Ecole nationale supérieur de l’énergie, l’eau et l'environnement

2A : Team Projet

Engineering Project Report: FruVendMach

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SUMMARY :

Introduction

The project we chose was proposed by the association GrainesE3, the main mission of which is to offer fresh fruit and vegetables from organic and local agriculture in the region of Grenoble. The idea of making a fruit vending machine came to them as a desire to simplify the current distribution of fruit, which until then had been in the *foyer*, distributed by members of the association. The aim was firstly to free up these volunteers during breaks and secondly to make organic fruit available at any time of the day at school.

A team of 7 students from the ASI (Automatique et Systèmes Intelligents) class was then formed to respond to this request. As the project was proposed by an association and not a company, the specifications had not been precisely described and we had few indications at the start of the project. We were therefore inspired by GrainesE3's values and our knowledge in order to design and produce a vending machine to their liking within the school.

We had several major parts in the progress of the project. The first one was the specifications. Then we had to dimension our product and make some decisions: which materials to choose, which electronic and electrical equipment, how to make the more complex parts, how to assemble each part together, etc. Finally, once this work was done, we were able to move on to the realisation at the FabLab of the Ense^3. Throughout these steps, we had to be thoughtful about the management of the project, the distribution of tasks and the efficiency of the group in order to meet the deadline.

You will therefore find in this report two major sections: a *scientific and technical* section and a *project management* section.

Scientific and Technical Section

In this section you will find details of the construction of our fruit vending machine. From the elaboration of the specifications to the different tests, through the description and explanation of each part of the project, you will have an overview of all the scientific and technical tasks that were necessary to set up our device.

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I- Specifications

Very soon after we became aware of our project topic, we realised that no specifications had been drawn up. The only constraints were to make a dispenser for two types of fruit and to have an autonomy of one week. In other words, our dispenser had to have a storage capacity of 7 days for 2 types of fruit.

We had to think in a fairly comprehensive way about what the students could expect, so we had the idea of doing a survey among the students of the school to get their opinion on this new vending machine. This allowed us to get an idea of how many fruits we should be able to offer but also to break down primary and secondary functions in order to develop our specifications.

Here are our conclusions:

PF	CF	Constraints
PF1: distribute fruit	Offer fruit diversity	Two different fruit types
	Avoid damaging the fruit	Max falling height of 10cm
	Fast dispensing	Max dispensing time of 10s
PF2: include a payment method	Pay on a website	
	Minimise the students association's fees	
PF3: fruit supply	Guarantee an easy supply of fruit	Trapdoor or container above the dispenser
	Have separate mechanisms for each type of fruit	Two different stages of fruit containers
	Store fruit without damaging it	No humidity; ~80 fruits/container; cooling system
SF1: design	Dimensions	180x60x60
SF2: safety	Secure access to the fruit storage	Add a lock
	Ensure electrical safety	No saturation for more than 2s; emergency stop button
	Service access	By adding a front door and trapdoor
	Respect food safety rules	Prevent contamination and rotting by using a fridge
SF3: accessibility	Waiting lines in front of the dispenser	
	Service access	Be able to open and close both doors (front door and trapdoor)
	Handicapped access	Hand out fruit at an appropriate height
SF4: feasibility	Document the project	3D modeling of the project; computer program; electrical modeling; instruction sheet
	Make the project open-source	

We have therefore isolated 3 main functions for our distributor:

- Fruit distribution, which includes distributing the fruit quickly enough, without damaging it and offering a choice between two fruits.

- The payment method should minimise the financial losses of the association and make the transactions secure and efficient for the students.

- Fruit supply, which involves storing fruit without damaging it with a different mechanism for each fruit and ensuring that the fruit can be easily reloaded.

Then 4 secondary functions to try to satisfy:

- Good security, both in the payment device and in the ATM itself.
- Accessibility to make our system accessible to as many people as possible, especially those with disabilities.
- A design that catches the eye of the student and thus encourages interest from the largest number of people.
- A good feasibility so that we can easily rebuild our distributor. This includes good documentation and an open-source distribution of the project.

Through these main and secondary functions, we can see the amount of work that had to be done and above all the variety of areas in which we had to work in order to guarantee the smooth-running behaviour of our distributor.

However, even if it seems simple at first, it took us a long time to determine all the important functions and how to realise each of them. But thanks to the responsiveness of Dorian BONIN, the project owner, on his expectations and the possibilities that were available to us, we were able to move forward properly.

II- Dimensioning

We are now going to explain some of our choices regarding the dimensioning of our solution.

First of all, after having studied the standards to which we were subjected in order to set up a dispenser in the hall of the Ense3, we decided to build our dispenser inside a refrigerator. Indeed, it would have been impossible to set up a dispenser that did not respect the hygienic norms of food conservation. It was also too complex to build ourselves a refrigeration system reaching 10°C in a closed box. The refrigerator was therefore both an idea that allowed us to simplify the work but also a sustainable action because we used a second hand refrigerator.

Once we bought it, we were able to take its dimensions and finish modelling the different parts that we planned to 3D print. This concerns in particular the distribution system and the tanks allowing to store the fruits.

Concerning the distribution system, we chose to create ourselves a model that does not exist, using 3D printing for each of the parts. We also chose to make two identical distribution systems for each fruit. We will come back in more detail on its functioning in the following of this report.

For the materials, we decided to recycle as much as possible by using what was available to us at the FabLab. This has two main effects: the decrease of the manufacturing cost of our dispenser and the Low-Tech aspect of the latter which allows to make it much more accessible to people living in countries with lower social-economical statuses, or those who cannot afford to buy a dispenser and want to build it themselves. However, we have used materials that respect the hygienic standards as much as possible and decided to cover those that do not respect these criteria with a food varnish usually used in kitchens. By combining the temperature of 10°C, the hygienic materials and the varnish, we should meet the required hygienic standards.

Finally, concerning the means of payment, we decided to opt for a card-based system to avoid handling coins or having to create special coins for our machine ourselves. On one hand it would have been too complicated and on the other hand people would have lost their coins too easily. However, after a lot of research, we concluded that it was impossible to make a system working for our bank cards and we had to fall back on the use of student cards thanks to an RFID sensor (we will come back in the next part on the exact explanations of our system).

