EscarGO

A home snail nursery

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Acknowledgement

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Glossary

Abbreviation	*Description*
B2B	Business to Business
B2C	Business to Consumer
CD	Compact Disc
CNISF	Conseil National des Ingénieurs de France
COD	Cash On Delivery
EPS	European Project Semester
EU	European Union
FAQ	Frequently Asked Questions
IOT	Internet Of Things
ISEP	Instituto Superior de Engenharia do Porto
LCD	Liquid Crystal Display
LED	Light-Emitting Diode
PESTLE	Political / Environmental / Social / Technological / Legal /Economic
PETA	People for the Ethical Treatment of Animals
PMMA	Polymethylmethacrylate
PP	Polypropylene
PVC	Polyvinyl Chloride
RAM	Responsibility Assignment Matrix
ROHS	Restriction Of Hazardous Substances
SEO	Search Engine Optimisation
SMART	Specific / Measurable / Attainable / Relevant / Time Based
SWOT	Strengths / Weaknesses / Opportunities / Threats
USB	Universal Serial Bus
WBS	Work Breakdown Structure
3D	Three-Dimensional

Introduction

1.1 Presentation

The team were undertaking the EPS Project in Portugal, studying at ISEP in Porto. The team named "Caracol", which means snail in Portuguese, consisted of five students all from different countries, cultures, speaking different languages, and above all with differing knowledge bases. This diversity, which could have been an obstacle, was instead the driving force that enabled the team to make this project unique, creative and innovative.

The team was composed of:

- **Lauri Hannah Borghuis**, from The Netherlands, studying Biology and Medical Laboratory Research
- **Benjamin Calon**, from Belgium, studying Product Development
- **John MacLean**, from Scotland, studying Mechanical Electronic Systems Engineering
- **Juliette Portefaix**, from France, studying General Engineering
- **Ramon Quero**, from Spain, studying Engineering and Architecture.

Team "Caracol" (see Figure 1) was a multidisciplinary, hardworking group of people who wanted to improve and develop communication and team working skills as well as other soft-skills, while learning about marketing, ethics and project management. Because of the multidisciplinary aspect of EPS, each team member learned something new from a field of study that they had not experienced before.

Figure 1 - Team 1 "Caracol"

Each member had a personal motivation to enroll on the EPS program:

Lauri Borghuis: *"EPS seems to me to be an excellent opportunity to make new social contacts with international students. I chose EPS to work in a group with international students with all different fields of study, so I can learn from their fields, and I can share my knowledge. Furthermore studying for six months abroad is good for my development in the English language".*

Benjamin Calon: "The EPS program trains us in a different way than normal school courses. It gives us soft skills to work with students from different backgrounds (professional and cultural). Going out

of my comfort zone, improving my language skills and enjoying the local culture are the ingredients for an extraordinary experience".

John Maclean: *"EPS gives me a chance to live abroad for a few months and experience a different culture. It allows me to meet people from all over Europe and make friends and connections for life. It puts me far out of my comfort zone and also gives me a chance to develop another language".*

Juliette Portefaix*: "EPS is for me a great opportunity to discover a new way of working. It is a chance to discover a new culture and new people. EPS also enables me to develop my management skills, and to learn to work in a team. Finally it's the best way to improve my English".*

Ramon Quero: *"I see EPS as a nice chance to improve my teamwork skills by working in a project with colleagues from different nations and backgrounds, an opportunity to speak in a foreign language and to learn other skills like communication, marketing or project management. It is also an unforgettable life experience".*

1.2 Motivation

The project that has been chosen was an "Escargot Nursery". This option was chosen for several reasons.

First of all, this was the subject which allowed the mix of each of the differing specialties thus allowing each member to bring their own experience and skill set from the various specialties.

Another reason for making this decision was that the team believed it was the most original and unusual project. None of the team members had any prior knowledge of escargot before the start of the project which provided its own challenge, but also allows the whole team to learn something completely new. It enabled the team to satisfy their curiosity, and be more open minded to new disciplines. The team believes that this product fulfills a genuine desire with families who want to learn more about food, and be more sustainable in food production.

In France there are not enough snails being produced for the amount of snails being consumed, so the French import a large number of snails every year. The team wanted to create a new way of producing food that would be fun for kids, that would include technology and that would provide a comfortable habitat for the snails. If the end user did not want to use the enclosure for producing food then they can also use it to keep the snails as pets. The team decided that education would be a main objective for the product, and that would be one of the main selling points. The enclosure would be able to house forty snails, which would take six months to reach full maturity.

