' worth of daily treatment. The main difference between these two systems, compared with other existing products, is the fact that the dispenser itself is able to prepare each dose by taking the medicines one by one from their storage area. The occasional intervention of an external person to prepare the different mixes of medicines over a period is no longer necessary. The dispenser is capable of doing this itself, once configured. In addition, Medacube has an interface directly on the dispenser, making it easy to configure. These advanced functions make these products very expensive, 1000 € or more [HeroHealth, 2024] and [Medacube, 2024]. All the examples can be seen in the Figure 6 below.



Figure 6: Different types of medication boxes and pill dispensers

In conclusion, there are many types of pill dispenser on the market, at different prices and offering different functionalities and user experience. However, they are all intended for the elderly and none are suitable for children.

## 2.5 Pill dispenser for kids

The team sought to identify an innovation that none of the existing dispensers offered. While there is a significant market for medication dispensers that can give signals, interact with users, or are connected to an app for easier monitoring, a gap was identified in addressing the needs of children. These pill dispensers are not intended for children. Most dispensers on the market are not appealing to the younger generation. With the exception of basic pill dispensers, which are colourful and could therefore be attractive to children, however, this type of dispenser is not intended for children. The proof is in the fact that all the advertising by the manufacturers mentioned above uses images of older people and is aimed solely at them. do not allow parents to allow their children to take their medication in complete safety on their own.

To fill this gap, the team aim to create a medication dispenser with a more playful and colorful design, facilitating direct interaction with the product. The team also envision incorporating elements of gamification, allowing children to engage in a game with the goal of receiving a reward upon medication adherence. Additionally, the goal is to enable children to take medication without supervision, a feature not found in current products.

The proposed solution entails employing a system that is attractive to children by using a reward system. For this, several solutions already exist such as the sweet dispenser, for example the ones sold by Drinkstuff [DrinkStuff, 2024]. Another example of system that is attractive to children are vending machines, like the ones produced by Smile Makers [SmileMakers, 2024]. They are attractive to children because they can see, through a glass window, what they could win. This makes them want to win, so they concentrate and make the effort needed to get the reward.

Another example of a stimulating game for children that contains no technology are the famous pop it games that have become very popular in recent years. The game stimulates children by simply pressing buttons, and is attractive because of its bright colours. The examples mentioned earlier can be seen in Figure 7 below.



Figure 7: Examples of games that are attractive to kids.

Thanks to the fact that this type of game requires concentration and is attractive to children, particularly because they can see the reward and because of the use of attractive colours. The team believes that this is a very good way of stimulating children while they are taking their medication, making it less restrictive and therefore more enjoyable.

2.6 Comparison

Now that the team wants to work on the development of a children's pill dispenser and to ensure the best possible results, the different types of pill dispenser, already on the market, have been compared in Table 3 below.

Table 3: Product comparison

Products	Price	Fonctionality	Sustainable	Ease of use	Appealing to kids	Reward
Plastic Medication Dispenser (gogooda)	5-10 €	Just a plastic box	No	No	Yes	No
LiveFine	60 €	Plastic box with an alarm	No	Yes	No	No
Hero	44.99 €/rent a month	Alarm system plus notification of medication taken to relatives. Connected to an app, self picking system but no security system. 90 days' worth of daily treatment	Yes	Yes, but the configuration is difficult	No	No

Products	Price	Fonctionality	Sustainable	Ease of use	Appealing to kids	Reward
Karie	200 € + subscription	Alarm system plus face recognition. Connected to an app to notify that the medication is taken to relatives, pin code security system.	Yes	Yes but a pharmacist is needed to fill the dispenser	No	No
PilloHealth	300 €	Alarm system plus face recognition. Connected to an app to notify that the medication is taken to relatives, pin code security system.	Yes	Yes	Yes	No
MedaCube	1700 €	Alarm system Connected to an app to notify that the medication is taken to relatives, pin code security system, self picking system. 90 days' worth of daily treatment	Yes	Yes, but the configuration is difficult	No	No

## 2.7 Conclusion

In conclusion, the exploration of smart health technologies reveals a landscape filled with diverse solutions aimed at improving well-being and addressing health challenges. From smart apps to wearables and innovative smart products, the market offers a variety of options for monitoring and managing health effectively. These technologies not only empower individuals to take control of their health but also enable remote monitoring and personalized care by healthcare professionals.

Based on the state of the art above, the team chose to focus on making a pill dispenser for kids that makes the annoying daily task of taking pills more fun. This device can be used with children and mentally disabled people. These users, most of the time, need to be under supervision. This is why the pill dispenser that the team wants to develop will be equipped with a fingerprint sensor. This will enable several profiles to be configured, such as one for the person filling the dispenser and one for the person receiving their medication. The child will only be able to take their medication once the alarm has sounded and they have placed their finger on the fingerprint reader, to ensure that it is indeed the sick child who is taking it. This also prevents users from taking more pills than they are supposed to. The dispenser will also feature a touch screen, to make it easier to configure the device and, in the long term, to play with it. Lastly, a reward system will be installed under a transparent dome to recall the principle of vending machines, explained in the state of the art. Access to the mechanism and the drug storage area will be reserved for parents, with a locking system that can only be activated by a fingerprint reader. A camera system will also allow children to take photos of themselves when taking their medication. At the end of a period of time defined by the parents, and if the child has taken his medication correctly during this period, he will be able to receive his reward. This device makes it possible for these people to take their pills on their own. And feel a sense of independence.

This product will be a good alternative to existing products, combining a number of features and being easy to use, as well as being attractive and fun for children while having a reasonable price.

The following chapter describes the project management used to carry out this project by addressing several subjects, describing the work planned each week and the progress made.

## 3. Project Management

The following chapter deals with project management, an essential key to the success of a project, which the team has put in place in order to organize itself as well as possible throughout the project period. It deals with all the main aspects of project management, such as deadlines, the different stakeholders involved in the project and their management, cost and quality control, a risk analysis and, of course, a detailed planning of all the tasks carried out and a retrospective on the periods of work.

### 3.1 Scope

The scope of the project defines the steps that need to be taken during the development of a project. All the deliverables are stated in the scope as well, allowing the team members to have an overview of what needs to be achieved at all times. However, the scope only gives key functions, therefore, the person responsible for the certain task has his individual freedom in creating.

As listed in the scope, in Figure 8, the project is divided into six steps which are named "Initial", "Design", "Interim", "Executive", "Testing" and "Final". Those six chapters are then divided into even smaller tasks or chapters, representing all of the requirements. In Figure 9, the scope of the product is shown, which is specific to the pill dispenser that the team is developing.







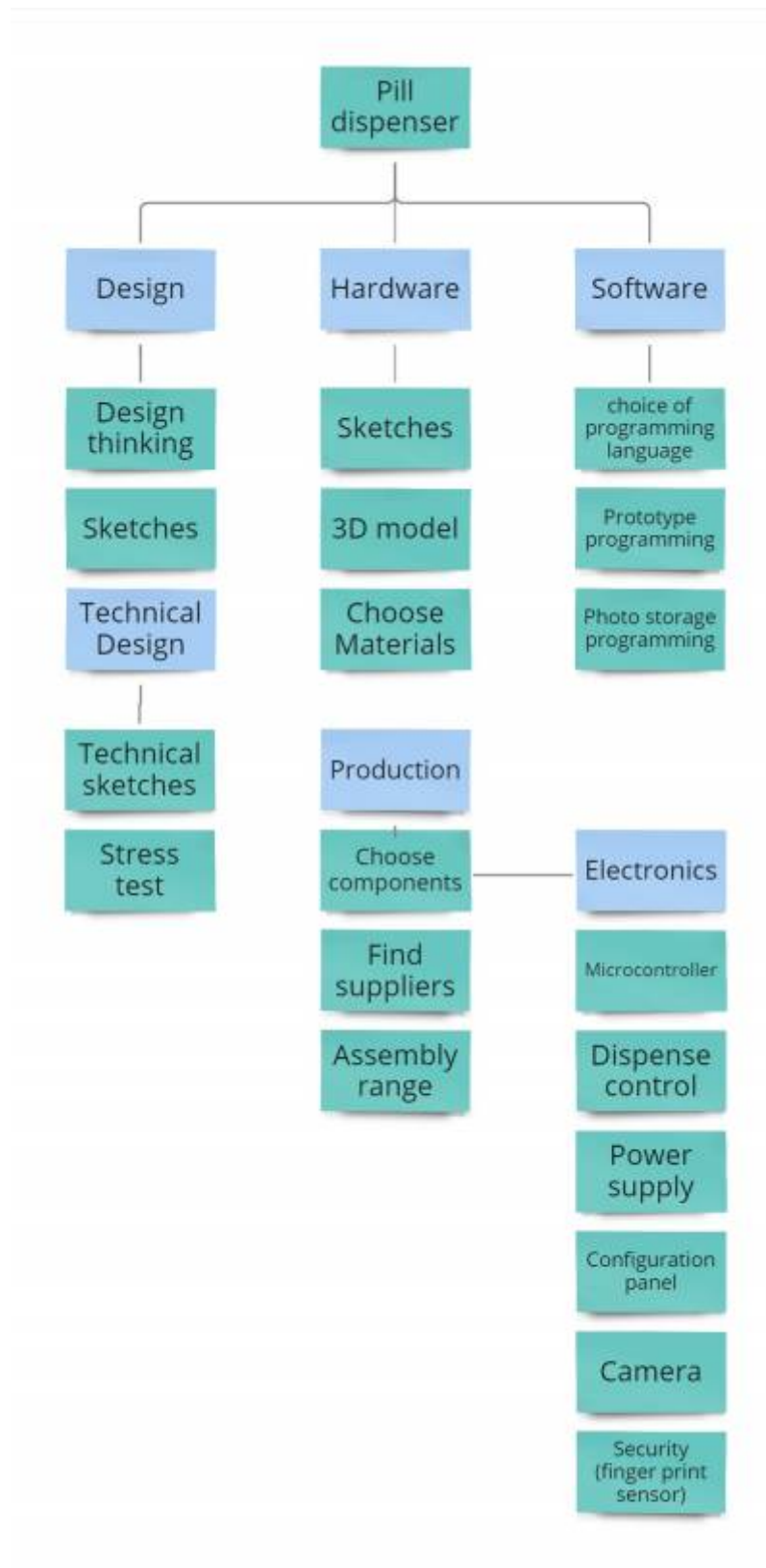


Figure 9: Product scope

### 3.2 Time

Below, is the list of the milestones all the teams had to follow:

- 2024-02-24 Choose a project proposal and send your choice via email to epsatise@gmail.com
- 2024-03-06 Upload the “black box” System Diagrams & Structural Drafts to the wiki
- 2024-03-08 Define the Project Backlog (what must be done and key deliverables - every

member should preferably participate in every task), Global Sprint Plan, Initial Sprint Plan (which tasks should be included, who does what) and Release Gantt Chart of the project and insert them on the wiki (planning)

- 2024-03-13 Upload the List of Components and Materials (what & quantity) to the wiki
- 2024-03-20 Upload the detailed System Schematics & Structural Drawings to the wiki and do the cardboard scale model of the structure
- 2024-04-07 Upload the Interim Report and Presentation to the wiki. The report must contain the the following chapters: Introduction, Project Management, State of the Art, Marketing Plan, Eco-efficiency Measures for Sustainability, Ethical and Deontological Concerns, Proposed Solution and Bibliography. In particular, the Project Management chapter includes the updated project progress register, the sprint report for completed sprints (tasks that were included, statuses, assignees, allocations) and the updated release Gantt chart
- 2024-04-11 Interim Presentation, Discussion and Peer, Teacher and Supervisor Feedbacks
- 2024-04-17 Upload 3D model video to the wiki
- 2024-04-23 Upload the final List of Materials (local providers & price, including VAT and transportation)
- 2024-04-30 Upload refined Interim Report (based on Teacher & Supervisor Feedback)
- 2024-05-15 Upload packaging solution to Deliverables and Report
- 2024-05-28 Upload the results of the Functional Tests to the wiki
- 2024-06-16 Upload the Final Report, Presentation, Video, Paper, Poster and Manual
- 2024-06-20 Final Presentation, Individual Discussion and Assessment (reserve the whole day)
- 2024-06-25:
  1. Update the wiki, report, paper with all suggested corrections
  2. Place in the files section of the MS Teams channel of your team a folder with the refined deliverables (source + PDF) together with all code and drawings produced
  3. Hand in to the EPS coordinator a printed copy of the refined report and poster
- 2024-06-27:
  1. Hand in the prototype and user manual to the client
  2. Receive the EPS@ISEP certificate
  3. Bring typical food from your country

### 3.3 Cost

Regarding the cost of the project, certain factors need to be taken into account. The first is the cost of the various components that make up the product. In the Table 4 below you will find a list of all the components and their costs.

Table 4: Cost of the components for the prototype

Component	Quantity	Price (with VAT)	Supplier	Shopping link
ESP32 CAM	1	11.49 €	Mouser Portugal	<a href="#">Shopping link</a>
FT232RL (USB to TTL Serial Converter)	1	6.77 €	PT Robotics	<a href="#">Shopping link</a>
DFRobot I2C LCD Screen	1	9.21 €	Mouser Portugal	<a href="#">Shopping link</a>
MCP23016 - i2c 16bit Expander	1	3.14 €	PT Robotics	<a href="#">Shopping link</a>
Passive buzzer	1	0.56 €	Mouser Portugal	<a href="#">Shopping link</a>
FPM10A (fingerprint sensor)	1	18.55 €	Mouser Portugal	<a href="#">Shopping link</a>
A4988 stepper driver	1	3.87 €	PT Robotics	<a href="#">Shopping link</a>

Component	Quantity	Price (with VAT)	Supplier	Shopping link
Stepper motor	1	7.44 €	Mouser Portugal	<a href="#">Shopping link</a>
Servo Motor	2	7 €	Mouser Portugal	<a href="#">Shopping link</a>
2x40 Pin Bar for PCB	1	1.23 €	PT Robotics	<a href="#">Shopping link</a>
AC/DC WALL MOUNT power supply 5V 15W	1	4.67 €	PT Robotics	<a href="#">Shopping link</a>
220 Ohm Resistor	1	0.22 €	Mouser Portugal	<a href="#">Shopping link</a>
MULTICOLOR BUTTONS (10 pack)	1	0.82 €	Mouser Portugal	<a href="#">Shopping link</a>
LED RED	4	1 €	PT Robotics	<a href="#">Shopping link</a>
Capacitor Ceramic 100µF	1	0.28 €	Mouser Portugal	<a href="#">Shopping link</a>
BreadBoard	1	2.99 €	Mouser Portugal	<a href="#">Shopping link</a>
Jumper Wires Pack - M/M	1	3.08 €	PT Robotics	<a href="#">Shopping link</a>
USB micro-B Cable - 6 Foot	1	0 €	We will use our personal cable	
Screws M4*25	1	0.63 €	Leroy Merlin	<a href="#">Shopping link</a>
PLA plastic for all the 3D printed parts (500 g because 1/2 scale prototype)	1	8 €	-	Provided by the teachers
Vidro sintético TRANSPARENTE plank 500*500*2mm	1	5.19 €	Leroy Merlin	<a href="#">Shopping link</a>
Total		96.14 €		

The second factor to take into account would be the cost of labour. For 5 months (from February to June) 6 people worked full time on the project. This cost is difficult to estimate, but given that the project took place in Porto, Portugal, a beginner mechanical engineer earns around 1500 € per month. Multiplied by 6 people for 5 months, the total cost of labour represents a cost of **45 000 €**. Salary is not the only cost to consider here. In Portugal, employers must pay social security contributions representing 23.75 % of an employee's gross salary. Employees must also pay social security contributions amounting to 11 % of their gross salary. They must also pay 13.25 % income tax in Portugal. That would leave the employee 804 € a month after tax.

However, as this project is being carried out within the framework of the team members' studies, no salary was necessary. What's more, the cost of the premises and the various associated charges (water, electricity, insurance, etc.) are not taken into account either, as the team work in a room provided by ISEP.

Finally, for the prototype the budget was 100 €, this was respected because the components were readjusted, for the prototype, to fit within the budget.

### 3.4 Quality

It is important not to forget quality management in a project [William L. Dixon, 1987]. It involves carrying out a project through its four phases (concept, development, execution, and finish) with zero deviations from the project specifications. The main benefits of quality management are : customer satisfaction (products meet customer expectations), cost reduction (by eliminating defects in the process, repair costs are also eliminated) and increased production.

To achieve this, the use of processes right from the start of the project to manage our quality is needed. The key components of quality management are :

- **Overall Quality Philosophy** - The involvement of all project participants in ensuring that project goals, requirements and performance standards are in compliance with the expectations of both the client and the project team.
- **Quality Assurance** - The managerial processes that determine the organization, design, objectives and resources, and that provide the project team, client and shareholders with performance standards and feedback on the project's performance.
- **Quality Control** - The technical processes that examine, analyze and report the project's progress and conformance with performance requirements.

It is important to note that quality management is also carried out at the planning stage, for example by checking the production processes and ascertaining their reliability.

For the project, quality management will begin by clearly defining objectives through sketches, models, and component and material specifications. The goal is to design an automatic pill dispenser for children, ensuring safe medication intake with reduced restrictions. Quality assessment will involve prototyping and conducting trials and tests to evaluate if the product meets expectations.

### 3.5 People

Now, let's introduce the key people involved in the project. They are all listed in the Table 5 below. These people form part of the key elements in a project and its management. It is therefore important to know exactly who these stakeholders are and what their role is in order to understand the impact they could have on the project.

Table 5: Project Stakeholders

Stakeholder	Role	Power	Influence
Team members	Owners	High	High
Benedita Malheiro	EPS coordinator	High	High
Supervisors	Supervising the project development	High	Medium
Teachers	Providing resources and support	High	Medium
ISEP	Main sponsor	High	Medium
Sick Kids	Main target group	High	High
Parents	Buyers (for the main target group)	High	High
Suppliers	Providing the components	Low	Medium
Competitors	External influence	Medium	Low

It is important to note that the people with the greatest impact on the project are those who are the closest to it. For example, the team members who will be working directly on the project, taking on tasks according to their abilities and their desire, while collaborating with the others. But also the supervisors, who provide regular feedbacks on the project, raising problems that the team had not thought of and will therefore have to adapt to. Finally, the last people to have the greatest impact on the project are the parents and the sick children, because they are the ones who will be using the product.

The detailed role of each team member changes with each sprint, depending on the deadlines and the work required. This is detailed later in the sprint planning.

### 3.6 Communications

To work as well as possible within the team, communication is needed to achieve all the objectives. To do this, there are many different tools available to communicate easily these days. Right from the start of the project the team created a WhatsApp group, which was used mainly for all the informal exchanges, like small ideas, asking for/sharing opinions when the team members are each working on a task, because it is a quick way of getting in touch with the other members of the group.

Teams was also used to share ideas and finished products (examples : flyers, logos, etc.).

Finally, most of the communication between team members was in person at ISEP, where the team met to work on the project. The team also met every Wednesday at ISEP to prepare for the weekly meeting with the supervisors and see how everyone was doing. Daily standup meetings took place, which was put on Jira to see what everyone had done during the day. the team also held a meeting in person at the end of each sprint, also on Jira, to see whether or not the sprint objectives had been achieved.