III - Payment Method

For the payment method, we thought of many different options:

- We considered tokens (like the fake coins you can get to insert in supermarket carts), but these wouldn't be efficient - they would require in-person interaction to buy them, which requires availability on both parts.
- We considered integration with the CROUS system, called Izly, but the CROUS administration said that this would not be a possibility.
- We considered coins but that would be unnecessarily complicated (as we would have to find ways to read the coins value and create anti-jamming, coin return, fake coin detection mechanisms, etc) and not particularly useful - students don't usually carry money around.

Summing up, we needed something that required no human vendor, no coins, and the best choice became obvious: we had to develop a website.

In this website, students would be able to register to their personal account (associated with the student card), buy any number of pieces of fruit, and pay by credit card. Their account would be credited with the right balance (eg. 3 fruits). When they went to the vending machine, they would scan their student card, the machine would read the balance and, if equal or superior to 1, allow for the user to choose between an orange or an apple. In the end, after the piece of fruit had been delivered, their balance would decrease 1 piece of fruit.

In practice, we ended up having to develop many more intermediate steps, which are shown below:

Preliminary Research

Web Hosting

Our initial approach was to ask for a web domain to the school. However, after our first talk with the IT department, we quickly realised that this would not be possible: the security rules made the process of asking to launch a website very complicated and time consuming and this solution also required for the student organisation to have someone ready 24/7 to do server maintenance. Due to these limitations we resorted to buying a private domain.

This meant that we had to investigate which hosting companies would offer the best deal for our client. We looked at various alternatives but we ended up choosing bluehost due to its cheapness, its online live help service and the integration with wordpress.

Payment Services

Searching for the right way to pay we took into account various factors such as:

- Security: we want to assure our client that it can trust our website to safely handle students' card informations and other private details; this means that we only looked at encrypted solutions or ones that did not require sharing of sensitive information
- Student's payment preferences: we prioritised payment methods more appealing to our target audience: we looked at services that offered card payment or Lydia, and opted out from services that used Paypal or bank transfers instead
- Fees: one of the main concerns for our client was that the service did not charge a fee per transaction, and instead had a fixed cost (per month or year) that could be easily accounted for in the organisation's budget; this was a criteria particularly hard to fill as most financial transaction companies follow the transaction-based model

We looked especially at paypal, monext and woocommerce, and in the end we opted for woocommerce as it is safe, free and easily integratable into wordpress.

Final User Experience

With the platforms chosen, the initial model still standed. The students would therefore log in to the website and choose the amount of fruit they wanted, and use the RFID sensor of the machine to buy it. What about new users?

Our original plan would be to have two options on the website: “sign up” and “log in”. However, we would have to control the access to the “sign up” option, since we wouldn’t want everyone to be able to join - only the school students. It would be hard to implement this, so we decided that the registration would have to happen with a Grainese3 member present. The student will go up to them, ask them to be registered, and be manually inserted into the database. From there, the student is registered and everything can go on smoothly. Next time, they only have to log in the website the regular way.

Implementation

Strategy 1 - Integrating parallely with wordpress and woocommerce

Initially we planned on implementing a ‘side-by-side’ strategy. For this we created our own database (with the user’s name, password, email, balance and such) and then we created php files that allowed us to start a session, create a session token, communicate with our database, and log the user in. Then we planned on redirecting woocommerce operation’s log to our database.

We encountered two problems with this solution:

- Lack of supporting woocommerce documentation for payments with external client databases
- Problem with the session token and changing pages on the website: this is apparently a recurring problem with wordpress, as we found a few people in forums talking about not being able to host native PHP sessions on their website; we tried to fix this problem and talked to the informatics service, reached out to a professor with a similar project and contacted both bluehost and wordpress, but we did not come up with a solution

Strategy 2 - Building code on top of the wordpress and woocommerce

We concluded that the best way to fix the problem was by eliminating it and changing the project’s direction. We then opted for a code “on top” approach.

Both Wordpress and Woocommerce have administrator-autonomous, run ‘out of the box’ databases where they keep user information and transaction information. On top of that we have an external database that communicates with the arduino (called ethrfruit_userDatabase), and that has to be updated every time a user uses the fruit vending machine, in order to ensure that all of the user’s balance is in order. The ethrfruit_userDatabase has two tables: one with every user’s ID and their balance, another with the log register of the last update.

We analysed the native Wordpress and Woocommerce tables and created a total of 21 PHP functions that work to check if the tables are up to date, to update them if necessary and to increase/decrease the balance when a user adds more credit to their account/buys a piece fruit.

Here is brief overview of the PHP files in use:

- Arduino.php → this file is the one responsible for the high level management of the ethrfrui_userDatabase table, as it is the file that implements functions for checking if the database is up to date and updating it if needed
- ArduinoDatabase.php → this file has important functions related to establishing the database connection and other functions needed for the Arduino.php file

```
class ArduinoDataBase
{
    public $connect;
    public $data;
    private $sql;
    protected $servername;
    protected $username;
    protected $password;
    protected $databasename;

    public function __construct()
    {
        ...
    }

    function dbConnect()
    {
        $this->connect = mysqli_connect($this->servername,
$this->username, $this->password, $this->databasename);
        return $this->connect;
    }
```

- ArduinoDatabaseConfig.php → this file contains informations related to the database such as database name, IP, user and password
- Website.php → high level management of the wordpress and woocommerce tables; example code below:

```
//checks if databases are both updated
function uptodate(){
    require_once "Arduino.php";

    $lastwb = lastwebsite();
    $lastard = lastarduino();

    if ($lastwb == $lastard) return true;
    else updatemachine($lastard,$lastwb);

}
```

- Database.php → analogous to the ArduinoDatabase.php
- DatabaseConfig.php → analogous to ArduinoDatabaseConfig.php

Figure 1 succinctly shows what happens when a user buys more credit on our website:

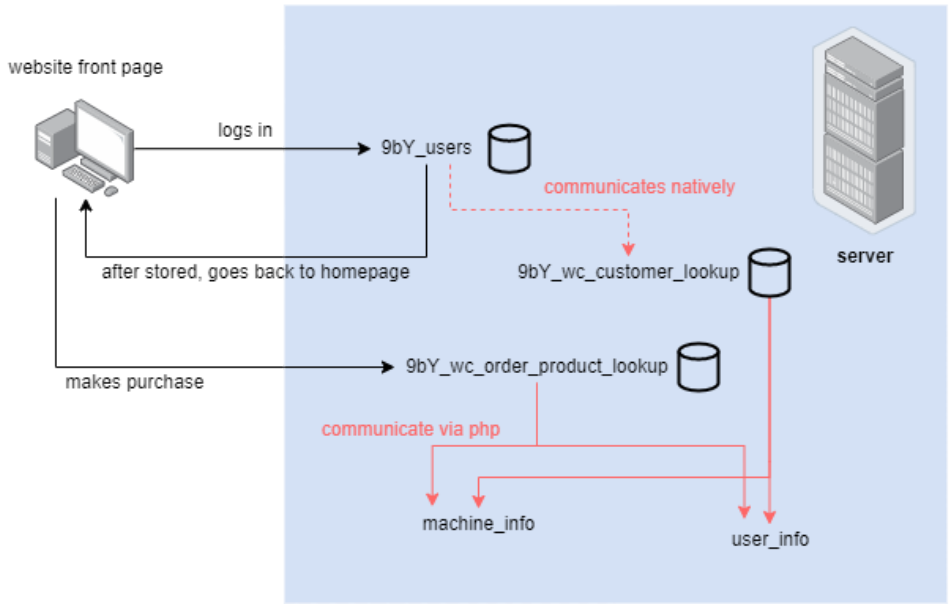


Figure 1: Diagram of User Procedure

And figure 2 shows a quick overview of the complex database processes that occur when a user buys a fruit:

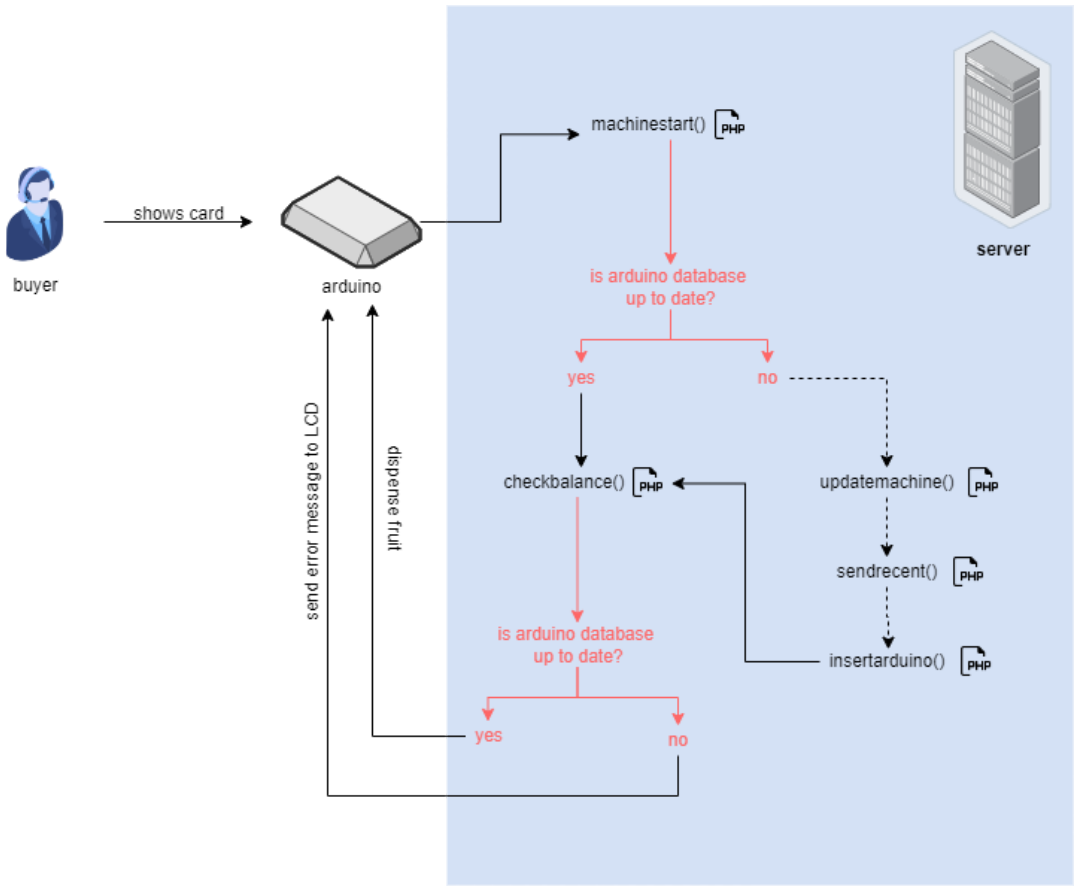


Figure 2: Illustration of Database Connections

Final result/ end user interface

We have the website currently running on our domain, e3fruits.space. The website is constituted by 3 parts, a “Our Story” (which is also the homepage), a shop (where you can buy any given number of fruits you would like and then pay by cart) and a “My account”.

The website is responsive for every screen size and very easily navigable. The official launch is not until later, when the dispenser machine is installed in the school and the new user accounts are created, a user will not be able to have access to their account.