1.3 Problem

In the modern era, more people are aware of the use of genetically modified organisms. Genetic modification is being used to improve food's colour, to make the food look more attractive or to increase the shelf life of the products. There are people who fear genetically modified food, and there are others who believe that it is the future and the way to end world hunger. The problem with genetically modified vegetables is that there is not enough scientific knowledge to prove the long term effects [1].

The digital revolution has improved our communication channels through the likes of social media, mobile phones, and video conferencing, but it has also isolated people becoming addicted to their smart phones and not living real social life. Social media comes with its pitfalls also, with people

trying to project the perfect life, and comparing themselves to others. Depression and mental health issues have become more common among young people [2].

The team saw this reality and decided they wanted to create something that would help towards a happier healthier lifestyle. They realised more people are opting for organic food, and want to know where their food has come from. Also, many more people are wanting to grow their own food at home and want to reduce their carbon footprint. This product fits into this brief well.

One of the problems that come with this project is that the snails have to be kept within the cage with no chance of escape. One of the issues is the laws in a particular country might not allow the production or domestic use of snails as they are believed to be pests or non-native species, which could severely harm the ecosystem, such as the Giant African Snail [3].

1.4 Objectives

The goal is to design and build a unique and innovative product that will help people to produce their own snails at home, whether for recreational purposes or consumption. The main objective is to bring families together and educate children about animals and food. Additionally the product provides two meals a year for a family of four members as the *Cornu aspersum* grows, one of the most commonly consumed breeds of snails, to the optimal size in six months [4].

This product should be sustainable and protecting the environment around us because since this is becoming more important because of the impact of climate change. The team is trying to reduce their environmental impact, by creating a low impact system and using low impact materials. The design needs to be simple but attractive.

The “EscarGO” must provide a way to produce food at home which allows for a reduction in food travel, since food can travel from all over the world before it ends up in the supermarket. This reduces the carbon footprint of the food that reaches the dinner table. It also provides a project which families can do together to bond.

The product should provide a mean for people to grow snails in an easy way**.** Temperature and humidity monitoring are also very important, so the sensors need to transmit all the relevant information to the controller, and allow full automation, with little human interaction.

1.5 Requirements

The Escargot Nursery has to meet several requirements:

- Attractive aesthetically pleasing design
- Set, display and control the internal temperature, light and humidity

Some other project requirements are:

1. Use sustainable materials
2. Use low cost hardware solutions
3. Stick to the budget (100.00 €)
4. Comply with the following European Union (EU) Directives:
    I. Machine Directive (2006/42/CE 2006-05-17);
    II. Electromagnetic Compatibility Directive (2004/108/EC 2004 12 15);
    III. Low Voltage Directive (2014/35/EU 2016-04-20);
    IV. Radio Equipment Directive (2014/53/EU 2014-04-16);
    V. Restriction of Hazardous Substances (ROHS) in Electrical and Electronic Equipment Directive (2002/95/EC 2003-01-27);

5. Mandatory adoption and use of the International System of Units (The NIST International Guide for the use of the International System of Units)
6. Use open source software and technologies.

1.6 Functional Tests

To evaluate the work, the team had to perform certain functional tests. These tests give an insight into whether the Escargot Nursery is ready to be released to the market.

1. **Temperature + Humidity Sensor:** Testing if the sensors work in the right way, it is possible to use ice to lower the temperature, and see if the temperature sensor works. To see if the humidity sensor works, it is possible to put rice around the sensor.
2. **Light Sensor:** Testing if the light sensors work, the lights need to be on, on time. It can be tested by covering the light sensor during day time and see if the lights go on.
3. **Cooling Fan**: Testing if the cooling fan works if the temperature increase above 25 °C. Putting a heating pack in the "EscarGO" and see if the cooling fan starts to cool the temperature in the enclosure.
4. **Electric Heater:** Testing if the heater works if the temperature decreases below 15 °C. Putting a cooling pack in the "EscarGO" and see if the electric heater starts to work.
5. **Liquid Crystal Display (LCD**): Testing if the LCD works, if it displayed the temperature, light and humidity.
6. **Sprinkler System and Water Tank:** Make sure that the sprinkler system for the soil moisture works fine, and that there are no leaks in the water tank.
7. **Snails:** Testing if the snails can live and grow in the Escargot Nursery. Put snails in the "EscarGO", care for them and see if they grow comfortable.