The team also communicates with the teachers by taking part in weekly meetings.

### 3.7 Risk

Risk management is an important part of any project [Lavanya N.| Malarvizha T., 2008]. It is important to do this in order to highlight the project tasks that are likely to represent a problem for the success of the project. To achieve the project's goals, identifying and assessing each task is essential. Through systematic evaluation, tasks can be prioritized, resources allocated efficiently, and potential risks identified and addressed proactively.

The steps to be taken to assess the risk are as follows:

- Risk identification
- Risk evaluation
- Risk handling
- Risk controlling

To assess the risk posed by each task, we need to determine the probability of the risk occurring:

1. High probability - ( $80 \% \leq x \leq 100 \%$ )
2. Medium-high probability - ( $60 \% \leq x < 80 \%$ )
3. Medium-Low probability - ( $30 \% \leq x < 60 \%$ )
4. Low probability ( $0 \% < x < 30 \%$ )

But also the impact that the risk would have on the project:

1. High - Catastrophic (Rating A - 100)
2. Medium - Critical (Rating B - 50)
3. Low - Marginal (Rating C - 10)

Risk Score is obtained by multiplying the Impact Rating with Risk Probability, see illustration in Table 6:

Impact	Probability				
		1 = high (80 % ≤ x ≤ 100 %)	2 = medium high (60 % ≤ x ≤ 80 %)	3 = medium low (30 % ≤ x ≤ 60 %)	4 = low (0 % ≤ x ≤ 30 %)
	A = high (Rating 100)	(Exposure - Very High) (Score 100)	(Exposure - Very High) (Score 80)	(Exposure - High) (Score 60)	(Exposure - Moderate) (Score 30)
	B = medium (Rating 50)	(Exposure - High) (Score 50)	(Exposure - Moderate) (Score 40)	(Exposure - Moderate) (Score	(Exposure - Low) (Score 15)
	C = low (Rating 10)	(Exposure - Low) (Score 10)	(Exposure - VLow) (Score 8)	(Exposure - Low) (Score 6)	(Exposure - Low) (Score 3)

Table 6: Risk exposure [Lavanya N.| Malarvizha T., 2008]

It's beneficial to determine the timeframe of potential events to understand when risks might occur. See illustration in Table 7:

Timeframe	Description
Near	Now - until one month
Mid	next 2 - 6 months
Far	> 6 months

Table 7: Risk occurrence timeframe [Lavanya N.| Malarvizha T., 2008]

The last step is the Risk Response. There are several types of response:

- Avoid (seeking to eliminate uncertainty)
- Transfer (passing ownership and/or liability to a third party)
- Mitigate (reducing the probability and/or severity of the risk below a threshold of acceptability)
- Accept (recognizing residual risks and devising responses to control and monitor them)

Applying this approach to our project yields a risk matrix, in Table 8, which helps identify tasks or problems with potential significant impacts on our project :

Table 8: Risk analysis of Billy

Risk identification	Probability	Impact	Timeframe	Response	Risk handling
Member does not want to work	4	A	Mid	Accept	The team tries to motivate the person or works more to compensate
Wiki does not work	2	A	Near	Mitigate	Work on Teams to save the documents.
Lose documents	4	B	Mid	Mitigate	Keeping documents in safe places
Conflicts between team members	2	A	Near	Avoid	Working on communication and teamwork
Components are not delivered on time	3	A	Mid	Avoid	Order in advance and choose reliable suppliers



Risk identification	Probability	Impact	Timeframe	Response	Risk handling
Not respecting deadlines	3	B	Near	Mitigate	Use/Improve Sprint plan
Parents don't trust the product	4	A	Mid	Avoid	A good market analysis and advertising is needed to show how safe the product is
Kids are not interested in the product	3	A	Mid	Avoid	Target group needs to be perfectly define (age,boy,girl, etc...)
Lack of knowledge	3	B	Near	Transfer	Ask the teacher for help/ Research on the internet
Too expensive	2	C	Mid	Transfer	The components/materials can be changed to cheaper ones or borrowed from school
Product does not work well	3	B	Far	Mitigate	Functional tests on the prototype and on the dispense mechanism are needed to make sure everything works.

### 3.8 Procurement

Procurement is a key element of a project in developing the prototype as proof of concept. This means analysing the costs and doing as much research as possible to keep within the 100 € budget. As the budget was very limited, the team decided to make most of the product themselves. Apart from the electronic components that were bought, all the assembly, programming, design and 3D printing of the pill dispenser were done by the students, to keep labour costs as low as possible, especially as the members of the group have experience in this field. Secondly, to reduce the cost of transportation for the components, most of the components were ordered from the same supplier, Mouser, a local Portuguese supplier, which allows the team to contribute to the local economy, to reduce transport costs and to stick to the planned schedule. Another advantage of working with local suppliers is the proximity that the team has with them. In other words, it is easier to talk to them if there is a problem for example if a component is not working, or to discuss delivery times.

However, some of the components used, have been loaned by the school (ISEP).

### 3.9 Stakeholders Management

The stakeholders are all the people involved in the project (team members, Supervisors, Teachers, ISEP, kids, parents, suppliers). It is therefore crucial to keep them engaged and happy for the project's success [Pedro Serrador, 2009]. Failure to identify stakeholders, understand stakeholder needs, and meet their needs can result in spectacular project failures. It is therefore important to recognise the stakeholders and their influence on the project. The following Table 9 shows the influence and power of each stakeholder.

Table 9: Stakeholders management

Stakeholders	Role	Influence	Power
Suppliers	Provide the components	Low	Mid
Team members	Build the project	High	High
Supervisors	Helping the team to carry out its project	High	High
Customers (parents and kids)	Buy the product	High	High
ISEP	Provide the premises and budget (sponsor)	Low	High
Teachers	Assists team members with courses	Low	High
Competitors	Work in the same field	Low	Low

Stakeholders all have a different influence on the project. The team therefore needs to adapt their communication with them to keep them engaged. For example, teachers, supervisors, team members and parents will need to be closely managed through extensive communication such as meetings, listening to their feedback and needs and creating a relationship of trust. Secondly, teachers and ISEP must be satisfied. It is also needed to keep suppliers informed throughout the contract to avoid supply problems.

All of this can be put on a graph, see Figure 10, which makes it easier to show the influence and impact of each stakeholder.



Figure 10: Stakeholder Management analysis [Magda E. Ramos, 2022]

### 3.10 Project Plan

The Global Sprint Plan is shown in the Table 10. The table shows the duration of every sprint until the end of the project. A sprint corresponds to a period of work during which we want to complete a certain number of tasks. For the project, the team has decided that a sprint will last 1 week (from Thursday to Wednesday). Each team member is assigned a task for each sprint. To facilitate this, the first letters of team members' surnames and first names are used to designate them as being responsible for or involved in a task: Łukasz Borowski (LB), Tibo Clauwaert (TC), Lena Ehrenhofer (LE), Tamara Kronshagen (TK), Noé Oliveira (NO) and Stijn Steyaert (SS).

Table 10: Global Sprint Plan

Sprint	Start	Finish
0	22/02/2024	28/02/2024
1	29/02/2024	06/03/2024



Sprint	Start	Finish
2	07/03/2024	13/03/2024
3	14/03/2024	20/03/2024
4	21/03/2024	03/04/2024
5	04/04/2024	10/04/2024
6	11/04/2024	17/04/2024
7	18/04/2024	24/04/2024
8	25/04/2024	01/05/2024
9	02/05/2024	15/05/2024
10	16/05/2024	22/05/2024
11	23/05/2024	29/05/2024
12	30/05/2024	05/06/2024
13	06/06/2024	12/06/2024
14	13/06/2024	19/06/2024
15	20/06/2024	26/06/2024

Table 11 shows the Project Backlog, this covers all the major tasks involved in the project. A letter is attached to each task to make it easier to keep track of them. The team uses Prioritised Backlog Items (PBI) which keeps the higher priority items at the top, and lower priority at the bottom. It allows team members to concentrate on the most urgent tasks.

Table 11: Project Backlog

PBI	Title	Status
A	Define Project	Done
B	System Diagrams (Black Box) & Structural Drafts	Done
C	Project Backlog	Done
D	Sprint & Initial Sprint Plan	Done
E	Gantt Chart	Done
F	List of Components and Materials	Done
G	System Schematics & Structural Drawings	Done
H	Cardboard scale model	Done
I	Interim Report and Presentation	Done
J	3D model video	Done
K	Final List of Materials	Done
L	Refined Report	To do
M	Packaging solution	To do
N	Functional Tests	To do
O	Final Report & Presentation	To do
P	Video, Paper, Poster, Manual	To do
Q	Prototype and User Manual	To do
R	Upload	To do

In the Table 12 the Sprint Plan is shown. At the start of each sprint, the team planned the work that was going to be done by grouping it in the Sprint Plan table.

Table 12: Sprint Plan

Sprint	Task	Duration [d]	Responsible	Involved
0	A	5	All	All
1	B	5	SS	LE and TK
2	C	5	SS and NO	LE and TK
2	D	5	NO	LE and TK
2	E	5	NO	LE and TK
2	F	5	TC	LB
3	G	5	SS and NO	SS and NO
3	H	5	TK	LE
4	I	5	All	All
5	I	5	All	All
6	J	5	LE and NO	LE and NO
6	K	5	TC and LB	TC and LB
7	K	5	TC and LB	TC and LB
8	L	5	All	All

At the end of each sprint, the Project Backlog Items are reviewed and updated on their status. This review is done in the Progress Register Table 13 below.

Table 13: Project Progress Register

Sprint	PBI	Responsible	Involved	Status
0	A	All	All	Done
1	B	SS, NO	LE, TK	Done
2	C, D, E, F	NO, TC	All	Done
3	G, H	SS,TC, LE	All	Done
4	I	All	All	Done
5	I	All	All	Done
6	J, K	LE, NO	LE, NO	Done
7	K	TC, LB	TC, LB, NO	Done
8	L	All	All	In Progress
9	M, N	LE, TC	All	In Progress
10	N, O	LE, TK	All	In Progress
11	P	TC, LB	TC, LB, SS	In Progress
12	-	---	-----	In Progress
13	-	---	-----	In Progress
14	Q	All	All	In Progress

Identify key project deliverables (when they will be started and completed) and build a release Gantt chart. See Figure 11 for inspiration.

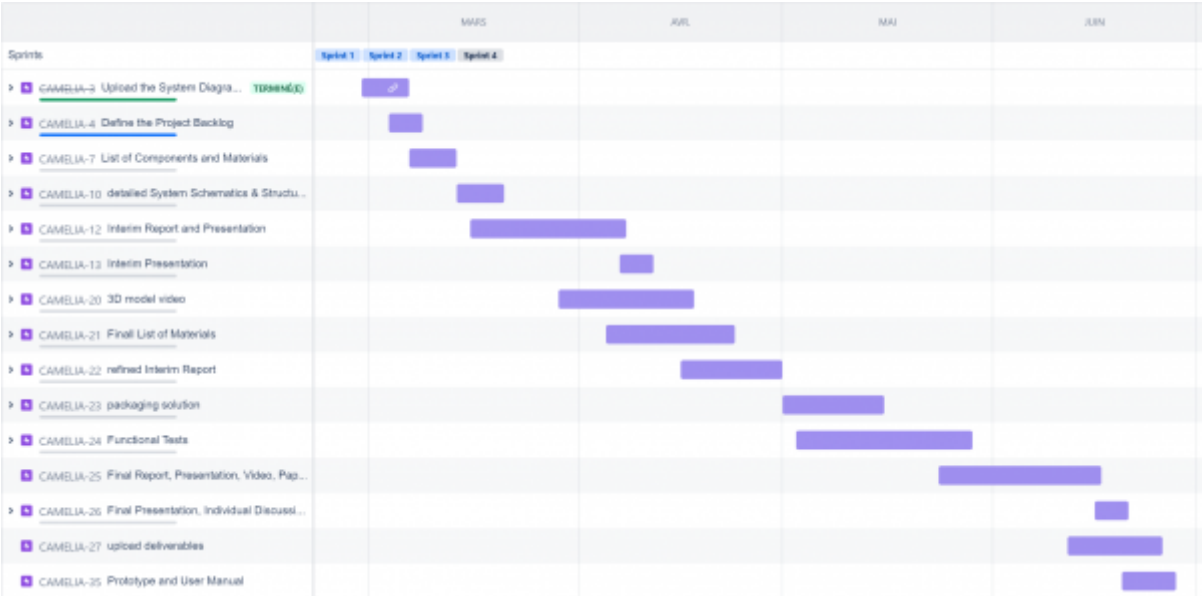


Figure 11: Gantt chart

3.11 Sprint Outcomes

To keep a clear view of how each sprint is progressing, it's important to keep track of them. To do this, every week the team met at the end of each sprint and discussed how the sprint was progressing. Whether the time spent was the same as planned, or more, or less, whether the task had been completed or not and whether there were any other elements to add to the task. The summaries of these meetings on the progress of the sprints are grouped together in the sprints outcomes from Table 14 to Table 22. A burndown graph is associated with each sprint outcome, illustrating the time spent on sprint tasks up to the end of the sprint. This is illustrated from Figure 12 to Figure 17. For more details on each sprint, this monitoring has also been carried out on [Jira](#).

Table 14: Sprint 0 - 22/02-28/02. Velocity planned: 28,5h. Real Velocity: 28,5h.

Product Backlog Item	Assignee	Planned Effort [h]	Completed	Not completed	Notes
Choose topic	All	4	X		The team chose 3 topics
Get familiar with jira	All	1	X		Take a look at jira's functions
Classes	All	23,5	X		

Table 15: Sprint 1 - 29/02-06/03. Velocity planned: 37h. Real Velocity: 37h.

Product Backlog Item	Assignee	Planned Effort [h]	Completed	Not completed	Notes
Define the target group	All	2	X		-
Structural Drafts and System diagram	SS, NO	3	X		BlackBox and Structural Drafts
Write our personal motivations on the wiki	All	2	X		Start of the wiki editing
Classes	All	30	X		

Table 16: Sprint 2 - 07/03-13/03. Velocity planned: 34h. Real Velocity: 34h.

Product Backlog Item	Assignee	Planned Effort [h]	Completed	Not completed	Notes
Define the project Backlog	NO	1	X		Global and initial Sprint plan, Gantt chart
List of Components and Materials	TC, LB	8	X		List of electronic and hardware components for the prototype and a list of materials
Create a flyer	LE, TK	4	X		Create a flyer to present our project for communication class
Create a logo	LE, TK	2	X		Create a logo for our product
Classes	All	19	X		

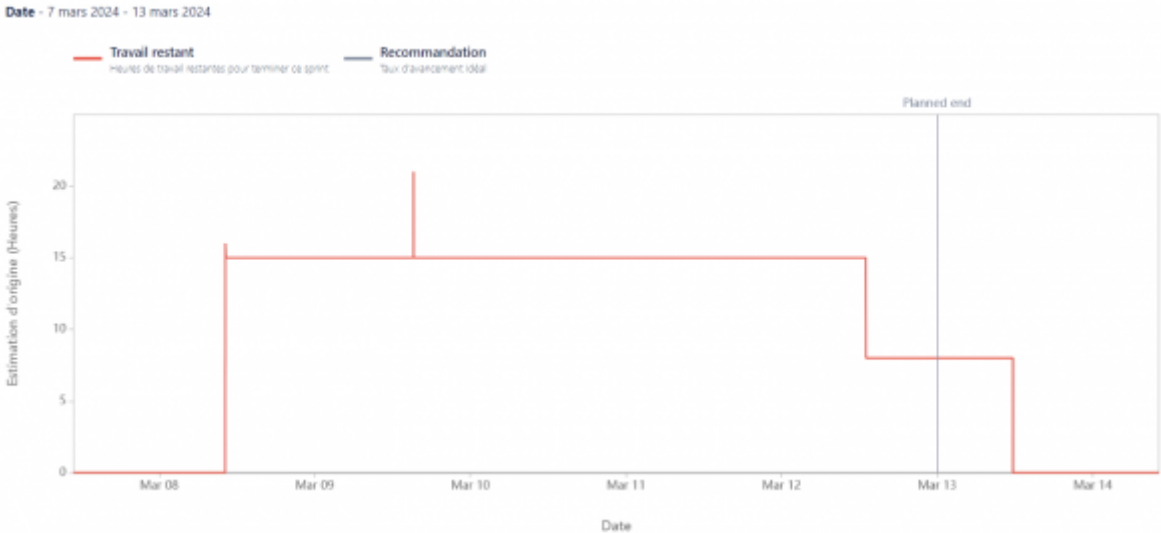


Figure 12: Sprint 2 burndown chart

Table 17: Sprint 3 - 14/03-20/03. Velocity planned: 37,5h. Real Velocity: 37,5h.

Product Backlog Item	Assignee	Planned Effort [h]	Completed	Not completed	Notes
Detailed System schematics	TC	5	X		Electronic schematics
Detailed Structural Drawings	SS,NO	6	X		Do a detailed drawing of the product
Cardboard model	LE, TK	4	X		Do a cardboard model of our product
Do the scope on the report	LE	1,5	X		Start to write the project development part
Classes	All	21	X		

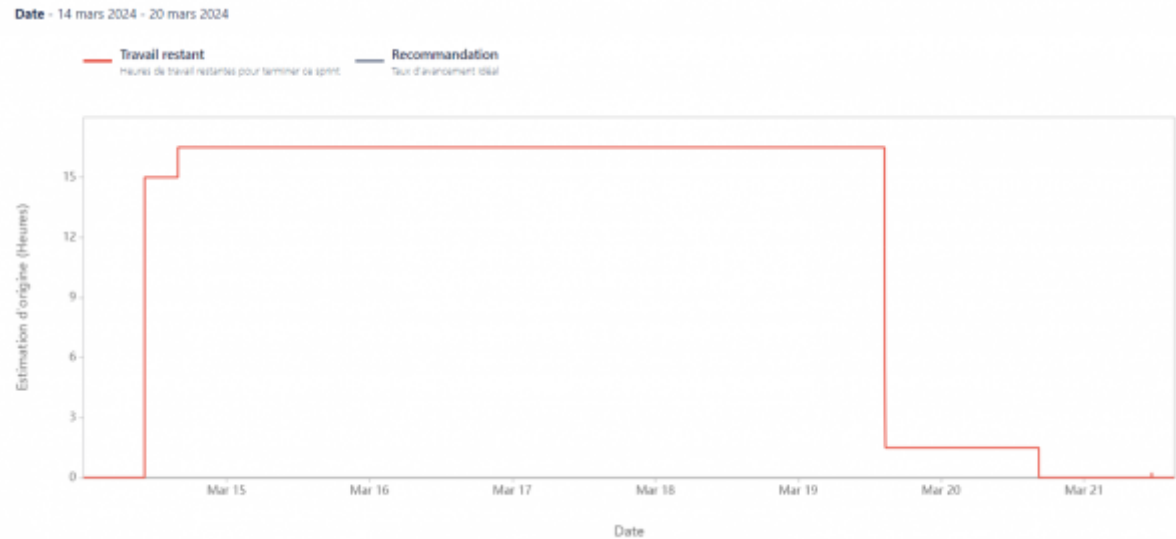


Figure 13: Sprint 3 burndown chart

Table 18: Sprint 4 - 21/03-04/04. Velocity planned: 80h. Real Velocity: 81h.