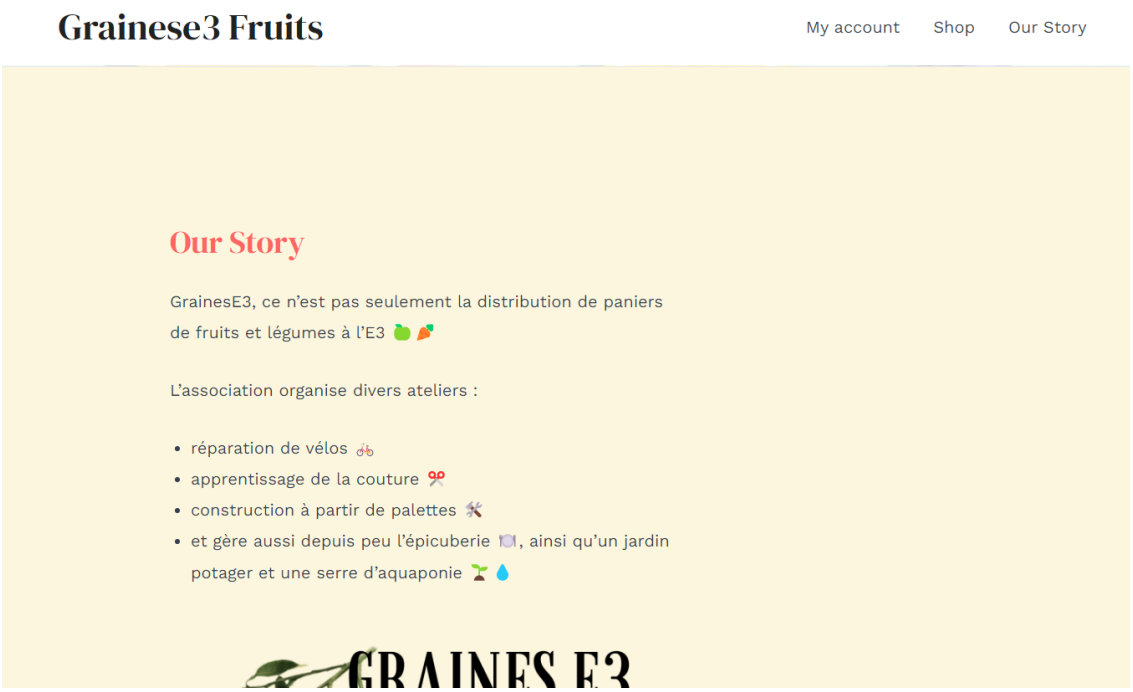


Figure 3a: Website Interface for Desktop - Our Story

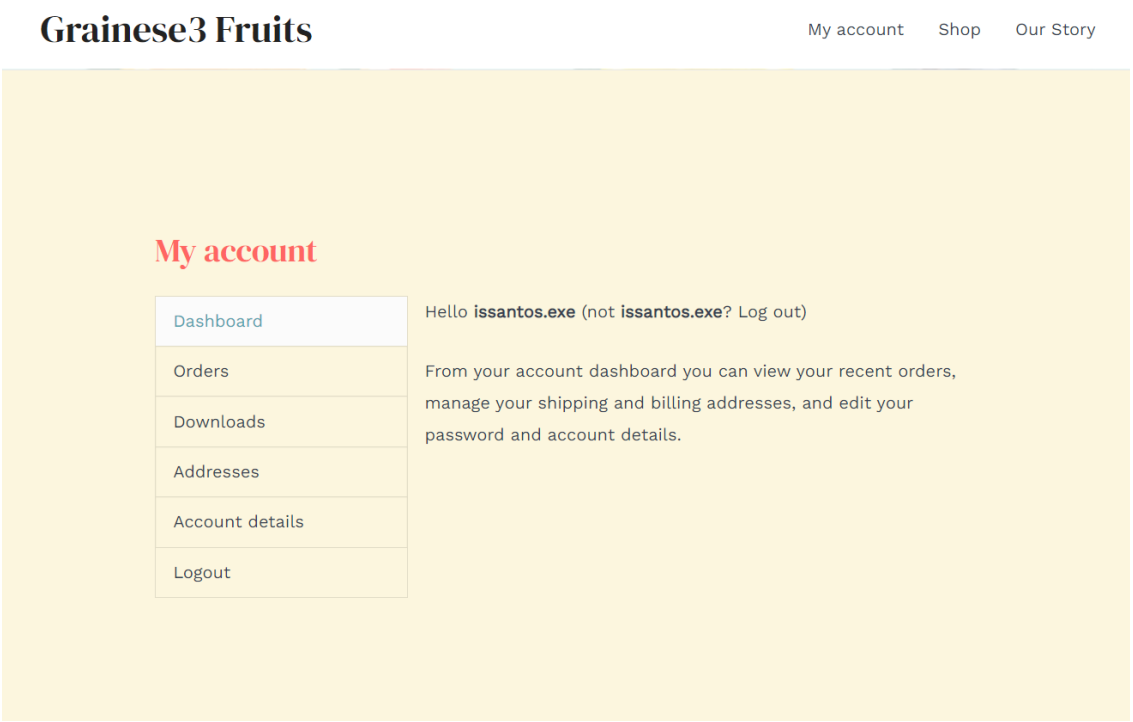


Figure 3: Website Interface for Desktop - My Account

IV - Distribution System

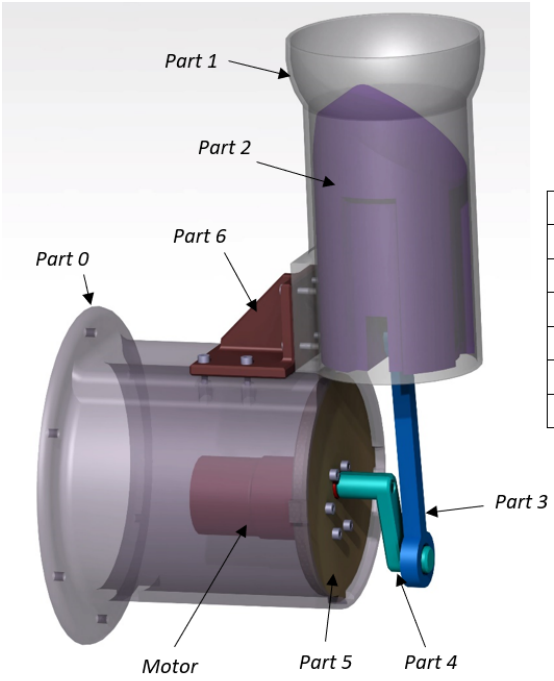
The distribution system was the first system to be considered collectively. We imagined many systems before converging on our final solution.

Our solution is inspired by an automatic lemon squeezer. It consists in using a half-sphere (*Part 1*) having the same characteristic size as a fruit (eg. for apples of average size about 7cm diameter) in order to contain the fruit that will be delivered. This form is perforated at the bottom so that a piston (*Part 2*) can rise and push the fruit to the side thanks to its special shape. Its shape can also stop the fruit behind and engage the next fruit in the half-sphere.

In order for the piston to be able to move back and forth, it was decided to use a connecting rod (*Part 3*) and crank (*Part 4*) device to enable it to do this. This device has many advantages: simple to set up with 3D printing, irreversibility of the torque at the low position (which is our default position) and no maintenance or wear.

To make the coupling between motors and cranks, we have chosen to use hose clips because it is the simplest and most effective solution. We decided to implement a direct coupling without load support by bearings or bushings because the axial and radial loads are not high enough to require such systems. In addition, the friction is compensated by an oversized motor torque.

The only thing left to do was to attach this system to a frame, and fix this frame in the fridge - knowing that it is impossible to fix anything to the bottom of the refrigerator because there are cooling pipes and blindly piercing in it, could destroy the cooling system and release refrigerant gas into the atmosphere. We chose to make the frame in 2 different parts in order to save time during 3D printing : one that holds the motor (*Part 5*) and the other one that holds the whole system and fixes it to the fridge (*Part 0*). The *Part 0* is fixed to the sidewall with aluminium rivets as these apply a lower pressure which prevents the plastic shell of the fridge from breaking.
As *Part 1* had to be supported, we created *Part 6* to connect it to the frame.