1.7 Project Planning

Every project needs to be planned carefully because a project plan gives an overview of all the tasks and deliverables that need to be completed. Having a good project plan and following it well allows the smooth running of the project, and keeps the project running on schedule. Table 1 shows the planning used for this project. In Chapter 3.3 there is a comprehensive project plan including a Gantt chart.

Table 1 - Project planning

Task	Responsible
Project Plan	
Task Allocation	All
Gantt Chart	Juliette
System Diagrams & Structural Drafts	Benjamin
System Schematics & Structural Drawings	Benjamin, John
Budget Planning	Ramon
Research	
Target	Benjamin
Sustainability Research	Lauri
Ethics Research	Juliette, John
Marketing Plan	Benjamin, Ramon
Research on Materials	All
Design	Benjamin
Building & Testing	
Building Prototype	All
Environment	Lauri
Programming	John
Testing	All
Delivery	
Report	All
Presentation	Juliette
Leaflet	Lauri
List of Materials & Components	John
Paper	John
Poster	Lauri
Manual	Ramon
Website	Ramon
Wiki	All
Video	Ramon
Product	All

1.8 Report Structure

This report follows a logical sequence, composed of eight chapters. Each of these chapters were divided into sections. The report was organized in such a way as to make the reasoning and explanations as clear as possible. The chapters are:

1. **Introduction:** Presentation of the team, of the reasoning and the motivation behind the choices, the main problems the team faced, and some requirements for the project.
2. **State of the Art:** Existing products, technological system and snail's life-cycle.
3. **Project Management:** Overview of how the team will manage the project, the management tools such as a Gantt chart, cost and time diagrams

4. **Marketing Plan:** Description of the current market situation and presentation of the marketing strategy.
5. **Eco-efficiency Measures for Sustainability:** Explanation of the choices to make the project as sustainable as possible.
6. **Ethical and Deontological Concerns:** Description of the ethical concerns the team has addressed.
7. **Project Development:** All of the technological choices, tests and results.
8. **Conclusions:** The conclusion the team has garnered from the project, any alternative solutions that may work.

State of the Art

2.1 Introduction

To get started, an explanation of Escargot Nursery is introduced. This chapter also comprises the description and comparison of five existing products meant for home use and four snail farm products which are already on the market, in order to draw conclusions and to take up relevant ideas that could be used in this product. This chapter adds information about the *Cornu aspersum* life-cycle and their optimal living conditions. In addition, there is an explanation of technologies used in "EscarGO" required for snail breeding.

2.2 Escargot Nursery

An Escargot Nursery is a product designed to grow snails, providing them with a comfortable living environment. The Nursery needs to be able to host an amount of snails with ample space, along with soil coverage and other things they may need to grow correctly (see Section 2.4 Escargot Research).

"EscarGO" was the commercial name chosen for the indoor snail farm the team was developing during the EPS program (see Chapter 4. Marketing Plan).

2.3 Existing Products

2.3.1 Products for Home Use

There were some existing products similar to this project as shown in see Table 2, meant for home use. These products were competitors of the "EscarGO" project, since they were designed for domestic use. There was only one direct competitor also designed for snails. Due to the lack of products designed especially for snails, people were using products designed for other pets and because of this, the team decided to study also some of those alternatives. Most of them were very basic without any technology. The "EscarGO" had to push the boundary and not to be only something technologically better and more advanced than what was already on the market, but also something that was aesthetically pleasing.