Product Backlog Item	Assignee	Planned Effort [h]	Completed	Not completed	Notes
State of the art	TK	6	X		Finish the state of the art for the interim report
Wiki's introduction	NO	1	X		Do the introduction for the interim report
Write the project management part on the wiki	NO	14	X		Finish project developement for the interim report
Ethics & deontology	LE	8	X		Finish Ethics & deontology for the interim report
Marketing	SS	24		X	Finish marketing for interim report - Did not have time to finish it, postponed to sprint 5
Eco-efficiency Measures for sustainability	TK	16		X	Finish Eco-efficiency - Did not have time to finish it Measures for sustainability for interim report, postponed to sprint 5
Classes	All	11	X		

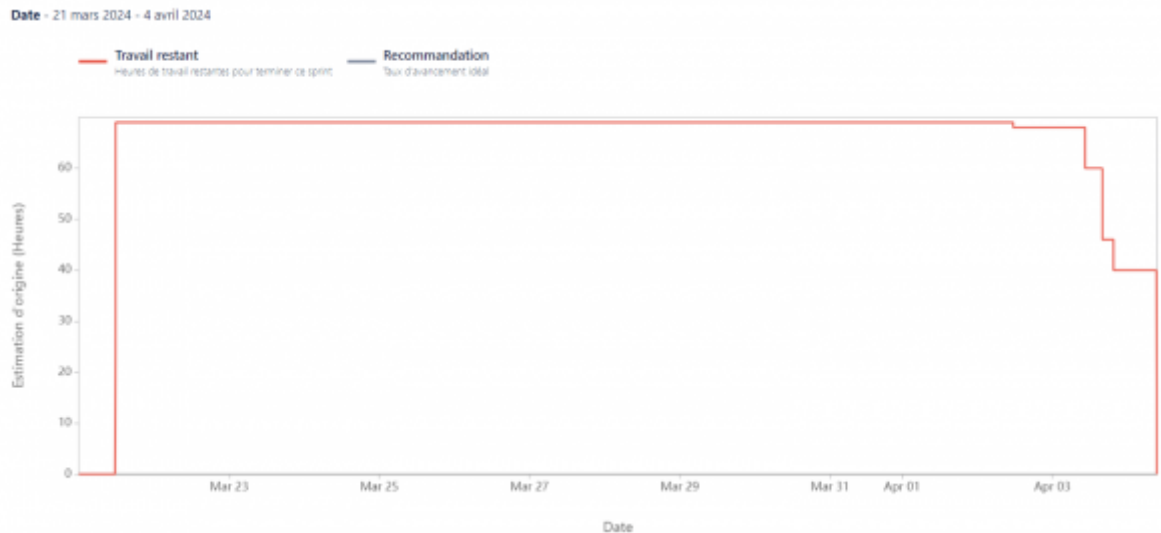


Figure 14: Sprint 4 burndown chart

Table 19: Sprint 5 - 04/04-10/04. Velocity planned: 28h. Real Velocity: 29h.

Product Backlog Item	Assignee	Planned Effort [h]	Completed	Not completed	Notes
Interim presentation	LE	5	X		Create the presentation and rehearse for the presentation, Presentation was on 1 day of the next sprint
Marketing	SS	3	X		Continue and finish marketing for the interim report
Eco-efficiency Measures for sustainability	TK	5	X		Continue and finish marketing for the interim report
3D model video	LE,NO	4		x	Started in sprint 5 but postponed to sprint 6 because it took more time than expected
Classes	All	11	X		

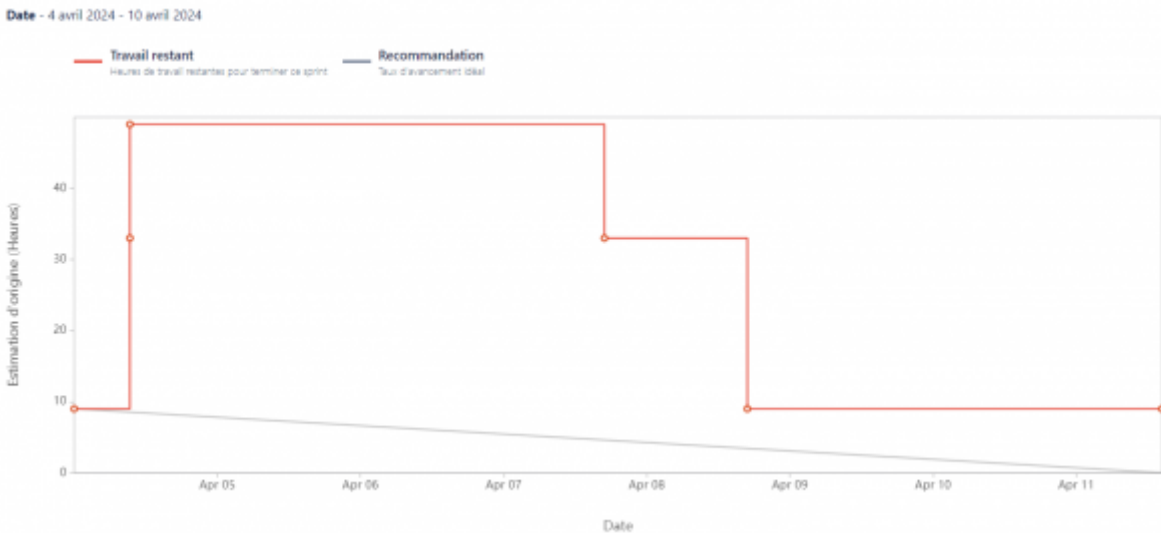


Figure 15: Sprint 5 burndown chart

Table 20: Sprint 6 - 11/04-17/04. Velocity planned: 25h. Real Velocity: 27h.

Product Backlog Item	Assignee	Planned Effort [h]	Completed	Not completed	Notes
Modify the wiki based on the teachers feedback	SS	3		X	Added to the sprint after the interim presentation (1st day of the sprint). Not finished during this sprint because it took more time than planned
Final list of components and materials	TC, LB	4		X	Not finished during this sprint because team member where not as available as planned
3D model video	LE, NO	4	X		Took more time than planned but finished it.
Classes	All	14	X		

Date - 11 avril 2024 - 17 avril 2024

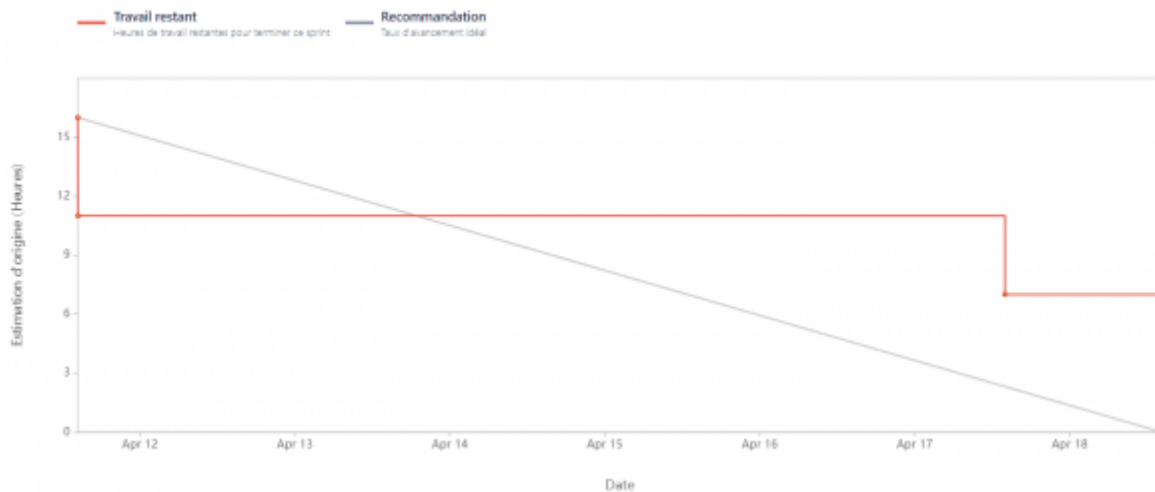


Figure 16: Sprint 6 burndown chart

Table 21: Sprint 7 - 18/04-24/04. Velocity planned: 36h. Real Velocity: 32,5h.

Product Backlog Item	Assignee	Planned Effort [h]	Completed	Not completed	Notes
Modify the wiki based on the teachers feedback	SS	3	X		-
Final list of components and materials	TC, LB	4	X		Took more time than planned
Ethic case presentation	All	4	X		Presentation, not for the project
Create the power budget in the wiki	LB	2	X		Start to write the Product Development part on the wiki
Update the detailed schematics	TC	1.50	X		-

Product Backlog Item	Assignee	Planned Effort [h]	Completed	Not completed	Notes
Calculate transport cost for the components	TC	0.50	X		-
Refine interim report	All	5		X	Out of the sprint because not enough team members were available this week
Classes	All	16	X		

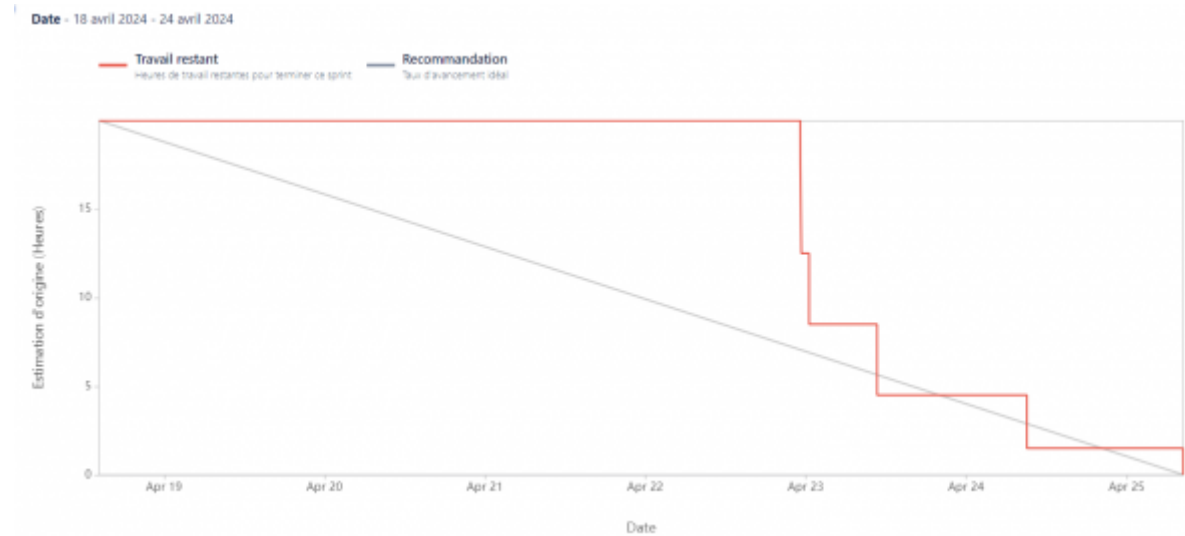


Figure 17: Sprint 7 burndown chart

Table 22: Sprint 8 - 25/04-02/05. Velocity planned: 14,5h. Real Velocity: h.

Product Backlog Item	Assignee	Planned Effort [h]	Completed	Not completed	Notes
Refine interim report	All	5			-
Start writing Software part in product development	TC, LB	3			
Update the detailed drawings	NO	1,5			
Do a leaflet	LE, TK	5			
Classes	All	0	X		

3.12 Sprint Evaluations

At the end of each sprint, the sprint evaluation was done. It is made up of the sprint retrospectives, including any actions implemented as part of the team’s continuous improvement strategy. The sprint retrospectives can be seen on Jira or in table 23 below.

Table 23: Sprint evaluations



Sprint	Positive	Negative	Start doing	Keep doing	Stop doing
1	Chose a project proposal - Brainstorming about ideas	-	Think about other ideas	Get to know each other	-
2	Completed the list of components and materials	Need to modify a little the list of components after the teacher's feedback	Think about solutions for the design of the product	Finish the task on time	
3	We managed to finalize all the documents (structural drawing, detailed schematic and cardboard model) 1 day ahead of schedule.	Teachers told us to modify the design to make it more attractive	Nothing	Still working as we are doing	Nothing
4	We managed to work on the wiki and finish some chapters	Not all team members up to date about the work in progress	Prepare for the interim report		Communicating too less
5	We managed to do a decent presentation for the interim report and got some good feedbacks	Saving problems in the wiki, forcing us to start again	Organize ourselves to edit the wiki	Working as we are	
6	We completed the 3D model video on time	We did not managed to improve the wiki as much as we wanted to. The 3D model video took more time than planned	Trying to better estimate the duration of a task according to everyone's availability		
7	The final list of components and material was appreciated by the teachers	This list wasted too much time focusing on unnecessary details and not making decisions	Be more responsive and take decisions more quickly		Waste time on small details

### 3.13 Conclusion

In conclusion, this section explains that project management is one of the key elements in project implementation. Project management gave the team all the elements needed to organize its work in the best possible way by clearly identifying the objectives, the associated deadlines and stay within the budget. This enabled the team members to concentrate on the important tasks at the right time and to be more productive when working.

What's more, the fact that the team carried out an analysis of risk, cost, quality and communication meant that no aspect or potential problem in managing this project has been overlooked. It also enabled the team to know how to respond when a problem arose, but above all to do it quickly, to get

back to work quickly and lose as little time as possible. Project management also enables clear communication with stakeholders, ensuring that expectations are well-managed and project progress is communicated transparently

Finally, the daily and weekly monitoring of the work, thanks to the use of the Scrum method and the Jira, enabled the students to be less stressed, happier, and to make their daily lives easier by not forgetting any tasks in the project.

The next chapter deals with marketing and its importance to the success of a project, detailing the strategy adopted and the people targeted by the project.

## 4. Marketing Plan

A marketing plan is a very important strategy that must be made for every new product, it is kind of a tactic the company has to develop to fulfill specific business goals. The company must make a marketing plan for the product it wants to bring on the market. Therefore, it is important to have a look on the target group. One has to make a market analysis in the beginning to gain better knowledge of the needs and behaviors a certain target group has. Moreover, it is important to know the needs in detail to be able to fulfill them and therefore gain the best chances for the product on the market. One of the first things you can do to get better knowledge is a SWOT (Strengths Weaknesses Opportunities Threats) analysis. The SWOT analysis is used to identify weaknesses and chances for the product. After that the Team is able to develop strategies to improve the market performance.

### 4.1 Market Analysis

#### 4.2.1 Introduction to Market Analysis

A marketing analysis serves as a guide for a company during the development of a product or service. It gives a view of where the project and company are in the market. In addition, the different components of a market analysis are interesting for a company to gain more insight and knowledge about their potential customers.

#### 4.2.2 Value proposition pitch

An elevator pitch is meant to give a potential customer or investor a concise and compelling summary that describes the product in a clear and effective way. The main goal is to captivate and excite the listener to learn more about the product. While this is a brief getting-to-know-you session, it is not to be underestimated. A comprehensive and detailed value proposition can be found in the next section, the pitch is below in Figure 18.

## Value Proposition - Elevator Pitch

For	sick children who have to
who	take medication
the	Billy
is a	pill dispenser
that	secures and monitors the
	children's pill intake
unlike	other pill dispensers
our	product offers pill intake in a
	fun and playful way

Figure 18: Value Proposition

### 4.2.3 Value Proposition

Every day, companies design products to improve consumers' lives. But 72 % of newly launched products fail to meet expectations [Strategyzer, 2024]. To prevent this from happening, there is a tool called business canvas model, that gives more insight into numerous aspects important for a successful product launch. These include key partners and activities, cost structure and customer relationships. The value proposition canvas is a tool that visualizes, designs and tests. It focuses on value proposition and customer segments.

The first part examines what a potential customer's tasks are, what pain or frustration is involved. Lastly, in the customer profile, it looks at what benefits and enjoyment the customers can get from the product.

In the second part, the value map, it begins by looking at the products and services on which the value proposition is based. Then it considers how this can help reduce customers' pain and make their lives more enjoyable. Finally, it paints a picture of how this can provide more pleasure and convenience and increase profits.

### 4.2.4 Micro-environment

Customers: Billy aims for specific customer group in example parents who struggle with their kids taking medications. Such caregivers can not devote all time to children in order to take control over medicine intake.

**Competitors:** Nowadays, on the market are many pill dispensers. They offer several functions such as: login panel, face recognition, reminder, integrated app and many others. Most of products are the same, so they don't introduce any innovation.

**Suppliers:** The pill dispenser can take electronic components from several sources, as they are commonly used in industry. Apart from these parts, our device will have custom cover and some mechanical which can be 3D printed.

**Intermediaries:** Pharmacies are the dream middleman. However it might be hard to have required certificate. Therefore at the beginning the team should consider our own internet store and advertisement.

#### 4.2.5 Macro-environment

- **Market Segment:** The target market is parents with children who resist taking pills, indicating a need for innovative solutions to ease the medication process.
- **Regulations and Standards:** Compliance with EU medical device regulations (such as CE marking) is crucial for market entry and ensuring safety and efficacy standards are met.
- **Competitive Landscape:** While there are several startups in the market, none offer features specifically designed to make pill intake more entertaining for children, offering an opportunity for differentiation and market capture.
- **Technological Trends:** Emerging technologies like gamification, interactive interfaces, or smart reminders could be leveraged to make the pill dispenser more engaging for children.
- **Healthcare Policies and Insurance Coverage:** Understanding reimbursement policies and potential incentives for medical devices can impact adoption rates among consumers.
- **Certification and Compliance:** Obtaining necessary certificates and complying with regulations is essential for market acceptance and building trust among consumers.
- **Socio-Economic Factors:** Affordability and accessibility may influence purchasing decisions, highlighting the need for cost-effective solutions and distribution strategies.
- **Distribution Channels:** Direct-to-consumer sales through the company's website can provide easy access to the product, but partnerships with pharmacies or healthcare providers could increase customer trust and popularity.
- **Cultural Attitudes:** Cultural perceptions of healthcare and medication management may vary across EU countries, requiring localized marketing strategies and product adaptations.
- **Design and Sustainability:** Ensuring the pill dispenser is child-friendly, perhaps through colorful designs or interactive elements, aligns with the need to make pill intake more enjoyable. Additionally, considerations for eco-friendly materials and manufacturing processes can appeal to wider group of consumers.

#### 4.2.6 PESTEL Analysis

The PESTEL (Political, Economic, Social, Technologies, Environmental and Legal) analysis is a type of model used as marketing research for companies (see Figure 19). It gives a company insight into

external factors that may affect their strategy. Usually the PESTEL analysis is used along with the SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis. Together, these two models help companies recognize and respond to opportunities and pitfalls. Each aspect of the PESTEL analysis says something about a different external factor [Alayna Wood, 2024].



Figure 19: PESTEL Analysis

- **Political factors**

**Government Regulations:** Compliance with regulations for medical devices in European countries, such as obtaining CE (Conformité Européenne) marking, is crucial for market entry and ensuring safety standards.

**Healthcare Policies:** Government healthcare policies and funding allocations may influence the adoption of medical devices like pill dispensers, potentially affecting reimbursement rates and market demand.