Part 0	Frame
Part 1	Piston chamber
Part 2	Piston
Part 3	Connecting rod
Part 4	Crank
Part 5	Motor support
Part 6	Connection part

Figure 4: Distribution System Model

V - Arduino Programming

After having the software chapter up and running, it was time to configure the electronics. Firstly, we sketched a finite state machine (FSM) to better understand what were the steps that needed to take place:

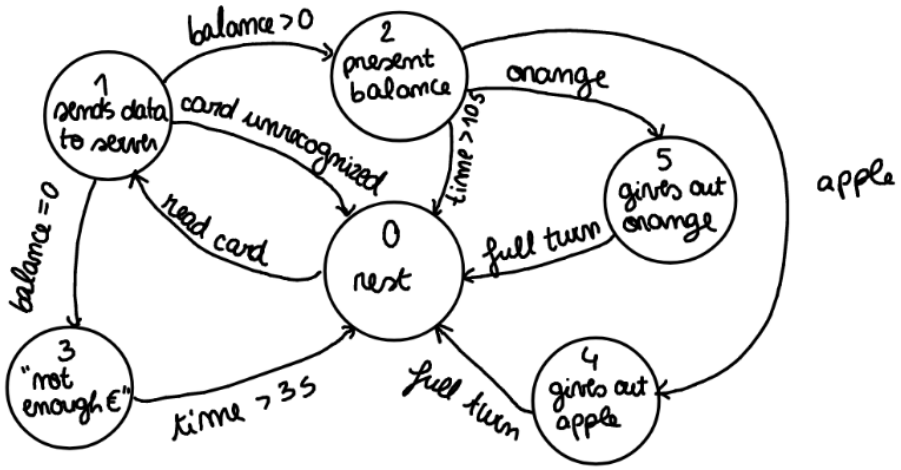


Figure 5: Arduino Program FSM

We programmed it on Arduino.

RFID and LCD

We then connected the RFID sensor to the Arduino board and wrote the code that allowed for the RFID to detect a card. Since we didn't want every card to be recognized by the RFID sensor, we only considered cards with student IDs (thus a hypothetical purchase attempt with, for instance, a hotel card won't work). We also connected the LCD to the Arduino and programmed it so that it would display messages (like "Waiting for card" or "Please Choose Fruit"), making the user experience more pleasant and easily understandable.

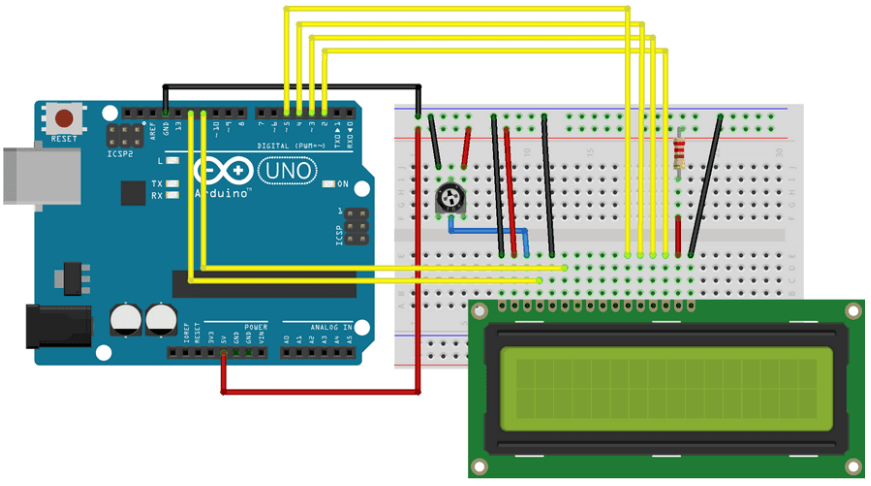


Figure 6: LCD schematics

Due to some bad contacts with the wiring of the LCD and the RFID, neither of those worked the first time. However, in the Fablab we learned how to desolder the arduino plastic caps and directly connect all the electronics, making for a sturdier and more reliable configuration. With more time, the ideal solution would be to design a PCB.

Ethernet Shield
All that was left to configure the payment-related electronics was the connection to the database. Up until now, our Arduino could theoretically jump from one state to another, and print messages on the LCD on command. But where did it retrieve its data from? The user would pass their card on the RFID sensor and the Arduino had to *get* the associated information (in this case, the balance) from the database before going on with the rest of the operations. To do this, we used an Ethernet Shield, which was, too, added to our circuit.

This was our initial plan. However, due to reasons that had nothing to do with us, our performance or our decision, we were forced to switch to a WiFi shield. We did not have the time to implement it or even order it. All of this is explained in the “Things that went wrong” module.

Motors
In order to make the dispensing system move, we had to use motors controlled by the Arduino. The main purpose of the code for these motors (one for each distribution system) was to be able to deliver the fruits one by one, in order to stop in the right position. To do this, we thought of using a delay on the motor to allow it to make only one turn (thus one delivery) each time someone asks for a fruit, using a button. The idea of using a delay was for us the best, because in a low-tech approach, we wanted to limit the use of sensors to the minimum required, our system does not need perfect precision and it makes - at most - 50 turns per week. We chose the delay as the best possible choice after testing and in case of a small mistake in the delay (stopping too early or too late) the system is designed to be put back to the initial position easily (by pushing on the piston to put it in the down position).

Power supply
For the power supply, we bought an AC to 12V DC converter, which will be plugged in a wall outlet near the foyer. This will be enough to fully power our Arduino and its peripherals. We also needed a power supply for the motor because it could not be powered by the arduino, so we took from the Fablab another AC to 12V DC. One is enough for both motors because the motors are not supposed to work at the same time.

Box containing the electronics
To make the dispenser functional, we needed a box containing all the HMIs. We also decided, to avoid having too many wires in all directions and to make only one box, to gather all the electronics - except the motors obviously - in this box. On the inside, we chose to replicate what is commonly found, by creating empty plastic tubes where the holes for screwing the cards are. We also added a hole to go inside the fridge to power the motor and a hole to go outside to receive power for the arduino and motors. On the outside, we made holes for the screen, the buttons and the RFID sensor. We have provided shapes to accommodate strips that will be used to indicate the type of fruit corresponding to the button as well as the price of that fruit. *Part 2* is attached to *Part 1* with screws and part 1 is screwed to the front of the fridge.