Table 2 - Products for home use

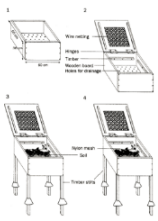
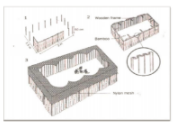
Name	Product	Price (€)	Animals	Technology	Size (cm)	Other specifications
Grow your own escargots by S'cargo [5]		46	Snails	No technology	30 x 30 x 30	Bell shaped propagator and saucer as attractive snail farmhouse with sterile bedding. Instructions to help you keep the snails healthy and growing. Some special dry snail food to give them a good start.
Aqueon® Glass Aquarium [6]		14	Fish	No technology	31 x 16 x 20	Material: glass, features: no assembly required
Zoo Med™ ReptiHabitat® Bearded Dragon 40 Gallon Terrarium Kit [7]		172	Reptiles	A custom dual screen top provides easy access to the habitat and keeps your reptile safely inside. Including UV lighting. A dual temperature/humidity gauge to maintain temperature.	91 x 45 x 45	Lamp bedding, food samples
All Living Things® Hermit Crab Habitat Kit [8]		30	Crabs	No technology	30 x 30 x 25	Kit includes a soaking dish, seashell palm tree, sponge, sprayer, resin coconut hut and instruction manual. Cage is made from plastic and metal for durability
biOrb® FLOW 4 Gallon LED Aquarium [9]		90	Fish	biOrb 12V Transformer. biOrb Air Pump. Airstone. Standard LED light unit.	21 x 30 x 31	Ceramic Media 450 g. Filter cartridge. Water Conditioner 5 ml. Beneficial Bacteria liquid 5 ml. Material(s): Acrylic Aquarium

The team decided to choose a concept similar to the design of an aquarium, because the product needs to be simple yet attractive. The use of transparent sides would allow the users to see and enjoy the growth of their snails. In order to distinguish the product from the competitors, the team decided to include several technological aspects in the design, like lighting, temperature and humidity control.

2.3.2 Snail Farm Products

There were already existing snail farms on the market, using different technologies to farm them. Since most of the home use competitors of the "EscarGO" were not designed for snails, a comparison between bigger snail farming solutions was made. The team considered this comparison relevant to the development of the product, due to the lack of techniques used in the products for domestic use. These technologies were dedicated to raise a much larger number of snails, whereas this project is designed for a much smaller number and for domestic use.

Table 3 - Snail farm products

Name	Picture	Size (m)	Description	Advantages/Disadvantages
Hutch Box [10]		Not given	This system is a square or a rectangular box. The floor is filled with sieved black soil to a depth of 18 - 25 cm. In addition, at the bottom of the box, there are holes in order to evacuate the excess water. The lid is in wood or steel frame lids with chicken wire and nylon Mesh. This system is particularly adapted to semi-intensive breeding.	Advantage: easy to move, to feed the animals and to take care of them. Disadvantage: the cost of the system.
Trench Pens [11]		0.6 × 0.6 to 1 × 1	This system is directly inserted into the ground. In addition, the wall consist of sandcrete blocks or mud bricks in either case.	Disadvantage: need to kneel to take care of the animals.
Mini-Paddock Pens [12][13]		The walls should be 50 cm high and be dug at least 20 cm into the ground	This system is a small square, usually within a larger fenced area. Built of bamboo, nylon mesh, or timber, chicken wire and nylon mesh.	Advantage: sustainable system because of the materials. Disadvantage: the snails are less protect against predators than the previous systems.
Free Range Pens [14]		10 × 20	Large system. The vertical fence must be extended inwards, to prevent snails from escaping.	Advantage: mimics the natural environment of the snails so the life conditions are optimal. Disadvantage: it required a lot of space and it may be expensive.

Unlike "EscarGO", the systems above were for outdoors and not for indoor use. These, despite following a very different approach to a home product, they had some ideas the team could look up to.

These do not include any control system on humidity or temperature. They were rather big and expensive and the ease of use seemed not to be one of their priorities. On the other hand, these systems were sustainable and recreated a natural place, and made a clever use of technologies like the curtain system.

The team agreed on the need for an environmental control system included in the product, but also added the idea of using a nylon mesh to prevent snails from going into the heating system and applying the curtain system (see Subsection 2.5.1 The Curtain System). Additionally, a natural environment had to be recreated.

To conclude, the purpose of these large scale farming technology was only to raise snails for food production. The team realized that the "EscarGO" could also have some different purposes such as promoting sustainability (see Chapter 5. Eco-efficiency Measures for Sustainability), ethics (see

Chapter 6. Ethical and Deontological Concerns) and family values, as well as having a much more attractive design.

2.4 Escargot Research

The *Helix pomatia* is the most consumed snail. It is a wild snail that does not bear the promiscuity of intensive farming. Moreover, it takes one year to grow. The team decided to use the breed *Cornu aspersum* because this is one of the most common snail breeds and the most consumed snail in France. This breed is ready for consumption after six months [15].