**Political Stability:** Political stability in EU member states ensures a conducive business environment for companies operating in the healthcare sector.

- **Economical factors**

**Economic Stability:** The overall economic stability of EU countries impacts consumers' purchasing power and willingness to invest in healthcare products like pill dispensers.

**Affordability:** Economic conditions affect the affordability of healthcare services and products, potentially influencing consumer demand for pill dispensers.

**Currency Exchange Rates:** Fluctuations in exchange rates can impact the cost of importing raw

materials or exporting finished products, affecting the pricing strategy of pill dispensers.

- **Social factors**

Children can take pills from the age of 5 years old [Ashley Rapske, 2018]. Although they are the exception because usually it starts around age 8 when a doctor will prescribe them pills. To make this process easier, they can use a pill dispenser designed for children. This device makes it more fun for the children to swallow the pills and also helps them remember when to take which pill. Statistics show that more and more children are becoming allergic to pollen and the like [Jin Schofield, 2023]. Therefore, the product can add value to the market.

**Health Awareness:** Growing awareness of health and wellness encourages individuals to take proactive measures, potentially driving demand for convenient medication management solutions like pill dispensers.

**Cultural Attitudes:** Cultural perceptions of healthcare and medication management may vary across EU countries, influencing preferences for certain features or designs in pill dispensers.

- **Technological factors**

**Advancements in Healthcare Technology:** Technological innovations, such as smart sensors, mobile applications, and connectivity features, enable the development of advanced pill dispensers with enhanced functionalities and user-friendly interfaces.

**Digitalization:** Increasing digitalization and adoption of telehealth solutions may create opportunities for integrating pill dispensers into remote monitoring and medication management platforms.

**Research and Development:** Ongoing R&D efforts in the healthcare sector drive continuous improvement and innovation in pill dispenser technology, leading to the introduction of new and improved products.

- **Environmental factors**

**Sustainability Concerns:** Growing environmental consciousness among consumers and regulatory bodies may influence the design and production processes of pill dispensers, leading to increased demand for eco-friendly and recyclable materials.

**Energy Efficiency:** Emphasis on energy-efficient manufacturing processes and product designs aligns with sustainability goals and reduces the environmental footprint of pill dispensers.

- **Legal factors**

**Regulatory Compliance:** Adherence to EU regulations and standards for medical devices, including safety, quality, and performance requirements, is essential for gaining market approval and ensuring product legality.

**Intellectual Property Protection:** Securing patents and trademarks protects proprietary technology and innovations associated with pill dispensers, safeguarding against infringement and unauthorized use by competitors.

**Consumer Protection Laws:** Compliance with consumer protection laws ensures transparency, product safety, and fair marketing practices, fostering trust and confidence among consumers in the pill dispenser market.

## 4.2 SWOT Analysis

The SWOT analysis is an abbreviation for strength, weakness, opportunities and threats. In this analysis the team looks at the product through these four points of view. It makes it clear what advantages the product has and what things can still be improved [\[Will Kenton, 2023\]](#).

### 4.2.1 SWOT for the market/business

#### Strengths:

- When consumers buy products, they buy benefits. The reason to buy products/services is to avoid pain or experience pleasure. This gives a lot of opportunities to develop products because there is a broad market for.

#### Weaknesses:

- Medical treatments can be very expensive.

#### Opportunities:

- More and more people are have allergic reactions form food and pollen. To prevent symptoms form those reactions a simple solution can be to take medication. Therefor a pill dispenser can be useful especially for kids to remind them and give them a right amount of pills.

#### Threats:

- The medical market is complex and crowed, start-ups are often sponsored with big budget. The development is done with a team of different experts. Therefor it is difficult to compete as a group of students and launch a successful product.

An overview of the SWOT analysis can be seen in Figure [20](#).



Figure 20: SWOT

#### 4.2.2 Product SWOT

##### Strengths:

- The device gives the user a reminder when to take the pills and can tell you how long you have to take them.
- The product is designed to be child friendly and playful.
- To make it attractive for kids, there is a reward system if they take their medication.
- To prevent overdoses, there is a system with finger print sensor to only give supervisors access to the pill containers. The computer knows when and how many pills it can release.

##### Weaknesses:

- The device is designed to be installed in a fixed place, that means that it is not portable so if children need to take pills at school for example, they will need to store there pills in an other container.
- As a parent or caregiver you need to manually place the pills in the containers, this can take a few moments to do.
- Despite the device have a camera system to reward and check if the kid has taken their medication, therefore, there can be no guarantee that the pill will be swallowed.
- Some medical treatments can be expensive, the purchase of an extra device can be too much for some parents.

##### Opportunities:

- Most kids will like this game and therefor not hassle when taking their medication.



- Many children take medication in the form of syrup or powder, but pills work more effectively. Helping them with Billy can help them heal faster.

**Threats:**

- By the fact that the product use a digital system that is connected to the internet, that means that the device can be hacked.
- For some situations the product is unsuitable and for that reason it can lack value.
- Some parents may have doubts or don't trust the device.

An overview of the SWOT analysis can be seen in Figure 21.



Figure 21: Product SWOT

### 4.3 Strategy

Strategic objectives are specific and concrete goals that a company sets for itself, taking into account its marketing analysis, in order to achieve its long-term goals. It is in fact a roadmap to turn the predefined vision into reality. These goals have the characteristic of being concrete and explaining in detail what they mean. Strategic objectives has several similarities to SMART (Specific, Measurable, Achievable, Realistic, and Timely) goals. SMART is short for smart, measurable, attainable, relevant and time-bound. Strategic objectives sometimes have slightly different parameters but both methods are very useful and usable to set goal-oriented goals and achieve long-term objectives.

Strategic Objectives:

1. Alignment with vision and mission.
2. Specific and clear

- 3. Measurable
- 4. Relevant and realistic
- 5. Time-bound
- 6. Hierarchy
- 7. Flexibility and adaptability

These are just a few guidelines that an objective must meet to be strategic. But in addition, there are different types of strategic objectives, distinguishing between growth, customer and financial strategic objectives, an example of this can be seen in Table 24.

Table 24: Billy's objectives

Description	Deadline	Status
Deliver a working prototype	2024-05-08	Ongoing
Delivering and presenting our pill dispenser	2024-06-20	Upcoming
Finding investors to produce Billy	2024-09-01	Upcoming
Launch online webshop for selling Billy	2024-09-05	Upcoming
Launch Billy on the market and start campaign in schools	2024-10-01	Upcoming

4.3.1 Segmentation and Targeting

Market segmentation is a business practice that companies use to divide their target market into smaller, more manageable groups of people. They do so on the basis of things common to their target group, to optimize their marketing, advertising, and sales efforts. Simply put, customers of each market segment have similar characteristics that businesses can leverage to advance their efforts [Hannah Tow, 2024]. A strong research of market segmentation can yield several benefits. The biggest benefit is probably that a company can better understand their audience and respond to it. As a result, they are able to better reach their customers, which is often accompanied by growth of the company, more efficient use of resources and a better customer experience [Adobe Business, 2024]. Not every market segmentation is the same, so there are different types, each for their specific application. This ensures that for each situation there is a tailored research to the target audience and thus can expect better feedback or results. Table 25 shows the different types of segmentations that exist [Aaron Carpenter, 2024].

	Demographic (B2C)	Firmographic (B2B)	Psychographic (B2B/B2C)	Behavioral (B2B/B2C)
Definition	Classification based on individual attributes	Classification based on company or organization attributes	Classification based on behaviors like product usage, technology laggards, etc.	
Examples	Geography Gender Education Level Income Level	Industry Location Number of Employees Revenue	Lifestyle Personality Traits Values Opinions	
Decision Criteria	You are a smaller business or you are running your first project	You are a smaller business or you are running your first project<	You want to target customers based on values or lifestyle<	You want to target customers based on purchase behaviors
Difficulty	Simpler	Simpler	More advanced	More advanced

Table 25: Market segmentation examples [Aaron Carpenter, 2024]

Within the project, the demographic market segmentation is the most relevant. The firmographic method is only suitable for business-to-business. The psychographic and behavioral methods, among others, are also suitable for consumers but have a higher degree of difficulty in terms of execution. That and the selection criteria are the deciding factors for choosing the demographic market segmentation. The content of these questions are very similar to the content of our target audience. This brings us seamlessly to the targeting.

Information such as age, gender, social class and location are of great value in determining the target audience. The persona and target audience are certainly not the same thing. A persona is a more detailed representation and moreover is of one person, it outlines more of a character and image of an individual. The target audience (see Figure 22) is a more general segment of people with similar similarities.



Figure 22: Target audience children

4.3.2 Positioning

The companies have been catalogued by product price and by innovation/functionality, which is defined in 4 categories: product smartification, adjustability, ergonomics and design. In Figure 23 there is an overview that shows similar products such as Medacube and Hero. Those products are highly innovative but also very expensive (over 1000 €), but offer features such as secure drug storage and the ability to dispense 1 dose for 90 days. In the middle of the chart are Pillohealth and Karie, which are less expensive but offer slightly fewer functions, in particular a much smaller number of doses. And finally Gogooda and Livefine offer products with less functionality (simple alarm or nothing at all) but at very economical prices.

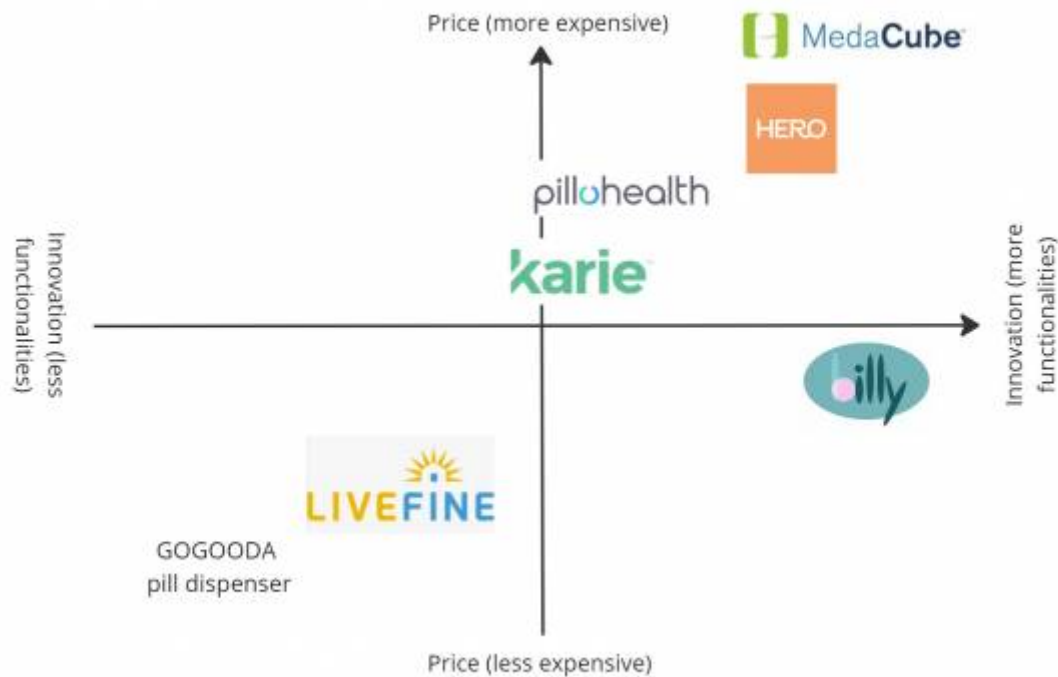


Figure 23: Positioning of Billy compared to the competitors

The comparison that can be made against the product can be difficult, because the product that the team is producing is not on the market. Billy will be more expensive than the average automatic pill dispenser offering many features but slightly fewer doses than the most expensive products.

#### 4.3.3 Marketing-Mix

- Product

The idea of a pill dispenser is not very innovative, although as a team, we believe that the product can make a change in this market. Billy, the name of the product, is a pill dispenser focused on children. It was decided to make a pill dispenser, although there are already a lot of products for elderly people on the market. Most of those devices are smart, have a connection with the customers smartphone and can track which kind and the amount of pills that have been dispensed. But none of these products are designed for kids. Lot of kids have issues with taking medication, especially if they need to swallow a pill. For that reason, there is an opportunity to design a product for children. The main goal was to making to process of taking pills more playful for children. In addition, the idea was to add other features to reward the children when they complete their treatment, a reminder system and a protection against overdoses. It is a strong belief that this product can add value to children

and by extension the family. More and more people, especially children, are sensitive to allergies. Often these symptoms are treated with pills. Learning children how to take medication in a playful way can avoid a lot of hassle and Billy is happy to help with that.

- Price

To have a highly competitive price, the product must be priced lower than competitors. Billy will therefore be on sale at a price of 250 €. However, it is the teams goal to offer the product as a purchase option but also give customers the flexibility of being able to rent the device for a certain period of time.

- Place

Billy will be available in health care stores and the product will be also sold on the online store of Billy.

- Promotion

The promotion will be done through different methods. There is no solution that fits perfectly for everything. Please refer the strategy for Billy's promotion to 4.5.1 Marketing Programmes.

#### **4.3.4 Brand**

##### **Name**

The name for the pill dispenser is "Billy". Since it is a product designed for children in order to make their medication intake more easy and add some fun to it, the intention was to give it a name that could also be the name of a friend. In some way, the "Billy" kind of does become a child's best friend during the time they have to take their medication. More explanation about the name and the logo is in chapter 7.

##### **Logo**

The logo is supposed to match "Billy"'s energy which is why the choice of the logo's colors and shape of it was made to be colorful, intensive and also round, the logo can be seen in Figure 24.



Figure 24: Logo

## 4.4 Marketing Programmes

### 4.4.1 Programmes

There is decided to promote the product through different methods. For example, it is the teams desire to create campaigns that target parents of young children and distribute them through social media. Through platforms such as Facebook, Instagram and Google Ads, it is very effective for targeting individuals to send targeted and customized advertising to. These individuals are determined through the marketing research. Part of the plan is also to distribute the flyers and leaflets at hospitals and healthcare providers. This is a place where children come together with their parents, which makes it interesting to leave the information here via flyers and the like.

The persona of the product are young children who need to take medication for whatever reason. But they are not the ones who actually purchase the product, the parents of the children are the ones that are buying the product. For this reason, it is not convinced that the help of an influencer can help. However, it is convinced that seeing the product in action has enormous added value. Therefore, there is also plan to donate Billy to a number of schools and day care centers for children. Children who need to take pills during the day can then use Billy to help them with this in a playful and accessible way. With adult supervision, the first introduction to the product is safe. If the children are enthusiastic about Billy they will themselves ask their parents to buy the product. The flyer can be seen in Figure 25.



Figure 25: Flyer

#### 4.4.2 Budget

To estimate costs, a financial plan is prepared specifically for marketing purposes. This means that all costs per item, such as flyers, online ads, etc., are noted in order to obtain an overview. This is important for the team to keep track of the total costs of the project but in addition, it also adds value for the shareholders. This way they can see how much is spent on marketing and make a ratio between this expenditure and the total income of the product. In Table 26, the data is shown with the expenses for marketing.

Table 26: Budget

Income	Price [€]
Budget	6000
Expense	Price [€]
Flyers	500
Posters	300
Leaflets	500
Facebook	1200
Instagram	2000



Income	Price [€]
Care centers	1500

#### 4.4.3 Control

To know and measure exactly what is going on companies make use of the PDCA (Plan, Do, Check and Act) method [\[ProductPlan, 2024\]](#). This is the abbreviation for Plan, Do, Check and Act. This method allows us to continuously evaluate and improve the work to achieve the pre-set goals, a diagram of this can be seen in Figure 26.



Figure 26: The PDCA Circle [\[ProductPlan, 2024\]](#)

- Plan: The team sets a goal or an advantage that they can take advantage of.
- Do: In the do phase, an idea can be tested or have a small trial.
- Check: Here the results of the do phase are analysed. If the results are found to be positive, it can be tried on a large scale. If not, it can be returned to the plan phase and the team has to develop a new idea.
- Act: Action is now taken with the knowledge gained from the previous stages.

#### 4.5 Conclusion

The chapter of marketing, the team has learned a lot of insight about the potential that the product, a smart pill dispenser, has. It is clearly know for whom and why this product is being developed as a solution. It is the task of the team to start implementing the knowledge acquired during these investigations in a proper way. Moreover, it is concluded that in addition to this niche group, children of the age of 8 to 12 years old, there are very limited to no direct competitors for this target group. All these aspects together ensure that the team is determined to bring a successful product to market.

The marketing chapter provided a strategy for Billy to make a reality. The next chapter is going to focus on making this project sustainable and is called Eco-efficiency Measures for Sustainability. In times of sustainable change, it is crucial to minimize the impact of development, materials,



assembling, transportation and use and possible recycling. In this way, our objectives can be achieved in a sustainable manner.

## 5. Eco-efficiency Measures for Sustainability

Over the last few decades, sustainability has gained importance. This chapter will first give an overview of the most important aspects of Sustainable development and eco-efficiency. Therefore, it will be focused on the three pillars of sustainability, the set of sustainable development goals, and the Life Cycle analysis of the product, Billy.

*What is sustainability?* Sustainability is a process that attempts to meet its goals continuously over time. Moreover, these goals include preventing the depletion of natural or physical resources. These could, for example be gas, coal or oil. In the past, they were used intensively and therefore had a big impact on the economy. But over time, it became visible that it had a bad impact on our planet and, therefore on the living species. So it would be in everyone's will to find a way to make life as sustainable as possible. This should point out that sustainability is not only about environmental aspects, it is also about our health as a society, and has to ensure that no areas suffer as a result of environmental legislation. One impact on that would be environmental engineering and therefore trying to produce the Billy as eco-efficiently as possible. To sum up, sustainability means protecting our natural environment, human and ecological health while driving innovation and not compromising our way of life.

### *Sustainable development*

The sustainable development engages in keeping the balance between the need to move forward technologically and economically while also protecting the needs of the environment and natural resources (see Figure 27).



Figure 27: Three Pillars of Sustainability [Shari Blanch, 2024]

Due to the sustainable development, the World Summit on social development identified three core areas in 2005 called “The three pillars of sustainability”. These areas try to provide a philosophy for sustainable development. The three areas include Economic Development, Environmental Development and Social Development.

*The Primary Goals of Sustainability* In 2015 the United Nations invented the Sustainable Development Goals (SDGs), also known as Global Goals, to make a process in the end of poverty and protecting the planet and sets the goal, that all people should live in peace and prosperity by the year 2030. There are 17 SDGs, as you can see in Figure 28, which all depend on each other. That means that if changes can be recognized in one SDG it will have an affect on another one [\[United Nations Development Programm, 2024\]](#).



Figure 28: Global Goals for Sustainable Development [\[United Nations Development Programm, 2015\]](#)

Every Indicator has its own goal to fulfill. If we take a closer look at for example number 3 Good Health and well-being, it shows that the goal is to guarantee healthy lives at all ages. Moreover, it is state why this goal should be achieved and what progress is made so far. In this example it points out, that the healthy lifestyle and therefore our social development can be distracted trough a lot of different things as for example pandemics as covid-19 which damaged the health system globally. Besides that it also points out what impact every individual can have [\[United Nations Development Programm, 2015\]](#).