Figure 7: Part 1, Part 2 and assembly

Schematics

RFID Reader	SDA	Digital 10
	SCK	Digital 13
	MOSI	Digital 11
	MISO	Digital 12
	IRQ	unconnected
	RST	Digital 9
Motors	Apple	Analog 4
	Orange	Analog 5
WiFi Shield	Tx	Digital 3
	1kΩ → Rx → 1kΩ →GND	Digital 2

LCD Screen	RS	Digital 7
	EN	Digital 6
	D4	Digital 5
	D5	Digital 4
	D6	Analog 3
	D7	Analog 2
Buttons	Apple	Analog 0
	Orange	Analog 1
Power Supply	+5V	
	+3.3V	

VI - Distributor Construction

For the construction of our dispenser, we first chose, as said before, to take a refrigerator. After taking the measurements, we were able to start sizing the different parts we planned to put in it.

We started with the tanks to store the fruit. Then we worked on the integration of the distribution system. Finally, we integrated a trap door to seize the fruit.

Realisation of tanks

In order to size the tanks, we assumed that we would need to have an autonomy of one week (that is to say to have tanks big enough to contain the consumption of one week of fruits). After a quick calculation based on the answers to the students' survey, we concluded that we should store 7kg per tank. In order to respect the sanitary norms, we decided to use aluminium. The sheet used was 2 mm thick so that we could cut it with a water jet cutter, fold it easily and assemble each tank. The dimensions chosen were 45 cm x 15 cm x 32 cm. We also had to plan to make a base in order to raise the tanks to save space in the rest of the fridge but also to allow us to reload them more easily. Indeed, thanks to this device, it is enough to draw the tanks to put the fruits inside then to put them back on the base. For that, we used wood from the FabLab.

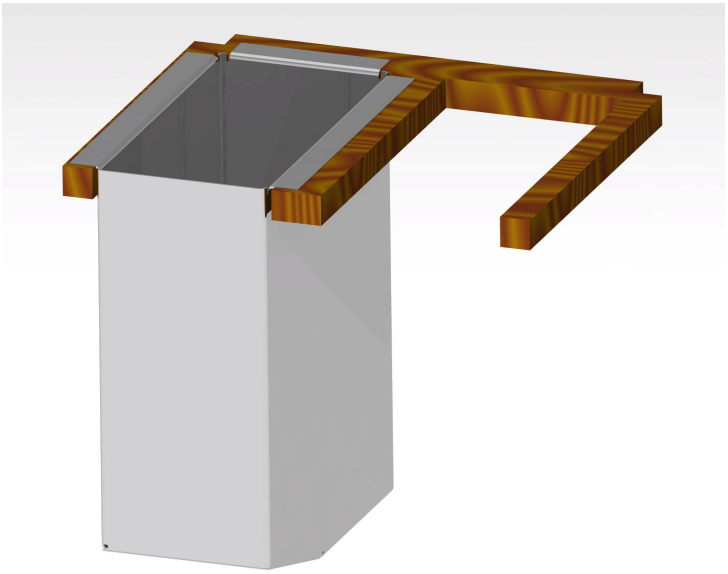


Figure 8: One tank on his base

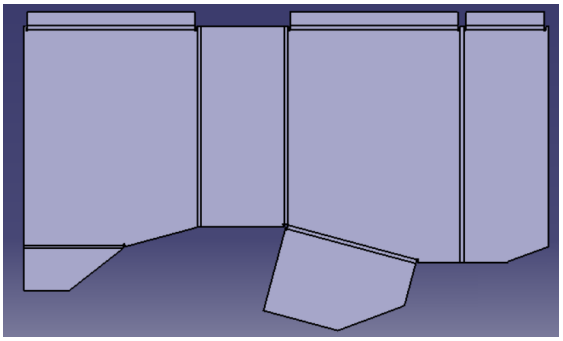


Figure 9: First cutting plan of a tank

What is difficult to discern in the image is the sloping bottom of the tank allowing the fruit to roll into a single 90mm x 90mm hole. These dimensions were chosen taking into account the average size of the fruits delivered to the GrainesE3 association and to prevent two of them from getting stuck.

At first, we wanted to cut a single plate with the hydraulic cutter (as shown in the diagram above) but we quickly realised that it was too difficult to bend it properly. So we decided to cut 4 sides, bend them and assemble them together with squares and rivets.

Integration of the dispensing system

Regarding the integration of the distribution system, we first worked on the interior walls of the fridge in order to smooth them to allow the fixing of our system (presented previously). Once this was done, we had to use PVC pipes to direct the fruit to the dispenser outlet. For this, we chose to use a 10 cm diameter PVC pipe. We also dimensioned supports to support these pipes, made of wood and of different sizes to create a reasonable slope.

It is shown in *figure 8* :

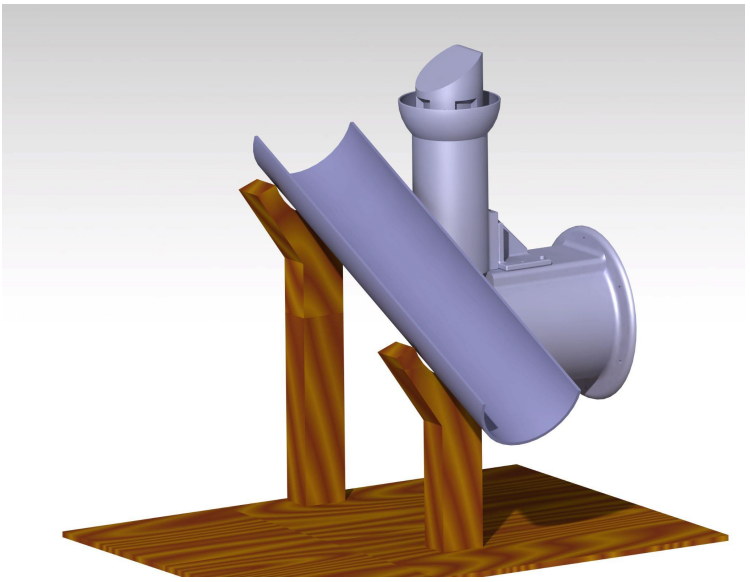


Figure 10: Distribution System on his base

How we made the Trap Door

In order to be able to recover the fruits, we also created a trap door by mixing 3D printing and the cutting of wooden boards. Indeed, for simplicity, we made the outline of the trapdoor with CATIA in order to make a 3D printing afterwards. As for the door, it is made of wood.