2.4.1 Life-Cycle

The *Cornu aspersum* belongs to the class *Gastropoda*, they prefer an undisturbed habitat with adequate high moisture and good food supply. The snail is hermaphrodite so a single snail may have male and female reproductive organs. The age of sexual maturity is reached between its first and second year of life and the breeding season is at the beginning of summer. Prior to reproduction, the *Cornu aspersum* perform courtship behaviors before mating, like reciprocal tactile contact. Just before mating, the snails shoot structures called “love darts”, the use of love darts is a form of sexual selection. The whole mating process takes 4 to 12 hours [16].

After mating, both snails can deliver a set of eggs, which increases the chance of survival. When fertilization occurs, eggs develop. Laying eggs happens about 3-6 days after the copulation. The snails will produce around 80-86 spherical pearly white eggs into crevices in the topsoil or sheltered under stones. Before laying their eggs, the snails build a nest digging a hole in the soil, between vegetation or on the ground. The snail digs with the aid of its ventral foot until obtaining a hole with a depth of 2.5 to 4 cm. The size of the egg is around 4 mm. The *Cornu aspersum* breed can produce up to six batches of eggs in a single year, each new-born will take one to two years to mature depending on the weather and region [17] [18].

Under favorable conditions, eggs hatch after approximately two weeks. The shells of hatch-lings are fragile and translucent and snails emerge with a soft shell. They therefore need to feed themselves calcium by consuming the remains of their egg and even other eggs that have not yet hatched. Eggs are particularly sensitive to dehydration and cold temperatures. The baby snails have, in addition to a soft shell, an almost transparent body that acquires strength and colour as it grows. The first colour they usually have is bluish but then turns to brown. They grow remarkably fast, but very few reach one year of age. Shells continue to grow with the snail over the course of its life, and the rings it has are indicators of their age. A single snail can live 2 to 7 years [19] [20].

2.4.2 Living Conditions

Cornu aspersum are herbivores, a polyphagous grazer with a wide spectrum diet. It finds its food in fruit, trees, herbs, cereals, flowers and bark of trees but occasionally, they add to their diet organic matter in decomposition. The *Cornu aspersum* is very sensitive to temperature, light intensity and humidity.

Feeding requirements

The snails move through all of the terrarium, to get food. Snails tend to keep company when feeding, and are generally social creatures. Sometimes several snails feed together on one piece of food, even if there are other food sources available. The snails will prefer to eat plants rich in calcium and reject plants rich in metals like zinc and nickel. There are herbs and vegetables that snails almost always want to eat, like cucumber, but even these lose their attraction if they are not given a change in diet, just like any other creature, they tire of the same food source and need a varied diet. Other

vegetables are only taken at certain times of the year. It is also possible to feed the snails with leaves from vegetables, like cabbage, turnip leaves or leaves from carrots and radishes. Kitchen waste from vegetables can be fed as well, for example aubergine peel, tomato slices and cucumber peel [21] [22].

Feeding activity is essentially nocturnal and occurs only when relative humidity is sufficient, around 80 %. The snails don't eat at random, snails use distance chemoreception and taste to discover their choices, feeding preferences being influenced by the biochemical composition of the plants and especially by secondary metabolites [23].

Environment requirements

Activity of the snails necessitates a temperature of between 15 and 25 °C and a humidity between 75 and 90 %. The optimal temperature is 21 °C, if the temperature comes below 7 °C, snails hibernate. If conditions are unfavorable, adult snails are able to remain asleep for a few months. They cannot withstand long periods of frost. Micro- habitats are variable, but the snails preferably choose habitats with greater light intensity and structural complexity. The *Cornu aspersum* lives in coastal dunes, grove and bush land, between rocks. The snail isn't dependent on a limestone underground, it needs habitats with hiding places in rock and wall crevices or below deep vegetation cover [24].

The soil is a major part of the habitat because good soil allows the snails to grow well. The snails dig into the soil to lay their eggs, so the soil should not contain too much sand or clay. The organic matter needs to be 20-40 % because this enhances cation exchange capacity of calcium which stimulates growth. In the soil there needs to be adequate calcium, the primary content of their shells. A good option to introduce calcium is to add ground limestone at a suggested concentration of 4.5 kg per 100 square feet (9.3 m^2). Snails need dampness. A soil moisture content of 80 % is recommended. In the hours of darkness, air humidity above 80 % will promote the activity and growth of the snails. The soil needs to be changed every three months [25] [26].