## 5.1 Environmental

When someone starts to think about the environment, one of the first things that comes to mind is its pollution. How can we, as individuals, have an impact on that? We can change things up in our daily lives to improve living the most sustainable way. The same goes for developing a product and therefore for companies. We are not able to control nature; therefore, we have to adapt to it.

The three common ways to reach environmental protection as you can see in Figure 29:

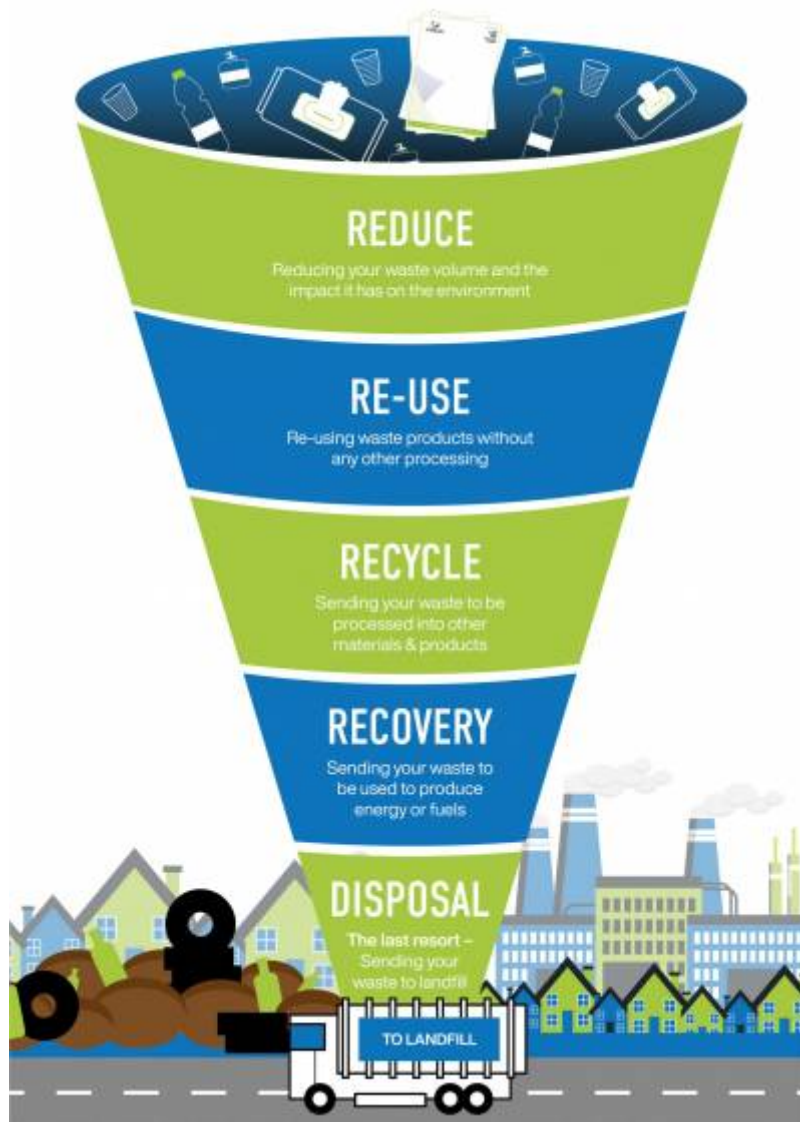


Figure 29: Aspects concerning environmental protection [UNISAN, 2024]

The goal is to keep the carbon emissions as low as possible. Moreover, one could help the environment by using renewable power sources or just don't overconsume not-needed goods. Since only local Providers get selected for the production of the Billy, the transportation ways are the shortest possible and therefore less emissions get produced.

*Reduce - Reuse- Recycle:* The renting option also makes it possible to reduce waste, since customers who only need the Billy temporarily are able to give it back. Moreover broken pieces can get exchanged, so there is no need to throw away the whole product. Furthermore the used items get recycled the best way possible and get used in other products again.

Some of the Goals of Sustainability (SDGs) try to improve this environmental pillar. One example would be the indicator 13 "Climate Action". The Goal is to take urgent action to tackle climate change and its impacts [United Nations Development Programm, 2015].

One could ask why this is so important. We can see big changes in climate change, therefore the warmest decade was 2010–2019. At first, this did not sound very dangerous, but within the warmth came massive wildfires, hurricanes, melting glaciers and much more. But this not only has an effect on the nature it also affects humanity and economies. With the Parisian Agreement In 2015, the United Nations took a significant first step to take action in climate change. The goal to which 195 states committed is to make the global temperature rise to below 1.5 °C at best, but at least below 2 degrees [United Nations Development Programm, 2015].

## 5.2 Economical

Economic Sustainability is the process of taking actions that help a business grow financially or in economic growth while also preserving the environment, society and moreover the culture. Therefore, a general understanding of sustainable business practices is needed. This includes avoiding harmful manufacturing techniques, the production of food waste and burning fossil fuels to help with climate change.

“The goal of economic sustainability is to achieve economic growth without making the negative environmental trade-offs that traditionally go hand in hand with growth. Economic sustainability is a broad collection of decision-making principles and corporate practices” [Schneider Electric, 2022].

Nowadays, sustainable economic development has gained importance. Rapid industrialization puts more and more pressure on the world's resources, and big companies need to adapt. Even businesses that try to help with economic growth need to take action when it comes to sustainability. It shows that the trend goes to “being sustainable” because it is a good and appealing marketing strategy. Most of the big Companies start to advertise sustainable products, but most of the time, this is only used as marketing method to reach a broader target audience.

“When it comes to environmental impact, the truth regarding the damage caused by the global business community is harsh. They are one of the worst contributors to the abuse of natural resources and carbon emissions. By not prioritizing environmental sustainability, businesses around the world are contributing to the negative environmental impact” [Schneider Electric, 2022].

Most of the time, companies try to make the biggest profit possible therefore, they use the cheapest way to produce and the most inexpensive raw materials possible. One example is the fast fashion industry, which uses single-use plastics. Costs might be more appealing for a business owner because it is usually cheaper to produce environmentally unfriendly products. Fewer costs in production make the pricing for customers lower, resulting in better sales on the market. Rising markets and product variability have a big influence on the competition, which every company tries to keep up with.

As a sustainable company, it is possible to make small changes in production that have an impact, such as:

- Selecting sustainable transport methods
- Choosing a production location that is not too far away from the delivery point to minimize transportation ways
- Using lightweight materials
- Buying from local suppliers
- Using recycable materials
- Creating coordinated processes to not lose time and resources

*Implementing in the Billy:* By choosing local Providers as our first material source the transportation gets easier provided. In addition to that the Billy firstly is only sold in Portugal and near regions which also creates short distances. Since the Billy is designed to fit in every household it is not very big. The packaging is also created to be practically while shipping and also easily stackable to make the most use out of the given transportation options. Also the packaging of the Billy should not only have the shipping purpose, by creating a game inside it is possible to give it a new life and not having the need

to throw it away.

## 5.3 Social

The social aspect of sustainability deals with the community, education, equality, social resources, health, well-being, and quality of life.

Definition: "Social sustainability includes achieving a fair degree of social homogeneity, equitable income distribution, employment that allows the creation of decent livelihoods, and equitable access to resources and social services, a balance between respect of tradition and innovation, and self-reliance, endogeneity and self-confidence (Sachs, 1999, pp. 32–33). A strong definition of social sustainability must rest on the basic values of equity and democracy, the latter meant as the effective appropriation of all human rights – political, civil, economic, social and cultural – by all people" [\[Jennifer McGUINNet al., 2020\]](#).

Therefore, it is important that our product is not having a big impact on destroying the nature by human influence. This can be changed by making the handling a way it is easy to use and to understand. Furthermore, it is Important that the Billy provides information about the right disposal. We even would like to make it possible for the costumer to send items back to us which are no longer needed by the costumer, so that there is a way to give them a new life. In addition, enough information must be provided beforehand about ethical and sustainable issues. Moreover, for the sake of Techno-centric-concerns the Billy is produced in the most sustainable and resource efficient way possible. Another way of ensuring social sustainability is trying to find a production place which is not destroying the environment or someone else's property. The shelter should be placed somewhere next to an urban environment, so it is easy to reach for customers and for the transport.

However, most importantly Billy tries to make an impact in social well-being by helping parents and their children with a common daily problem, without destroying the environment.

## 5.4 Life Cycle Analysis

A life cycle analysis or also known as a life cycle assessment is a way of measuring the impact of a product during each stage, from product to waste or recycling. Since for these measurements very many parameters play a role in the result, this is not an easy exercise to perform correctly. LCA has therefore been defined as a European standard, the ISO 14040. This standard ensures that all measurements are done according to the same method and rules, thus through the data used a realistic estimate can be made about the total impact on environmental impacts [\[European Commision, 2024\]](#).

Some questions to be asked during this calculation include, for example, what raw materials were used for production and from where do they come? How are these raw materials and the final product transported and how is the product produced. These are some of the questions for which answers must be formulated, supported by data [\[Ecochain, 2024\]](#).

Despite not being a simple and very specific analysis, it can still add value to most departments of a company.

- Product management/R&D
- Supply chain management

- Marketing & Sales
- Executive management

The insights from analysis allow more thoughtful decisions to be made throughout the company. When decisions are made based on data, it is possible to make decisions that not only ensure that the company or product becomes more sustainable but also that other goals such as marketing goals are achieved more quickly and sustainably.

A product life cycle consists of 5 phases [\[Ecochain, 2024\]](#).

1. Raw materials extraction
2. Manufacturing & processing
3. Transportation
4. Usage & retail
5. Waste disposal

A diagram of this can be seen in Figure 30.

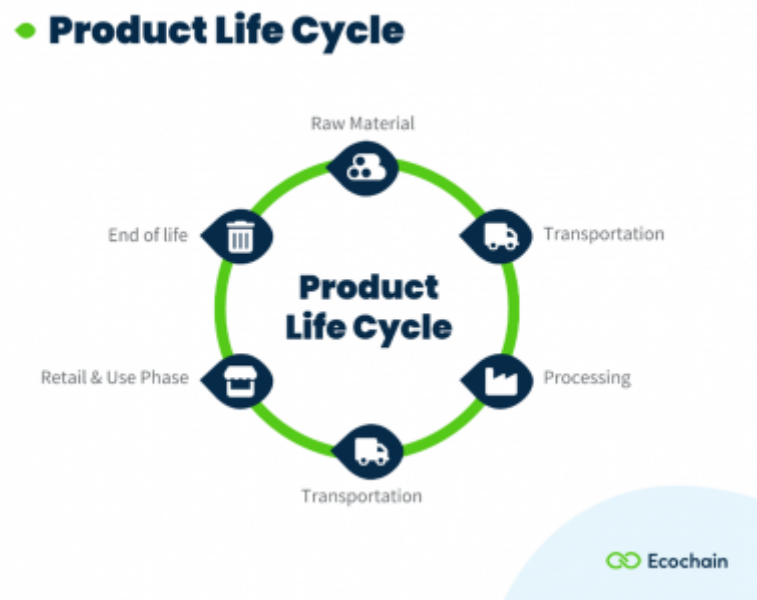


Figure 30: Product life cycle [\[Ecochain, 2024\]](#)

There are 4 different methods to analyze the LCA. Depending on the product for which the LCA is being analyzed, the method is determined.

- Cradle to grave

This is an LCA for products that have no further function after use and are then destroyed.

- Cradle to gate

This looks only at the environmental impact of production until it leaves the factory. The impact of consumer use and processing or recycling is not taken into account. Therefore, it does not capture all the stages and the result does not give a complete picture.

- Cradle to cradle

This is the LCA for products in the circular economy. It corresponds to the cradle to grave with the



only difference that the waste disposal is replaced by the recycling process. In this process, that product is given a new life or the raw materials are reused in another product.

- Gate to gate

This LCA is sometimes used by companies to know internally what impact their processes have. This can be added later to another LCA to get a complete result.

These methods are summarized in Figure 31.

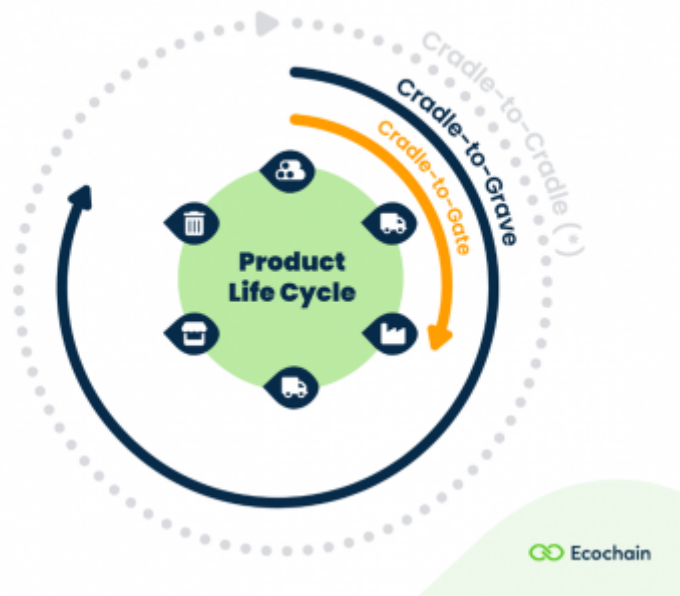


Figure 31: Product life cycle diagram [Ecochain, 2024]

There are still some special methods that are only used for specific applications. An example is from “well to wheel,” which is an LCA (Life Cycle Analysis) specifically intended for the automotive industry.

Now that we know more about a product life cycle, we can move on to the content of a life cycle assessment. It consists of 4 phases.

1. Goal and Scope
2. Inventory analysis
3. Impact assessment
4. Interpretation

The first step of the analysis is determining exactly what we want to analyze and how comprehensively we want to do it. How it will be examined is also important. This is all written out in the first step of the analysis, Goal and Scope. The first step says something about what will be investigated, and the second step will collect and inventory the data. Information must be gathered anyway about the raw materials, production process, transportation and the like. Other parameters needed for the research are established in the first step, what exactly is all being researched. The way of surveying the data currently leads us too far away from this chapter. In the third step, an evaluation is made of the data with the predetermined goals. To process all the data, a software will be used. This software will process all the steps and provide an overview with the necessary results. In the last and fourth stage, an interpretation of the results is done. All phases are reflected in Figure 32. The interpretation is defined in the ISO 14044:2006 standard [Ecochain, 2024].

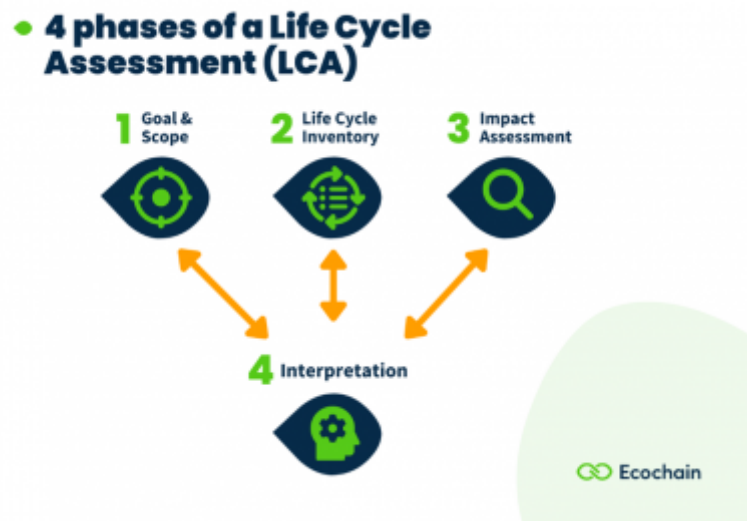


Figure 32: Phases of a LCA [Ecochain, 2024]

## 5.5 Conclusion

As a pill dispenser developer, we want to bring about an improvement in children's lives in terms of health. To complete our value and mission we want to do this in a sustainable and ecological way. Although the choice of our materials is not yet fixed we have a strong preference to use mainly plastic for 3d printers. For the production of this material not much energy is needed which makes that this material has a limited impact in terms of its ecological footprint. Moreover, this plastic is also fully recyclable. In addition, our product also contributes to goal 3 of the United Nations “Good health and Well-being”. This by helping children take their medication, and doing so through a product that is sustainable.

## 6. Ethical and Deontological Concerns

Deontology is an ethical theory that helps distinguish right from wrong by using rules. Philosopher Immanuel Kant, who is often associated with deontology, believed that “human beings have a duty to perform or not to perform certain actions, because they are right or wrong in themselves, irrespective of their consequences”, making these concerns a part of every person’s every day lives [D. M. Daniel, 2013].

When developing a product, ethical and Deontological concerns are always aspects and concerns that need to be considered. The goal of “Billy” is, that it gets as much personal information as needed and as little as possible the same time. The aim is to make the product valuable to the children as well as the caretaker by following all ethical and deontological guidelines. In the following chapters, all concerns that may come up will be elaborated on.

### 6.1 Engineering Ethics

Engineering ethics are guidelines adapted for engineers to follow in order to make sure that they make decisions that also match the public’s, their client’s and the industry’s standards [E. Han, 2023]. Since engineers play a big role in the development of the world, it is crucial that they



uphold ethical and deontological standards.

The [National Society of Professional Engineers' \(NSPE\) code of ethics](#) sets the standard for ethical behavior in engineering. The **fundamental canons** are listed below [\[National Society of professional Engineers, 2019\]](#):

1. Hold paramount the safety, health, and welfare of the public.
2. Perform services only in areas of their competence.
3. Issue public statements only in an objective and truthful manner.
4. Act for each employer or client as faithful agents or trustees.
5. Avoid deceptive acts.
6. Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.

In addition to the canons, The National Society of Professional Engineers has also defined Rules of Practice as well as Professional Obligations.

#### **Rules of Practice:**

1. Engineers shall hold paramount the safety, health, and welfare of the public.
2. Engineers shall perform services only in the areas of their competence.
3. Engineers shall issue public statements only in an objective and truthful manner.
4. Engineers shall act for each employer or client as faithful agents or trustees.
5. Engineers shall avoid deceptive acts.

#### **Professional obligations:**

1. Engineers shall be guided in all their relations by the highest standards of honesty and integrity.
2. Engineers shall at all times strive to serve the public interest.

3. Engineers shall avoid all conduct or practice that deceives the public.
4. 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.
5. Engineers shall not be influenced in their professional duties by conflicting interests.
6. Engineers shall not attempt to obtain employment or advancement or professional engagements by untruthfully criticizing other engineers, or by other improper or questionable methods.
7. Engineers shall not attempt to injure, maliciously or falsely, directly or indirectly, the professional reputation, prospects, practice, or employment of other engineers. Engineers who believe others are guilty of unethical or illegal practice shall present such information to the proper authority for action.
8. Engineers shall accept personal responsibility for their professional activities, provided, however, that engineers may seek indemnification for services arising out of their practice for other than gross negligence, where the engineer's interests cannot otherwise be protected.
9. Engineers shall give credit for engineering work to those to whom credit is due, and will recognize the proprietary interests of others.

Of course, as engineers, the team has to and also wants to work according to these rules implemented by The National Society of Professional Engineers. All of the members are aiming to work with a good ethical consciousness and try to avoid every conflict of interest.