Before installing it, we drilled a hole in the fridge door with the help of the mechanical workshop of ENSE3. One of our main concerns with the cut we had to make was the fire hazard while cutting the door, as cutting the metal part could induce some heat onto the styrofoam which could then catch on fire. When it burns, styrofoam releases some toxic chemicals and is very hazardous for the environment. Along with the mechanical workshop, we took all the precautions in order to avoid fire. We first drilled four holes in the door and cut the plastic side of the door with a manual saw to avoid heat generation. Then we took out some of the insulation (styrofoam), and tried using a nibbler. That tool did not work because the quality of the metal of the fridge door was too poor. We wanted to avoid using a grinder because it generates a lot of heat, but we had to use it because it was the only option. However, to avoid starting a fire, we waited about 5 minutes for the door to cool between every cut we made.
That way, we were able to make a cutout in the fridge door to the dimensions we needed.

Figure 11: Frame of the trap door and completed trap door

VII - Testing and Conclusion

After every step of the designing and building of our dispenser, we decided to test the whole system to be sure it was working well. Unfortunately, we were not able yet to test the dispenser with a full tank of fruits.

Still, when we tested it with just a few fruits, it was working as intended. Some improvements could be made on the reliability and consistency of the system. For example, sometimes one apple can get stuck after exiting the tank, so increasing the steepness of the tube at the exit of the tank could be a good idea.

Project Management Section

In this section we will discuss how we managed the project. To get to the bottom of the issue, we will do different parts:

I. **Ownership of the Topic and Objectives**

II. **Organisation and Group Effectiveness**

III. **Time and Schedule Management**

IV. **Strengths, Weaknesses and Improvements**

V. **Things that went wrong**

After addressing the previous points, it will be possible to get an overview of how we managed our project and the mistakes we made.

I. Ownership of the topic and objectives

From the beginning of the project we quickly got into a good momentum. After talking with Dorian, we got the first information about the expected final product and we quickly started to think about how to make the dispenser. As two of the seven students in the group are Erasmus students, it was difficult at first to get used to speaking English. However, we all quickly converged on the same ideas and questions. The objective was clear: to design a fruit vending machine from scratch for Ense^3 .

Thanks to the work to be handed in for the follow-up of the project, we had no difficulty in organising ourselves. We managed to create our own specifications in order to have a clear goal.

II. Organisation and group effectiveness

Concerning the organisation of the group, we first distributed the key roles to different people: Thomas was the team leader, Florent the technical manager, Yusuf the IT manager and Romain the financial manager. We then worked together during the first few weeks of the project and in particular on drawing up the specifications, the flow chart of the tasks to be done and in which order, the equipment to be used, looking at the standards to be respected and contacting the first people to ask questions to. Once the main parts of the project were determined, we divided the group into each of them in order to move forward simultaneously and thus be more efficient.

However, it is important to mention that we were delayed because for several weeks we did not know at what temperature our vending machine had to be in order to meet the hygienic standards of conservation. We also struggled with how to implement the payment system and this caused us some problems with planning and task allocation. After deciding to use a refrigerator to keep the fruit at a constant temperature of about 10°C and choosing to use a payment system specific to our project with an RFID sensor and a server specific to the GrainesE3 association, we ended up dividing up the tasks in this way:

- Payment method and Arduino coding (Inês and Matilde)
- Part sizing and 3D printing (Florent and Yusuf)
- Manufacturing and assembly in FabLab (Thomas, Theodore and Romain)

This division of labour was effective from the moment Florent and Yusuf finished their first piece to be manufactured in the FabLab. The principle of operation was simple: while Inês and Matilde worked on the payment method, the rest of the group took care of the layout of the vending machine. It is important to note, however, that in parallel to this organisation, each person in charge was busy doing the work that was asked of them. For example, while Romain was busy placing orders for new products/tools, he was not working on manufacturing and assembly.

III. Time and schedule management

Thanks to the various reviews requested, we quickly made a schedule of the tasks to be carried out. Before that, it was necessary to identify all the steps to complete the project but this was quite quick as we did not need to detail precisely what each step included as tasks. We then all agreed, including the dates we needed to prepare the deliverables, the order of the steps and the duration of the steps.

Regarding time management, we were not particularly good at the beginning of the project. As said before, there were some problems that kept us very busy and sometimes it took us a long time to find a solution. The problem was that without these answers we could not really move forward. For example, until we had an idea of how to refrigerate the dispenser, we couldn't predict the dimensions of the dispenser and so it was impossible to size the parts to put inside our dispenser. Similarly, without knowing the payment system, it was complicated to foresee how it could be integrated into the final product and, above all, whether or not there would be room to change the system along the way.

In addition, there were questions that we did not have the answers to. It was sometimes difficult to reach a teacher or a professional who could advise us on the way forward. For example, it took us a long time to figure out how to power the refrigerator, the arduino board, the motors and the payment system from a single mains supply. We felt that we didn’t have many people we could reach to to ask questions about the IT component of the project, and there were many constraints that were external to us and that kept us from being faster (for example, the unauthorization and special requests needed to be able to host a database inside the school, due to privacy and security concerns).

In conclusion, apart from these particular cases that we did not necessarily take into account in the initial planning, our organisation enabled us to follow more or less correctly the planning set at the beginning of the project. (See Annex 1). We also did not hesitate to advance the project, when necessary, in our free time, outside the hours initially planned for the project.

IV. Strengths, Weaknesses and Improvements

There were many strengths in our team. First of all, our team was multicultural, with two Portuguese students, but above all, a multitude of talents. Matilde and Inês are very good at the computer aspects of the project, Florent and Yusuf were good at the machine modelling software (Catia), and Romain, Thomas and Theodore were comfortable in the fablab for the actual realisation of the dispenser.

In addition, everyone was quite fluent in English, so communication was good in the group. On the same principle, the atmosphere in the group was great, which motivated us to work in a good mood and made us happy to be together in the morning.

The team was also quite efficient. Indeed, as soon as it was necessary to model, or to manufacture, it was settled rather quickly, which was pleasant because one had the feeling to advance.

For administrative management, our project manager was always able to quickly find the necessary staff to sign the different annexes, and Romain was able to handle the financial issues when it came to purchasing equipment without any problems.

As for the weak points, they were not numerous. However, we struggled with the slow-pacedness of the purchasing process. Sometimes we decided we need a specific component, but since it required a complex and time-consuming procedure, it happened that we had already changed our minds by the time the component arrived at our hands.