Climate

The team focus on France, and in most of France there is a Cs climate, based on the Köppen climate system. A Cs climate means "Mediterranean climate", a warm temperature climate with dry winters. For the *Cornu aspersum* this is the preferred climate [27].

Light requirements

Light is very important to the snails, the light influences their behavior. To have an optimal reproduction and breeding process, this factor needs to be controlled. The *Cornu aspersum* needs 16 hours of light. A simple timing device can be set for the time lengths. A system that can be used is watertight fluorescent tubes, they have the capacity to deliver a 40 W power output and spaces at distances. It will acquire a diffusion of light within the reproductive environment [28] [29].

Space requirements

Population density is also very important, too many snails affects the successful growth and breeding capacity of snails. Snails tend not to breed when packed too densely or when the slime accumulates too much. The slime suppresses the reproduction of the snails. The snails grow slower when they are in a densely populated area. Another disadvantage of high density is the high rates of parasitism and transmission of diseases. An advised density for *Cornu aspersum* is 1-1.5 kg per m^2. An adult snail is around 10 grams, so it is possible to put 100 snails on one square meter [30] [31].

2.5 Escargot Nursery Structure Requirements

In order to host 50 snails in optimal conditions the team had to provide the snails with enough (half of a square meter) space as stated above (see Subsection 2.4.2 Living Conditions - Space Requirements). To increase their living surface while keeping a product's size that would fit its home use, the team would apply a curtain system (see the following section). It was also important to keep the volume inside the box as low as possible. That way the "EscarGO" would require sustainable amount of power to keep the humidity and temperature at the appropriate intervals.

The materials should also stand the test of time the way the competitor's product do (see Section 2.3 Existing Products); Polypropylene (PP) plastic was the material the team decided to use to achieve this.

2.5.1 The Curtain System

A new method for snail farming is the curtain system. The curtains hang in the box and the snails can climb up the curtains. With the curtains, it is easier to keep more snails, because of the larger surface area for the snails to live on [32].

The use of the curtains have many more advantages, the feces of the snails falls down to the ground. This method has no impact on the life cycle of the *Cornu aspersum*. They do not need to be placed in horizontal position, they can also move, mate and sleep in vertical position. It is also easier to make daily inspections because the user has visible contact with the snails without touching them [33].

The curtains can be made of nylon. This is a textile and is easy to clean.

2.6 Advantages and Disadvantages of the Escargot Nursery

Based on the state of the art study, the team realised some of the product's advantages compared to the existing technologies. As per the "space requirements" section, it is possible to put 100 snails on one square meter. This is why the team has chosen the dimensions 400 mm x 300 mm x 350 mm with a curtain system, so the project takes up less space. With the curtain system that has been chosen there can be a larger concentration of snails in a smaller area.

Another advantage of the "EscarGO" was the inclusion of the environmental control system, that provides a comfortable ambient environment, with little input from the end user. The team decided the systems of heating and cooling needed to be automatic, so the users do not need to interact with the system much, and do not need to be home at all times such as they do with other pets.

Product's design was also an advantage compared to other similar products. The product is designed to be sat in a home, such as in a living room or kitchen, so the product needed to be attractive enough that it would blend well with other pieces of furniture.

On the other hand, compared with existing technologies, the "EscarGO" seemed to have some disadvantages. Despite it being useful for the breeding of snails, the addition of an environmental control system to the product made it need a power source, while the competitors do not need any.

The cleaning of the "EscarGO" would be slightly more difficult than the other products as a result of the inclusion of the curtain system. Despite being easier to clean, the curtains may need to be cleaned more often than other parts of the snail enclosure.

2.7 Conclusion

To conclude, this state of the art proved that the product must have dimensions of 400 mm x 300 mm x 350 mm in order to breed 50 snails.

Moreover, the study showed that this particular breed of snails is sensitive to humidity, temperature and light. Thus, the team has decided to add an environmental control system, including light, humidity and temperature control to the “EscarGO” so the user did not need to pay attention to the snails that often because they felt the need to make the product more user-friendly.

Based on the snail farm products, the team decided to adopt the curtain system to increase the usability of the product because the surface area will be larger. The use of nylon is useful to separate the snails from the heating system.