## 6.2 Sales and Marketing Ethics

Sales and Marketing are a big part of today's society since every product or service uses it in order to gain and, in the long term, build long-term relationships with those customers. However, keeping customers requires ethical behavior. In order to achieve that and not to act unethically when it comes to competition or profit, there are certain ethical marketing values that all brands are supposed to strive for [J. Bradford, 2023]:

### Honesty

Being truthful and transparent when it comes to the features of a product

### Respect for individual rights

Being respectful when it comes to preserving the privacy of costumers and avoiding discrimination

## Respect for Human Dignity

Avoiding tactics that manipulate costumers, like using influencers that in fact do not actually use the product for advertisement

## Responsibility

Being responsible when it comes to harmin people or society which includes advertising an unhealthy product, like colorful vapes for teenagers

With selling the product "Billy", the team, just like any other company, is also obligated to act according to these values when selling a product or a service. All of the team members aim for a honest, respectful and responsible marketing practice and want to build trust with the costumers, leading to a long-term relationship with them.

## 6.3 Environmental Ethics

The team's goal is to build a product that has the least environmental impact as possible since the team members do not want to add to environmental issues, starting with using components that are as environmentally friendly as possible. In addition, the team members are trying to follow sustainable practices throughout the entire value chain, from sourcing materials to manufacturing, packaging, and distribution. Furthermore, the option of borrowing the completed product, making it reusable, so that it does not just end up in the dustbin when it is not used anymore, will be offered. Furthermore, a broken product can be returned, even though the date has passed the guarantee, and reusable parts of it will be recycled. Environmental ethics is a part of philosophy that deals with the moral questions of the relationship between human beings and everything not human, including the environment [[StanfordEncyclopediaofPhilosophy, 2021](#)]. Looking at the world, it is impossible not to notice that human beings have altered the world and the environment as they please. Just by looking at the devastation of the rainforest, we have already destroyed more than 50 per cent of all the rainforest just for human gain, such as the attaining mineral resources, livestock farming or building monocultures. Even though destroying the rainforest is twice as harmful since the CO2-memory function and photosynthesis of the trees get lost, human beings still do not stop [[OroVerde, 2024](#)]. This might be an extreme example, however, ethnical environmental issues can be found nearly everywhere when looking around. Trying to work against that, environmental ethics are supposed to motivate human beings and companies to work ethnically justifiable.

The goal of all the team members is to build a product that has the least environmental impact as possible since no more additional environmental issues are supposed to be added, starting with using components that are as environmentally friendly as possible. In addition, the team is trying to follow sustainable practices throughout the entire value chain, from sourcing materials to manufacturing, packaging, and distribution. Furthermore, the option of borrowing the completed product, making it reusable, so that it does not just end up in the dustbin when it is not used anymore, will be offered. Furthermore, a broken product can be returned, even though the date has passed the guarantee, and reusable parts of it will be recycled.

## 6.4 Liability

The aim of product liability is to encourage product safety [M. J. & Moore W. K. Viscusi, 1993]. As with any technology, ethical concerns arise when it comes to the production, the use as well as the disposal of that product. Apart from creating a product that supports sick children and their caretaker, the team's main goal is primarily also to develop a product that is safe for them to use and ethically justifiable. In this chapter, some key ethical concerns will be addressed. In order to avoid product liability issues, the team will work according to the following EU-directives:

### **Radio Equipment Directive (RED) (2014/53/EU) [European Commission, 2014]**

This directive has set crucial requirements for safety and health, electromagnetic compatibility and efficient use of radio waves. In addition, it gives the basis for deeper going directives, like technical aspects for protection of privacy, personal data and against fraud as well as for interoperability, access to emergency services and compliance when it comes to the merging of radio equipment and software.

### **Low Voltage Directive (LVD) (2014/45/EU) [European Commission, 2014]**

This directive makes sure that a high level protection for European citizens is provided by electrical equipment that is within certain voltage limits.

### **Electromagnetic Compatibility (EMC) Directive [European Commission, 2014]**

This directive ensures that side effects that are a result of an interconnection or a close distance between electric devices and installations are kept under reasonable control.

The team will work with personal data, however, since nothing will be stored, liability will not be become an issue in this matter. For reasons of completeness, the Regulation (EU) 2016/679 of the European Parliament and of the Council on the protection of natural persons with regard to the processing of personal data can be found here: [Regulation on the protection of natural persons](#)

## 6.5 Conclusion

In conclusion, ethical concerns and criticism from outside will always arise, however, it is good to work with them and consider them in order to develop a product that is as ethically correct as possible. Since Ethics and Deontology are subjective topics, it is important to stick to the guide lines give by the European Commission. In case of failure, not only ethical problems arise but also potential legal liabilities, such as the violation of privacy laws, discrimination laws or consumer protection laws amongst others. Therefore, the group's aim is to work in good consciousness, always considering the above mentioned guidelines.

Based on this ethical and deontological analysis, the team members chose to use PLA plastic which will be used for 3D printing nearly all of the components for our prototype since it is more sustainable

than common plastic. Furthermore, in order to prevent unnecessary waste, the team provides the option of renting our product which is a good opportunity, especially for people who “only” deal with a short-term illness and will not need the product afterwards. By offering that service, the product being just put away and not being used anymore will be avoided. In addition, the possibility of a return in case of defect will be offered. Even if the product guarantee doesn't apply anymore, the team will take it back and reuse all the working parts and components, producing as little waste as somehow possible.

In the next chapter, the progress and the development of the project will be elaborated on. This includes the origin of the name, the development of the logo as well as the design and the prototype.

## 7. Project Development

This chapter clarifies the development of Billy. The entire project development will be explained in a number of sections, including ideation, concept and design, followed by packaging. In addition, all the more technical elements needed to make our project will be covered through a choice of components, software and hardware. At the end, a number of tests will be carried out. This chapter traces all the different stages the team went through to complete the project and the prototype.

### 7.1 Ideation

The team started this project by doing a lot of brainstorming about the subject. It took several workshops and discussions before the team was sure they wanted to work on an automatic pill dispenser.

The idea was to create an automatic pill dispenser that would be used by children. The market is full of many different types of pill dispenser for the elderly. But none exist for children. So the team wanted to create one. They came up with a design based around the idea of making it more fun and less stressful for children to take their pills. To achieve this, the team came up with the idea of introducing a reward system to motivate children to take their medication properly in order to obtain it.

### 7.2 Concept

Through the various brainstorming sessions and workshops in which the team participated, the idea of developing a smart pill dispenser was born. The idea of creating an object that has a direct effect on the health of the people who use it was very appealing to the team. Similar products already exist on the market, but they are only intended for older people, unlike children, for whom there are no products specifically designed.

To address this problem, the team wanted to develop an automatic pill dispenser designed for children, which would be fun and attractive to them, making it less stressful for them to take their medications. To this, they have added a digital recognition system to ensure that the child taking the dose is the one who needs it. An 'admin' profile can also be created for a parent, giving them access to the medication dispensing mechanism and enabling them to refill the dispenser.

The team also wanted the dispenser to be able to store boxes of medicines safely, like a safebox.

After discussions with the supervisors, a camera was added, which will allow the child to take a photo of him/herself when taking his medication and thus reassure the parent when the child is left alone at home.

### 7.2.1 Logo

The name for the pill dispenser is “Billy”. Since it is a product designed for children in order to make their medication intake more easy and add some fun to it, the intention was to give it a name that could also be the name of a friend. In some way, the “Billy” kind of does become a child's best friend during the time they have to take their medication. The logo is supposed to match “Billy”'s energy which is why the choice of the logo's colors and shape of it was made to be colorful, intensive and also round.

Figure 33 gives some insights in the creation process of the logo.



Figure 33: Logo creation process

2 main colours have been chosen, a dark turquoise and a light turquoise. The other two colors are a result of negative multiplication with the color of the main shape. The goal was to create positivity and different shades of colors while them still harmonizing with each other. The color palette of the logo is shown in figure 34 below.

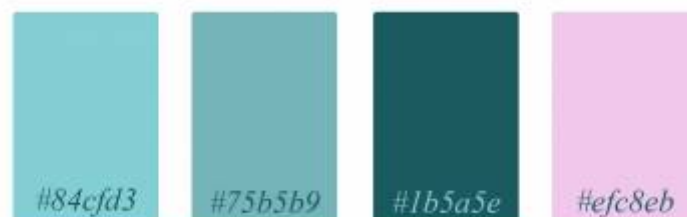


Figure 34: Color palette

When trying to choose the font for the product's logo, it was difficult to find one that matched the team's expectations for “Billy” completely. The team then decided to create its own font, trying to keep the single characters in a style that reminds one of a pill. That is also what the circle in the background symbolizes. Considering all aspects, the third draft was chosen since it combines everything we want the logo to stand for. The final logo is shown in Figure 35.



Figure 35: Final logo

## 7.3 Design

### 7.3.1 Structure

#### 1. Initial structural drafts :

As mentioned earlier, the team decided to develop a pill dispenser to help sick children take their medication. To do this, a design that would be attractive and that would appeal to children needed to be defined. The team therefore went through several solutions before finding the one that best suited the project.

**Version 1:** The original idea was to create a dispenser that looked like a robot. The first drawing is visible in Figure 36.

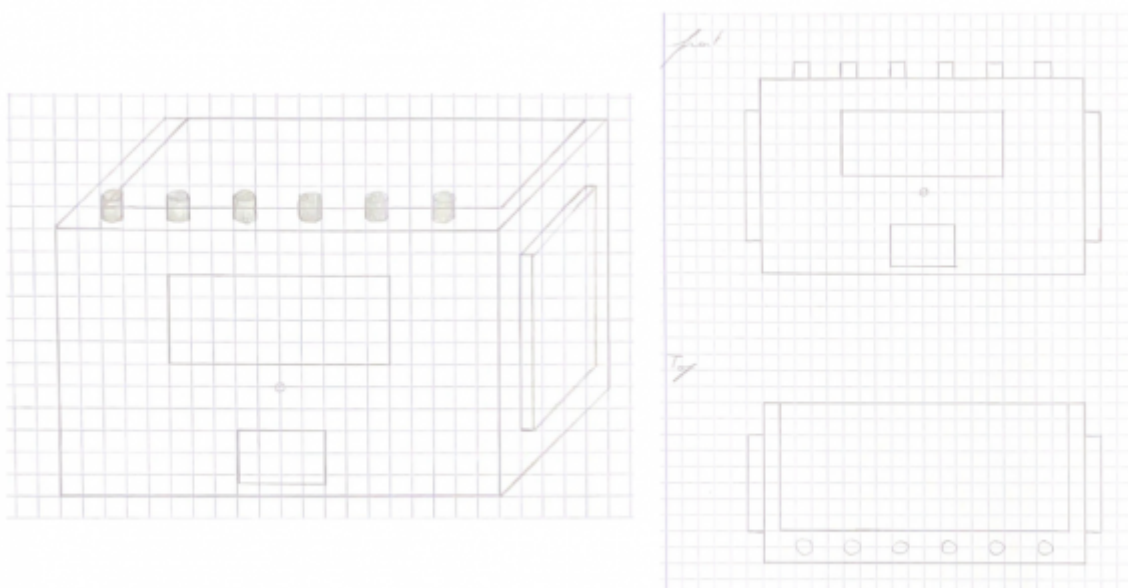


Figure 36: First version

**Version 2:** After negative feedback from teachers on the design, the team decided to modify it and make it look like a children's toy dispenser, an appealing and fun object, with a transparent dome through which the child can see his reward. Solution 2 can be seen in Figure 37:

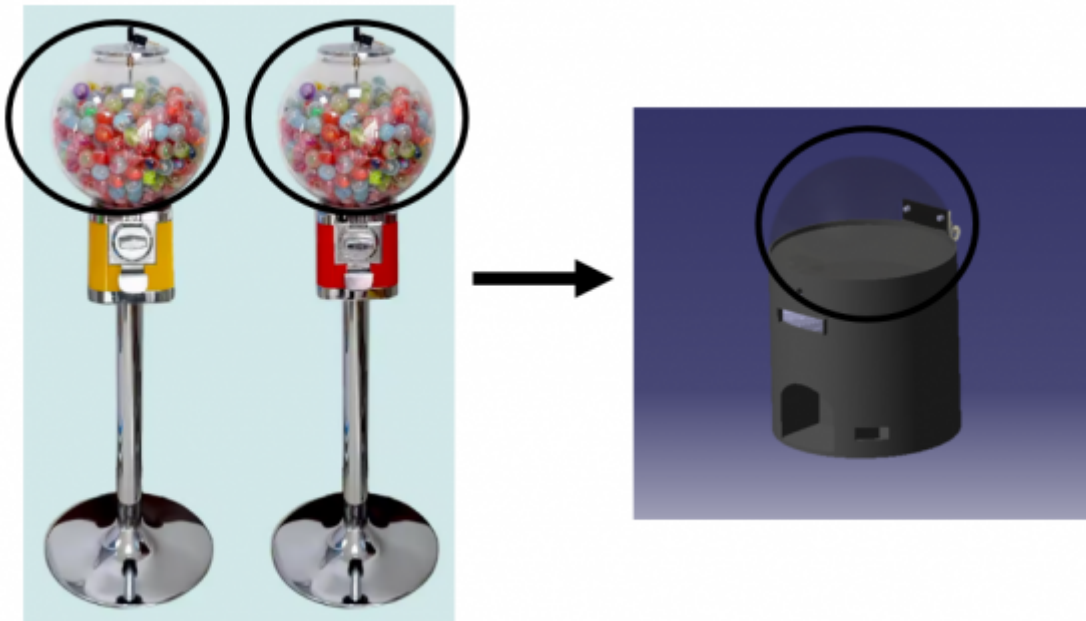


Figure 37: Second version

**Version 3:** The team then decided to modify it one last time by adding a transparent slide, again to resemble a toy vending machine, so that the child can see the pills falling. The concept is shown in Figure 38:

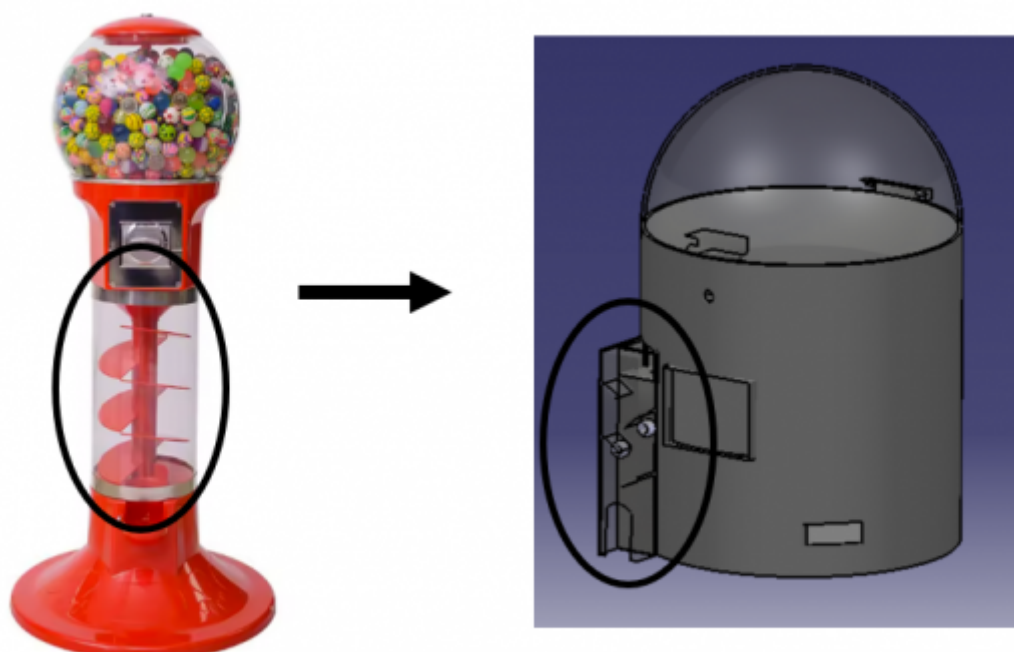


Figure 38: Third version



7.3.1.1 Material Selection

For the materials of the project the team chose to 3D print every single part of the prototype except for the dome containing the reward. We would like to use Polylactic Acid (PLA) plastic to print the parts because it is cheap and it is more sustainable than common plastic. Moreover, PLA is a lightweight plastic with good mechanical strength and is 100 % bio-based and biodegradable. The amount of PLA that is needed for the product will be explained later when the when the dimensions are fixed. For the dome, plexiglass will be used. It is important for the dome to be transparent so that the kid can see the reward inside which will make him want to have it and therefore want to take his medication correctly to get it.

7.3.1.2 Detailed drawings

Once the design had been defined, the first detailed drawings of our pill dispenser were produced. Its size was defined by calculating the number of doses of medicine that could be stored in the dispenser. The team wanted to store 21 doses which makes it possible to have 1 dose per day for 3 weeks. Having determined this, the design was built around the dispensing mechanism. Our detailed drawings are shown in Figure 39 and Figure 40 below.