Another problem was the sense of division between the two major parts: the payment system and the machine itself. Oftentimes, Inês and Matilde went somewhere and the rest of the group went somewhere else - after all, the two parts took place in different locations - and it was sometimes hard to know what each group was doing or how things were going. We fixed this more towards the end, since both groups used the Arduino board to program the electronics, forcing us to communicate more and better.

Finally, we sometimes struggled with the difficulty of motivating the whole team at the same time, especially when we found ourselves in an impasse. Particularly in the beginning, we felt like we didn’t know where to start and that could be overwhelming. Once we got a sense of direction, we were able to overcome this.

V. Things That Went Wrong

As explained in the “Arduino Programming” section, our original plan was to use an Ethernet Shield. We ended up not doing it. Here, we explain why this happened and how we came to our solution.

We had to ask the IT department to authorise access to the school’s internet, via Ethernet. We sent them an email, in which we specified that we would be using the “Ethernet Shield”, and told them the type of request we were going to send to the server. They replied that they authorised it, and told us to pass by their office later to configure it. A week later, when we passed by their office, with most of the code implemented and the Ethernet Shield already bought, we were told they misread our email and thought that we were talking about WiFi. We were told they did not authorise Ethernet, because of security reasons, and we weren’t offered an alternative. We informed ourselves and got two other options:

1. Take an access point to use the Ethernet Shield as a WiFi module. This would solve our problems - it would give us the security of WiFi, with the functionality of Ethernet. We asked if the IT services had a spare one they could lend us, and they didn’t. The option of buying it ourselves was off the table - we didn’t have enough time, since we would have less than a week to make the budget, order it, get it, and implement it. It would have been impossible.

2. Use a WiFi module instead. Once again, the time constraint made this impossible for us.

This was a source of great distress for us. All of a sudden, our project wouldn’t work as promised, we weren’t at fault, and we had no way to fix it. We could find a temporary solution for the presentation, but what mattered the most to us was not letting our client, Dorian, down. After explaining him the situation, we agreed on buying the WiFi module, and leaving GrainesE3 instructions on how to implement it once it arrived. We chose the WiFi module over solution 1 due to its cheapness and ease of use. We were therefore able to somewhat fix this sudden issue, with as little collateral damage as we could possibly hope for.

Conclusion

To conclude, this project was a very enriching experience on many points. On a technical level, it allowed us to see different fields of engineering such as electronics, computer-aided design or web development. We were also able to develop different qualities essential to engineers: dimensioning of the specifications, design, assembly and production of parts, tests and validations of the final product...

But this project also allowed us to develop management and organisational skills. In particular, the planning of the tasks to be carried out, distributing the work between various people, making meetings on the progress of the project... Good communication was also essential in order to be efficient throughout the project.

Finally, this report allows us to make a synthesis of all the points discussed and also allows us to realise the positive and negative points while training us to synthesise a work over several months.

It was also a good experience because we started from scratch and it was really interesting to commit to a project and do everything to get it done. The fact of exchanging information with professors, researchers, Fab manager, commercial service of the school was also very enriching as much on the technical as on the social level.

We also enjoyed working under the "orders" of the association GrainesE3 because we had to adapt to their vision, their values and their "customers". This project was not only to realise a fruit vending machine but to be able to realise one under certain constraints as for example the Low Tech aspect (and thus durable) of our device. All this while managing a budget and a deadline.

Finally, even if we could not finish everything we had planned, we hope that this project will motivate other people to continue it, improve it and why not share it in open source to be able to benefit the greatest number.

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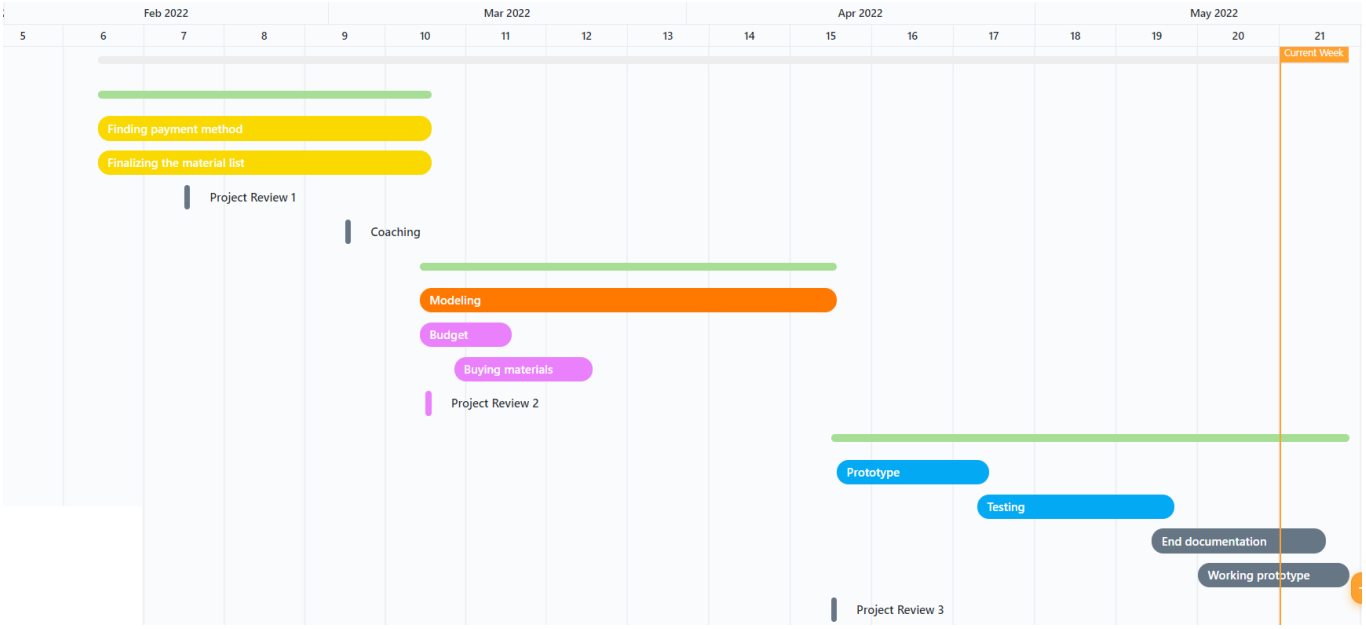
Annexes



Annex 1: Schedule (Both Predicted and Actual Schedule)