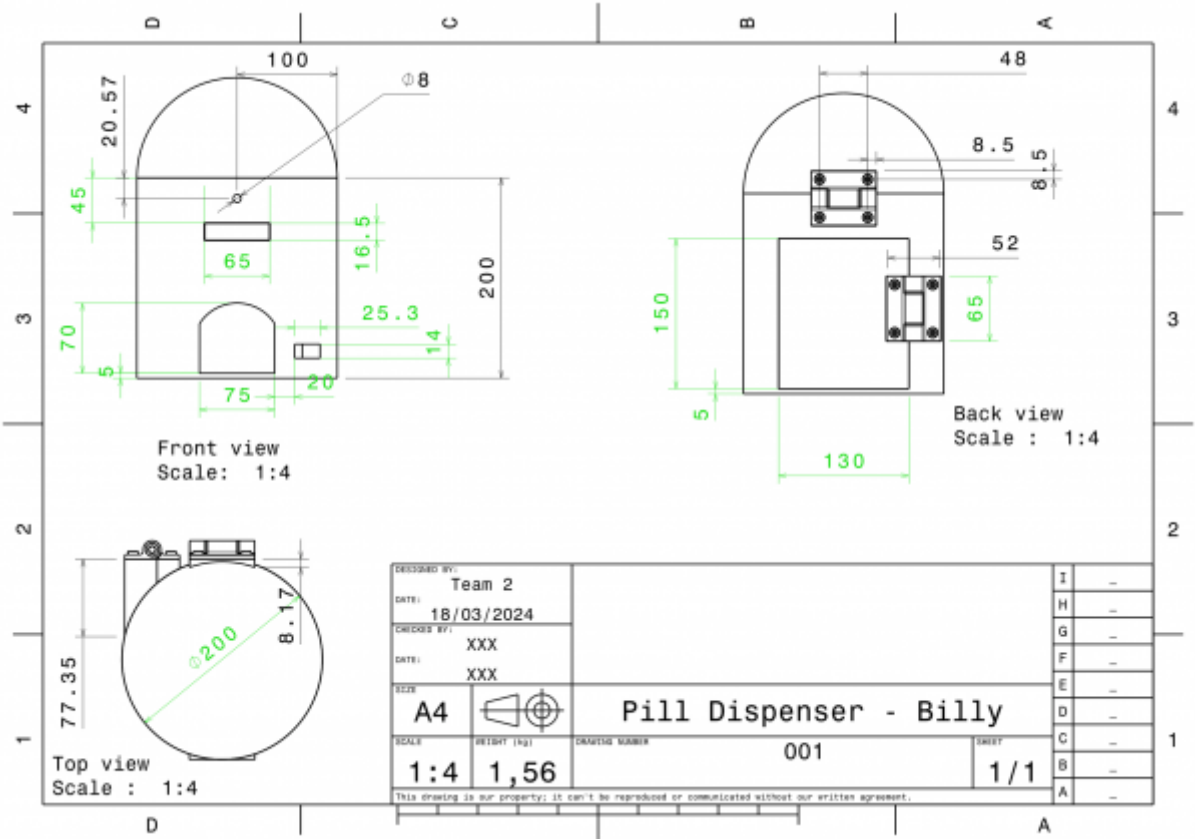


Figure 39: Detailed drawing of the pill dispenser

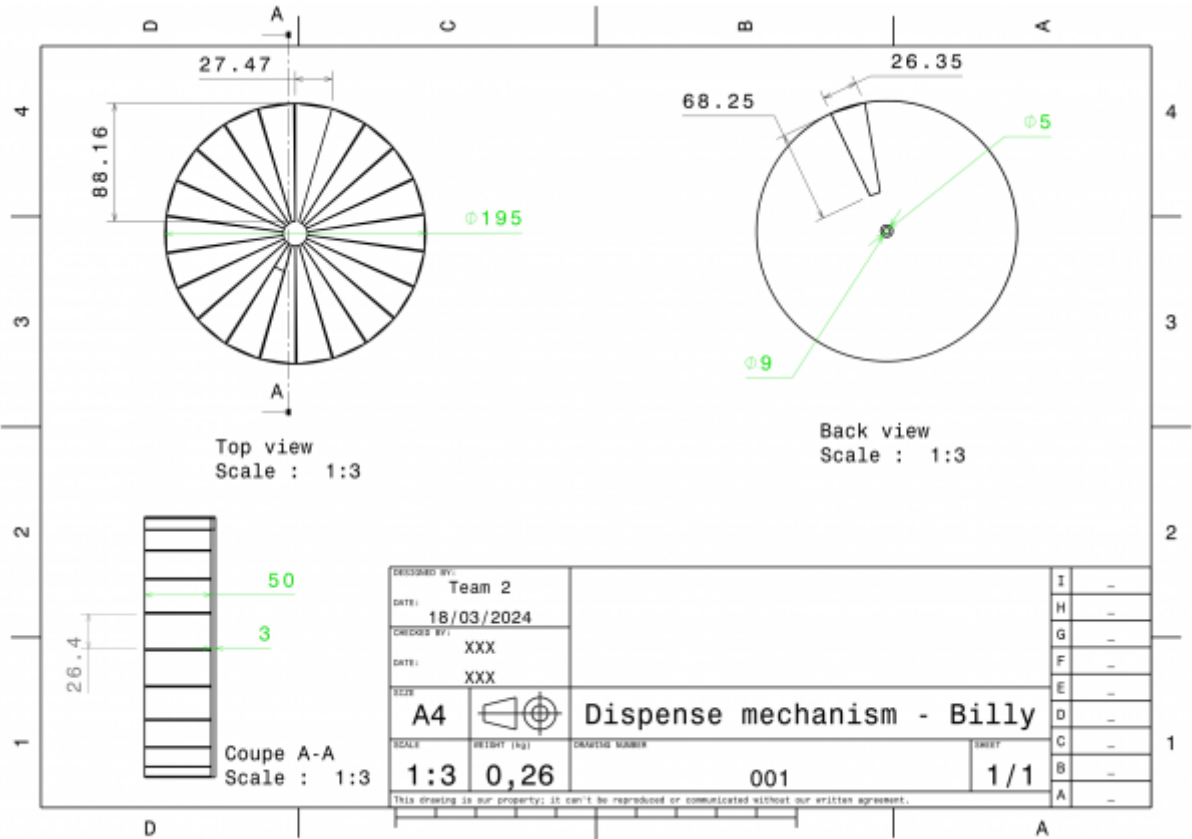
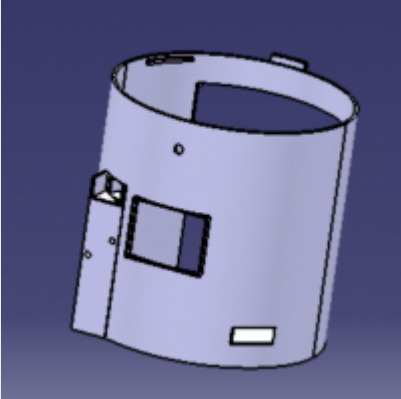
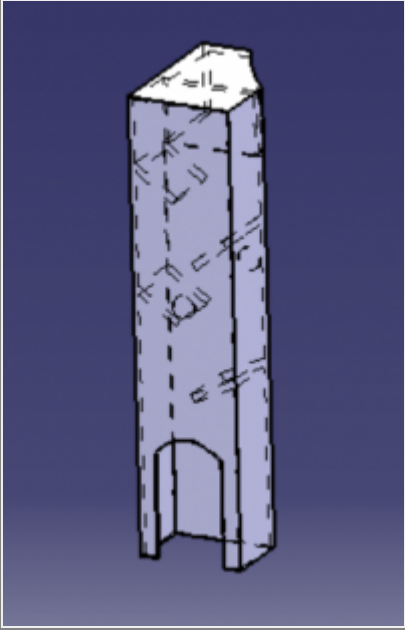
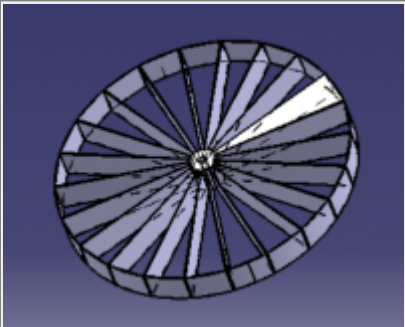
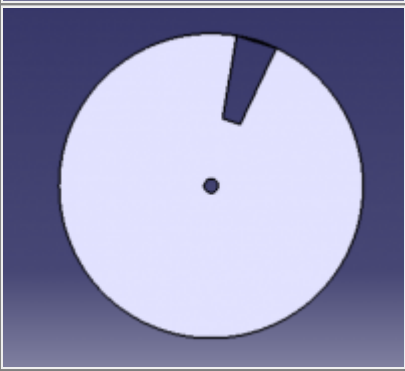
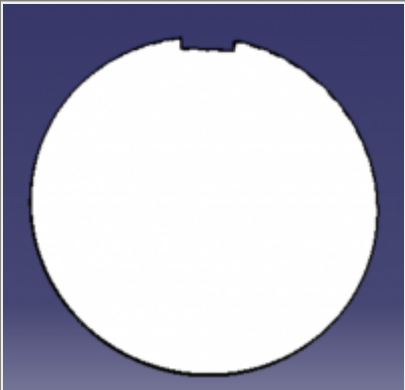


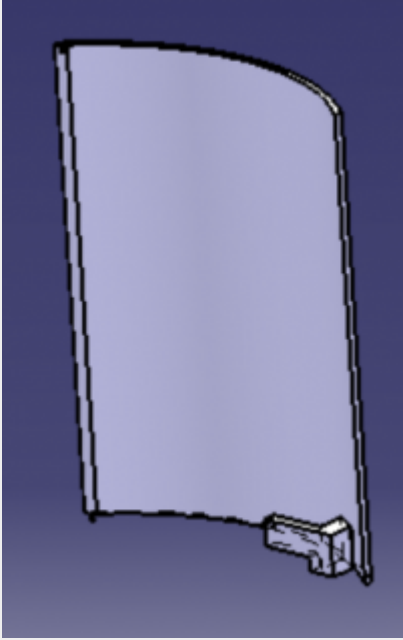
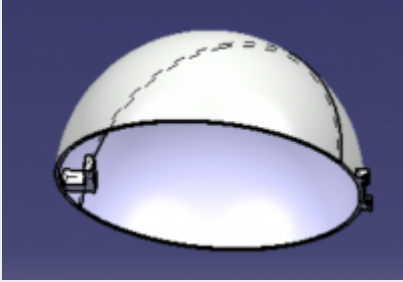
Figure 40: Detailed drawing of the pill dispenser mechanism

Billy is made up of a number of parts, the main ones being the product body cylinder, the dome above which contains the reward, the slide which allows you to see the pills fall and finally the dispensing mechanism. The various parts of this product are shown in the Table 27 below, and Figure 41 illustrates the assembled product.

Table 27: List of the different parts of Billy

Name	Picture	Note
Body		The body is a cylinder 20 cm in diameter, 20 cm high and 2.5 mm thick. At the back, a large opening, which will be closed by the door, gives access to the mechanism and electronics. It will therefore be possible to recharge the dispenser from here, as well as storing boxes of medicines in the same way as in a safe. On the front there is a screen, with the fingerprint sensor on the right and a flat surface on the left for attaching the slide. On the inside of the body there is an elevation on which the pill selector will rest. This elevation is inclined to allow the medication to slide towards the slide.

Name	Picture	Note
Slide		The slide is made up of multiple small and stiff surfaces so that the pills fall right through to the opening. It is attached to the body using two M4 screws. The slide is also transparent.
Pill container		The pill container is a wheel containing 21 pill storage sections, running through it, as well as a solid section which is useful when setting up the machine. It will be placed on the pill selector and contains a small slot in its center so that the motor can fit in and therefore turn it. It is 195 mm in diameter and 20 mm high.
Pill selector		The pill selector is a simple disc with an opening the same size as one of the sections of the pill container. Thanks to this, the pill selector allows you to distribute only one dose at a time. It is 195 mm in diameter and 3 mm thick.
Plain disk		The plain disk is a simple disk with an opening on the side to allow the lock system to close the dome. It allows you to create a separation between the mechanism and the sphere which contains the reward. It is 195 mm in diameter and 3 mm thick.

Name	Picture	Note
Door		The door provides access to the product mechanism. At the bottom we find a hook to be able to lock access to the mechanism thanks to a servo motor
Sphere		The sphere is a transparent empty dome so you can see the reward inside. It is equipped with a hook so that it can be locked like the door so that the child does not have access to the reward all the time but only at a desired time.

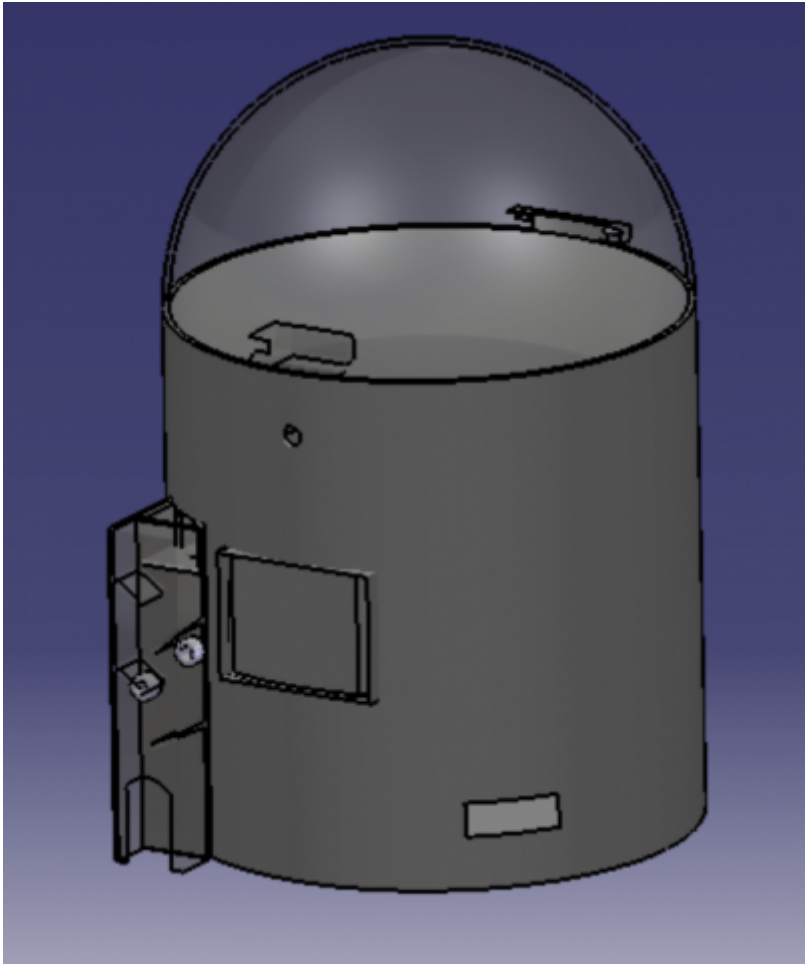


Figure 41: Photo of billy assembled with all the parts

### 7.3.1.3 3D model with load and stress analysis

## 7.3.2 Smart System

### Hardware

#### 1. Black Box Diagram :

During our brainstorming session, we decided on the features we wanted to see in our pill dispenser. We want it to alert the patient at the desired time and that the patient, thanks to a digital fingerprint reader, would be the only one able to collect the medication. The dispenser also has a medication storage area that is locked by an adult's fingerprint. The machine is configured using buttons and a screen. The final feature we would like to have is a camera so we can take photos when the child is taking their medication and notify the parents. The black box diagram of our project is shown in Figure 42.

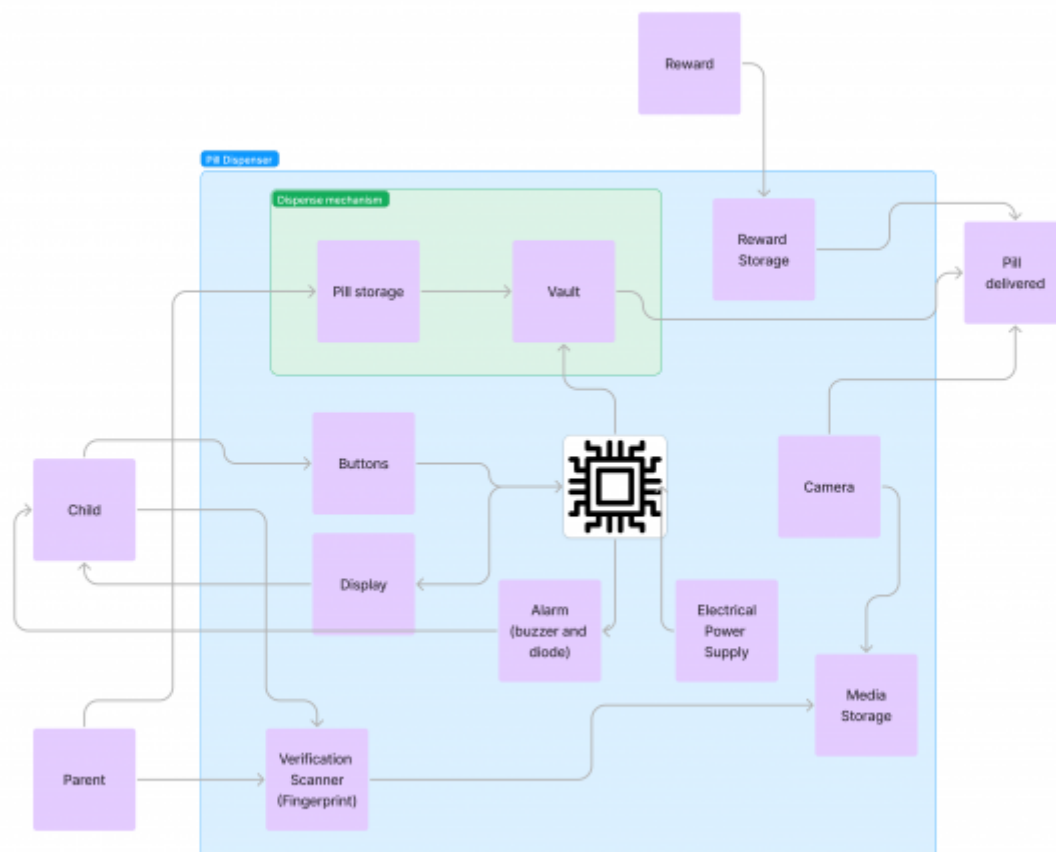


Figure 42: Black Box Diagram

After the first feedback from the teachers on our black box diagram, we needed to do it again. Our new Black Box Diagram is visible in Figure 43:

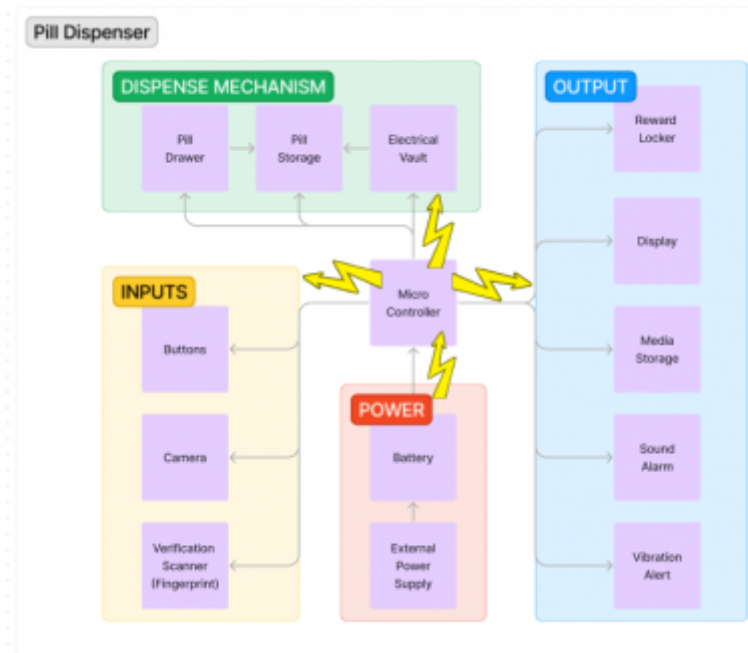


Figure 43: Black Box Diagram 2

2. Component Selection :

Electronics are needed to operate the pill dispenser. In the Table 28 below you will find a comparison of the different microcontrollers, screens, motors and fingerprint readers that correspond to the project's requirements, as well as a justification for the choices made.

Table 28: Components comparison

Component	Options/Description	Alternatives
ESP32-cam	ESP32-CAM is a development board with built-in camera module primarily based on the ESP32 chip. It's widely used for Internet of Things (IoT) and camera-related projects.	Raspberry Pi Camera Module
		Arducam ESP32 UNO PSRAM
		AI-Thinker ESP32-CAM
		ArduCAM Mini Module
FT232RL	FT232RL is a Universal Serial Bus (USB) to Transistor-Transistor Logic (TTL) Serial Converter chip commonly used for interfacing microcontrollers with computers or other devices via USB.	CH340G
		FT231XS
		PL2303HX
ili9341 (touchscreen)	ili9341 is a popular controller chip for small to medium-sized Thin-Film Transistor (TFT) Liquid Crystal Display (LCD), often used in conjunction with touch panels.	2.8 inch TFT LCD
		2.8 inch TFT Serial Peripheral Interface (SPI)
		3.5 inch TFT Touch
		SSD1963

Component	Options/Description	Alternatives
PCF8575 IO Expander	PCF8575 is an Inter-Integrated Circuit (I2C) based Input/Output (IO) expander chip used to increase the number of General Purpose Input/Output (GPIO) pins available to microcontrollers.	MCP23017
		MCP23008
		PCF8574
		MCP23S17
FPM10A	FPM10A is a capacitive fingerprint sensor capable of storing and recognizing multiple fingerprints. It's commonly used in security applications.	GT-511C3
		R305
A4988 stepper driver	A4988 is a popular stepper motor driver module capable of driving bipolar stepper motors with microstepping capability.	DRV8825
		TB6600
		TMC2208
		LV8729
FIT0278 stepper motor	The FIT0278 is a simple 2 phases hybrid stepper motor.	MIKROE-1530

Component Selection Reasons

- **ESP32-CAM:** Selected for its integrated camera module and compatibility with the ESP32 chip, offering a cost-effective solution for IoT and camera-related projects. Alternatives considered such as the Raspberry Pi with camera module were too expensive.
- **FT232RL:** Chosen for its widespread compatibility and reliability in USB to serial conversion, making it suitable for interfacing microcontrollers with computers or other devices. Alternatives like CH340G and FT231XS offer similar functionality but might differ in driver availability and stability.
- **ili9341 (touchscreen):** Selected for its widespread availability and compatibility with various touchscreen applications. Alternatives like 2.8 inch TFT SPI might offer faster communication through SPI interface, while options like 3.5 inch TFT Touch provide larger display size with touchscreen functionality.
- **PCF8575 IO Expander:** Chosen for its ease of use and compatibility with various microcontroller platforms, providing a cost-effective solution for expanding GPIO pins via the I2C interface. Alternatives like MCP23008 offer similar functionality, suitable for applications with limited GPIO requirements.
- **FPM10A (fingerprint sensor):** Selected for its reliability and compatibility with various fingerprint recognition projects, offering a cost-effective solution for security applications. Alternatives like R305 provide a budget-friendly option with comparable performance, suitable for less demanding applications.
- **A4988 stepper driver:** Chosen for its widespread usage and reliability in stepper motor control applications, offering a cost-effective solution with microstepping capability. Alternatives like TB6600 provide higher current handling capability for more demanding stepper motor applications, while options like TMC2208 offer advanced features like stealthChop for quieter

operation.

### 3. List of components for Billy

Using the component comparison tables detailed earlier, the team was able to draw up a list of all the components needed to complete the project. This list can be seen in the Table 29 below.

Table 29: Cost of the components for Billy

Component	Quantity	Price (with VAT)	Supplier	Shopping link
ESP32 CAM	1	14.70 €	PT Robotics	<a href="#">Shopping link</a>
FT232RL (USB to TTL Serial Converter)	1	15.40 €	Farnell	<a href="#">Shopping link</a>
ili9341 (touchscreen)	1	29.47 €	RS	<a href="#">Shopping link</a>
MCP23016 - i2c 16bit Expander	1	3.14 €	PT Robotics	<a href="#">Shopping link</a>
Passive buzzer	1	0.66 €	DigiKey	<a href="#">Shopping link</a>
FPM10A (fingerprint sensor)	1	22.65 €	DigiKey	<a href="#">Shopping link</a>
A4988 stepper driver	1	3.87 €	PT Robotics	<a href="#">Shopping link</a>
Stepper motor	1	13.20 €	Farnell	<a href="#">Shopping link</a>
Servo Motor	2	13.50 €	DigiKey	<a href="#">Shopping link</a>
2×40 Pin Bar for PCB	1	1.23 €	PT Robotics	<a href="#">Shopping link</a>
AC/DC CONVERTER 12V 15W	1	10.68 €	DigiKey	<a href="#">Shopping link</a>
Voltage Regulator 5v	1	0.66 €	DigiKey	<a href="#">Shopping link</a>
220 Ohm Resistor	1	0.11 €	DigiKey	<a href="#">Shopping link</a>
MULTICOLOR BUTTONS (kit)	1	1.99 €	DigiKey	<a href="#">Shopping link</a>
LED RED	4	1.28 €	DigiKey	<a href="#">Shopping link</a>
Capacitor Ceramic 100µF	1	0.34 €	DigiKey	<a href="#">Shopping link</a>
BreadBoard	1	8.17 €	DigiKey	<a href="#">Shopping link</a>
Jumper Wires Pack - M/M	1	2.38 €	DigiKey	<a href="#">Shopping link</a>
Jumper Wires Pack - M/F	1	2.38 €	DigiKey	<a href="#">Shopping link</a>
USB micro-B Cable - 6 Foot	1	4.19 €	DigiKey	<a href="#">Shopping link</a>
Screws M4*25	1	0.63 €	Leroy Merlin	<a href="#">Shopping link</a>
Washer D6	1	2.59 €	Leroy Merlin	<a href="#">Shopping link</a>
PLA plastic for all the 3D printed parts (1 Kg)	1	16 €	-	Provided by the teachers
Acrylic sheet/plank 500*500*4 mm	1	15.99 €	Leroy Merlin	<a href="#">Shopping link</a>
Snap ring 3 mm	1	0.58 €	Leroy Merlin	<a href="#">Shopping link</a>
Total		185.79 €		

### 4. Detailed Schematics :

Figure 44 is the electronic schematic for the pill dispenser. The brain of the dispenser is an ESP32-cam, which is located at the top left of the schematic. This microcontroller is directly connected to the display (ili9341). This allows for fast and reliable communication. To flash the software to the microcontroller, we need an adaptor. This connection is shown with dotted lines. This is because we do not need this connection once the board is flashed. As you can see, the connection to the display



takes up a lot of pins on the microcontroller. This is why we use an IO pin expander to control the other components, such as the fingerprint sensor, the stepper motor controller, the servo motors, some buttons and Light Emitting Diodes (LED).

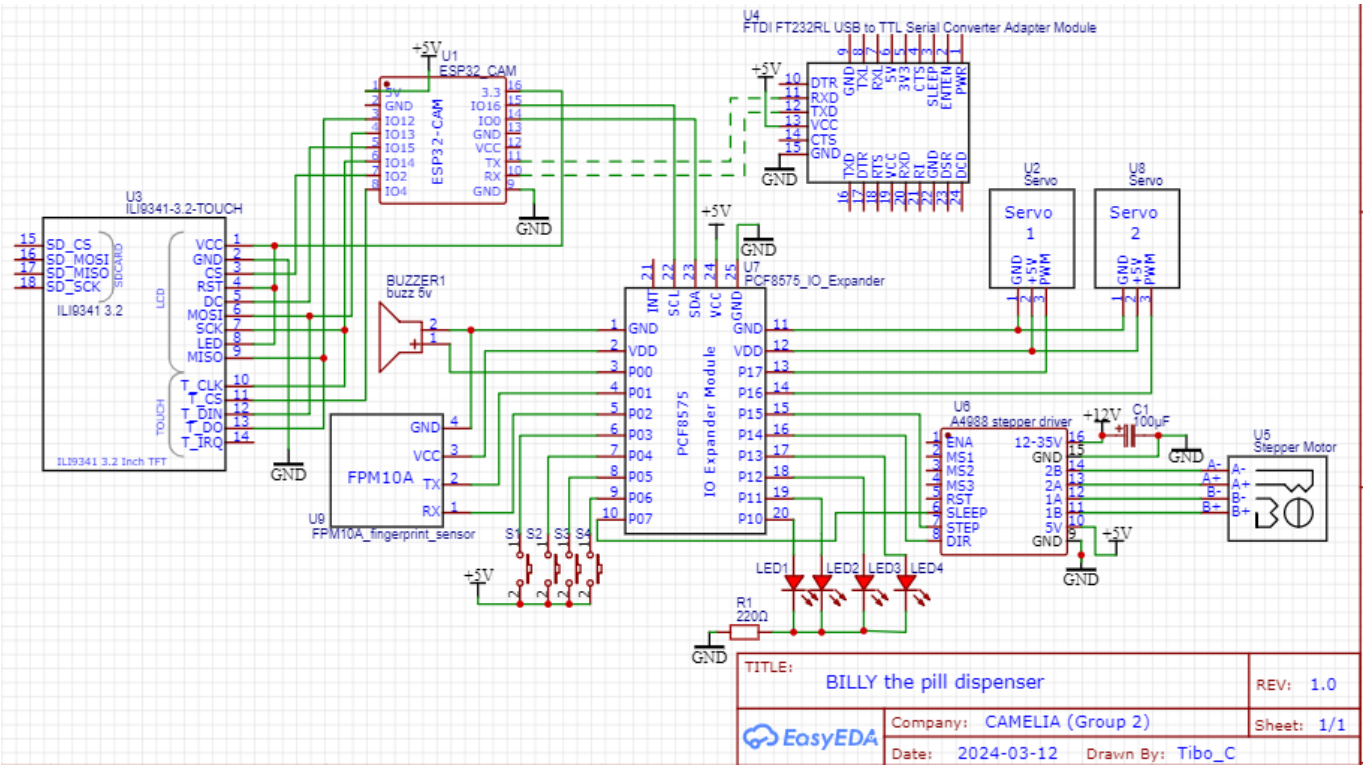


Figure 44: Detailed Schematics

5. Power budget :

The power budget, in Table 30 below, lists the power consumption of each component in the project. The voltage and current ratings are provided along with additional notes where applicable. The theoretical maximum power consumption 13.47 W. The closest standard power supply is 15 W. This is good because it allows for some overhead.

Table 30: Power budget

Component	Power (W)	Voltage (V)	Current (A)	Additional Notes
ESP32-CAM	1.55	5.00	0.31	2 A recommended
FT232RL (USB to TTL Serial Converter)	0.35	5.00	0.07	
ili9341 (touchscreen)	0.12	3.30	0.06	10 mA module + 50 mA backlight
MCP23016 - I2C 16bit Expander	2.00	5.00	0.40	
Passive Buzzer	0.25	5.00	0.05	
FPM10A (fingerprint sensor)	5.12	5.00	0.12	
Stepper Motor	2.00	5.00	0.40	
Servo Motor	2.00	5.00	0.20	2 motors
<b>Total</b>	<b>13.47</b>			
	<b>~15</b>			

## Software

Describe in detail the: (i) use cases or user stories for the smart device and app; (ii) selection of development platforms and software components (use tables to compare the different options); (iii) component diagram.

### 7.3.3 Packaging

Present and explain the: (i) initial packaging drafts; (ii) detailed drawings; (iii) 3D model with load and stress analysis, if applicable.

### 7.3.4 Cardboard Model

An initial prototype was made out of cardboard in order to get a better idea of how the final product is going to look like. By physically seeing and touching this “prototype”, the team gets a better feeling of the product and whether or not the form and size of this pill dispenser is suitable for children. The initial prototype is shown in Figure 45.



Figure 45: Cardboard Model

## 7.4 Prototype

Refer main changes in relation to the designed solution.

### 7.4.1 Structure

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

### 7.4.2 Hardware

#### 1. List of components and Materials

In order to respect the budget of 100 € that was given for this project. Choices had to be made about the components used in order to reduce the overall cost of the prototype. To do this, the team concentrated on components with important functions that should not be modified. Obviously, security was the most important function for the team, so security components, such as the fingerprint reader, were retained, despite their high cost. To fit within the budget, the changes were made using a lower-performance, non-touch screen display, to display only the main information. The stepper motor and servo motor have also been changed for less powerful and less precise models. Finally, the main supplier has also changed, from DigiKey to Mouser, which turned out to be cheaper. In the Table 31 below you will find the list of components used for the prototype.

Table 31: Cost of the components for the prototype

Component	Quantity	Price (with VAT)	Supplier	Shopping link
ESP32 CAM	1	11.49 €	Mouser Portugal	<a href="#">Shopping link</a>
FT232RL (USB to TTL Serial Converter)	1	6.77 €	PT Robotics	<a href="#">Shopping link</a>
DFRobot I2C LCD Screen	1	9.21 €	Mouser Portugal	<a href="#">Shopping link</a>
MCP23016 - i2c 16bit Expander	1	3.14 €	PT Robotics	<a href="#">Shopping link</a>
Passive buzzer	1	0.56 €	Mouser Portugal	<a href="#">Shopping link</a>
FPM10A (fingerprint sensor)	1	18.55 €	Mouser Portugal	<a href="#">Shopping link</a>
A4988 stepper driver	1	3.87 €	PT Robotics	<a href="#">Shopping link</a>
Stepper motor	1	7.44 €	Mouser Portugal	<a href="#">Shopping link</a>
Servo Motor	2	7 €	Mouser Portugal	<a href="#">Shopping link</a>
2x40 Pin Bar for PCB	1	1.23 €	PT Robotics	<a href="#">Shopping link</a>
AC/DC WALL MOUNT power supply 5V 15W	1	4.67 €	PT Robotics	<a href="#">Shopping link</a>
220 Ohm Resistor	1	0.22 €	Mouser Portugal	<a href="#">Shopping link</a>
MULTICOLOR BUTTONS (10 pack)	1	0.82 €	Mouser Portugal	<a href="#">Shopping link</a>
LED RED	4	1 €	PT Robotics	<a href="#">Shopping link</a>
Capacitor Ceramic 100µF	1	0.28 €	Mouser Portugal	<a href="#">Shopping link</a>
BreadBoard	1	2.99 €	Mouser Portugal	<a href="#">Shopping link</a>
Jumper Wires Pack - M/M	1	3.08 €	PT Robotics	<a href="#">Shopping link</a>
USB micro-B Cable - 6 Foot	1	0 €	We will use our personal cable	
Screws M4*25	1	0.63 €	Leroy Merlin	<a href="#">Shopping link</a>

Component	Quantity	Price (with VAT)	Supplier	Shopping link
PLA plastic for all the 3D printed parts (500 g because 1/2 scale prototype)	1	8 €	-	Provided by the teachers
Vidro sintético TRANSPARENTE plank 500*500*2mm	1	5.19 €	Leroy Merlin	<a href="#">Shopping link</a>
Total		96.14 €		

2. Detailed schematic for the prototype

As you can see in figure 46 the details schematic has changed a bit. The main difference is the use of a different display. The prototype does not require a full on touch display to function. A simpler and cheaper LCD is used to display the most imported information. This change freed up a lot of GPIO pins of the microcontroller. This allows for a component rearrangement. More components are now directly connected to the microcontroller.

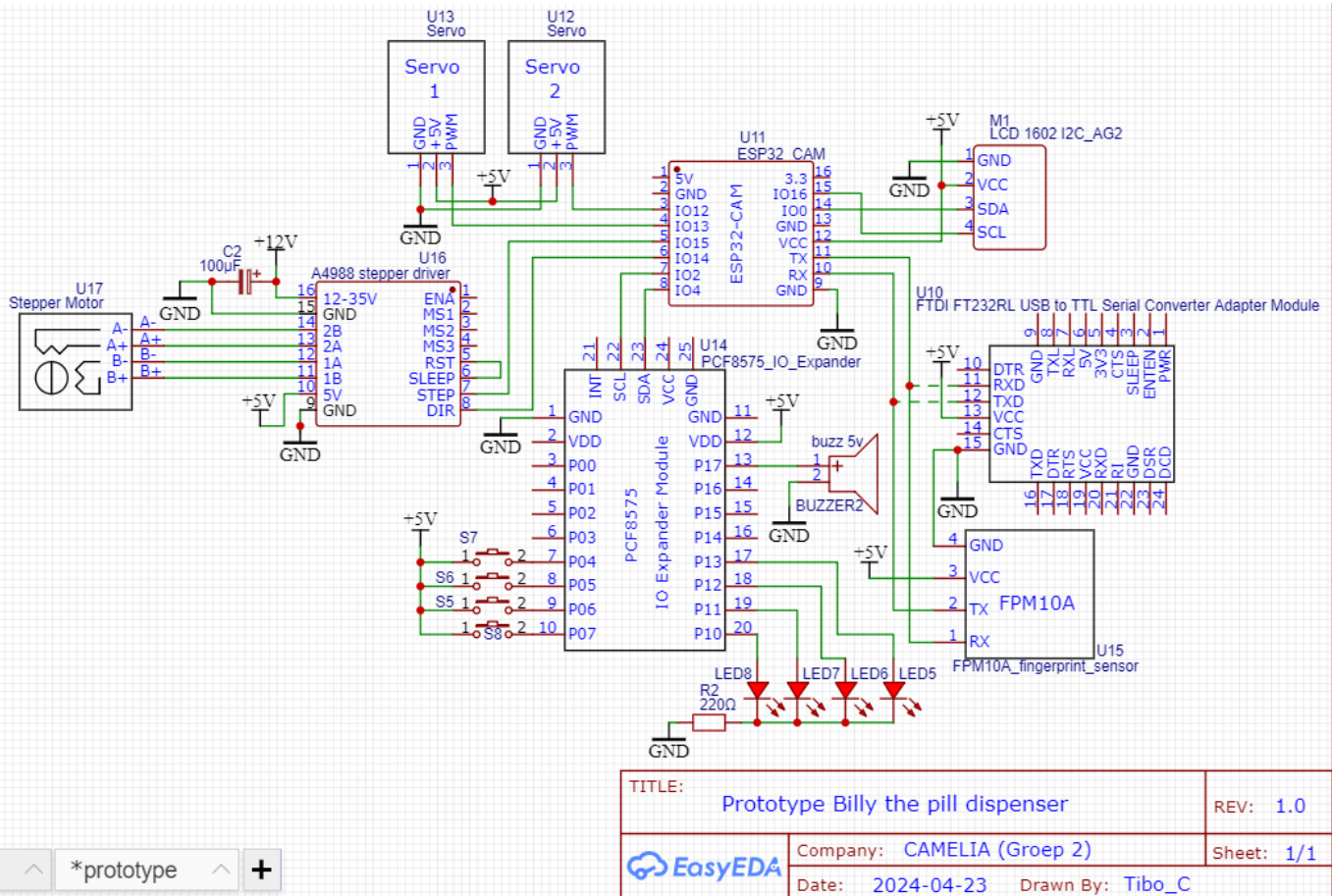


Figure 46: Detailed schematic for the prototype

7.4.3 Software

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

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

flowcharts.

All the software will be written in Visual Studio Code, making use of the Platform-Io and the Wokwi simulation plugin. The code for the microcontroller will be mostly C++. This code will host a small web server with some HTML, JavaScript and CSS files. All code can be found in our [GitLab repository](#)

#### 7.4.4 Tests & Results

##### Hardware tests

Perform the hardware tests specified in **1.6 Functional Tests**. These results are usually presented in the form of tables with two columns: Functionality and Test Result (Pass/Fail).

##### Software tests

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

#### 7.5 Conclusion

*Provide here the conclusions of this chapter and introduce the next chapter.*

### 8. Conclusions

#### 8.1 Discussion

*Provide here what was achieved (related with the initial objectives) and what is missing (related with the initial objectives) of the project.*

#### 8.2 Future Development

*Provide here your recommendations for future work.*

### Bibliography

*Will be added automatically by citing, in the body of the report, entries specified in BibTeX format and stored in the <https://www.eps.dee.isep.ipp.pt/doku.php?id=refnotes:bib> file*

PS - If you have doubts on how to make citations, create captions, insert formulas, etc. visit this [page](#)

with examples and select "Show pagesource" to see the source code.

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