Project Management

3.1 Introduction

According to its definition, a project is above all unique. So, there is no pre-established organization for its realization. Thus, project management is the set of tools, techniques and methods that enable the project manager and his or her team to lead, coordinate and harmonize the various tasks carried out within the framework of the project. The aim of the project management is to respect all the relative imperatives related to the projects like time, delays, costs, quality risks. In order to make our project successful, the team has run the following project management study, including:

- Scope
- Time
- Cost
- Quality
- People
- Communication
- Risk
- Procurement
- Stakeholders Management

3.2 Scope

The Work Breakdown Structure (WBS) is an important part of Project Management. The team has recorded all tasks and divided them into categories. By doing this, the team could make the WBS as shown in Figure 2.

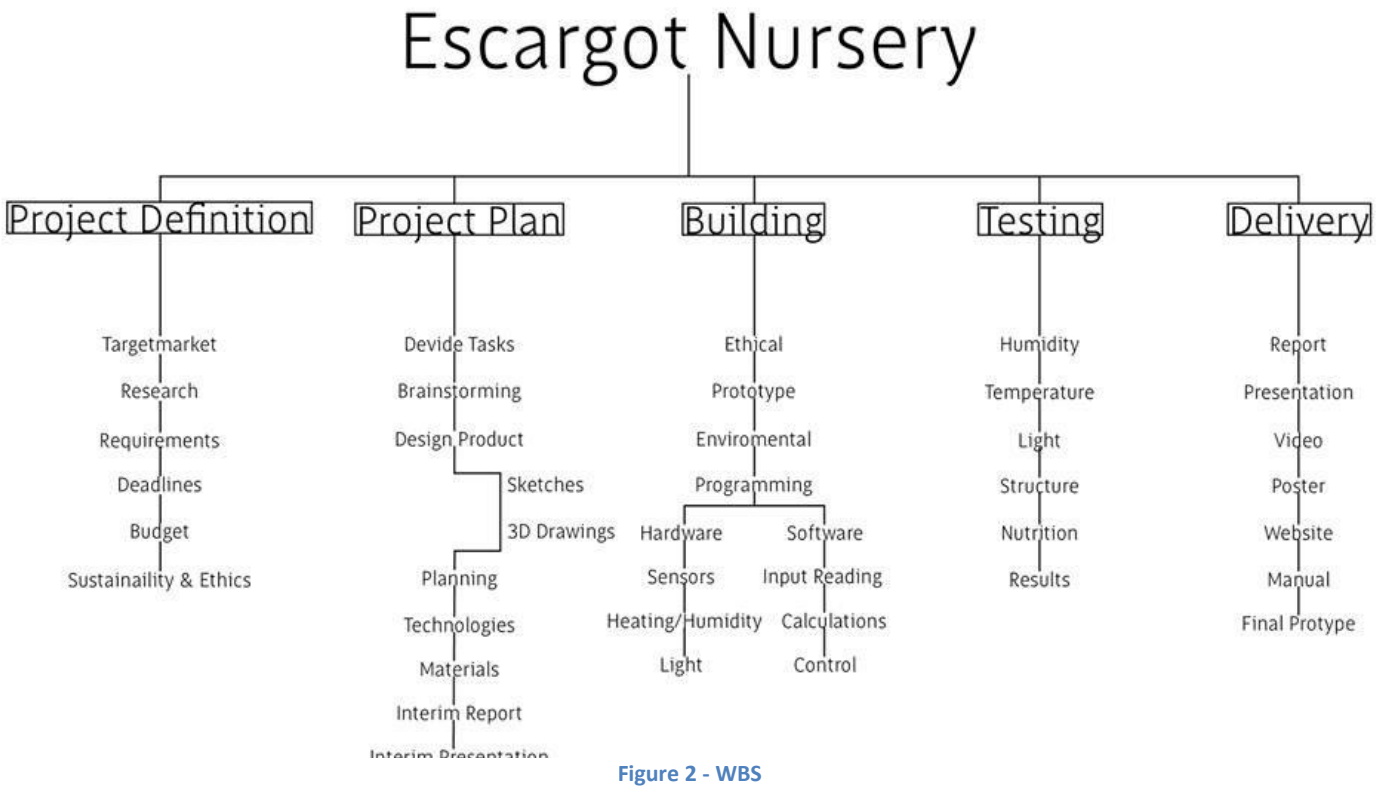


Figure 2 - WBS

3.3 Time

The team established the planning of the project using a Gantt chart (see Figure 3).

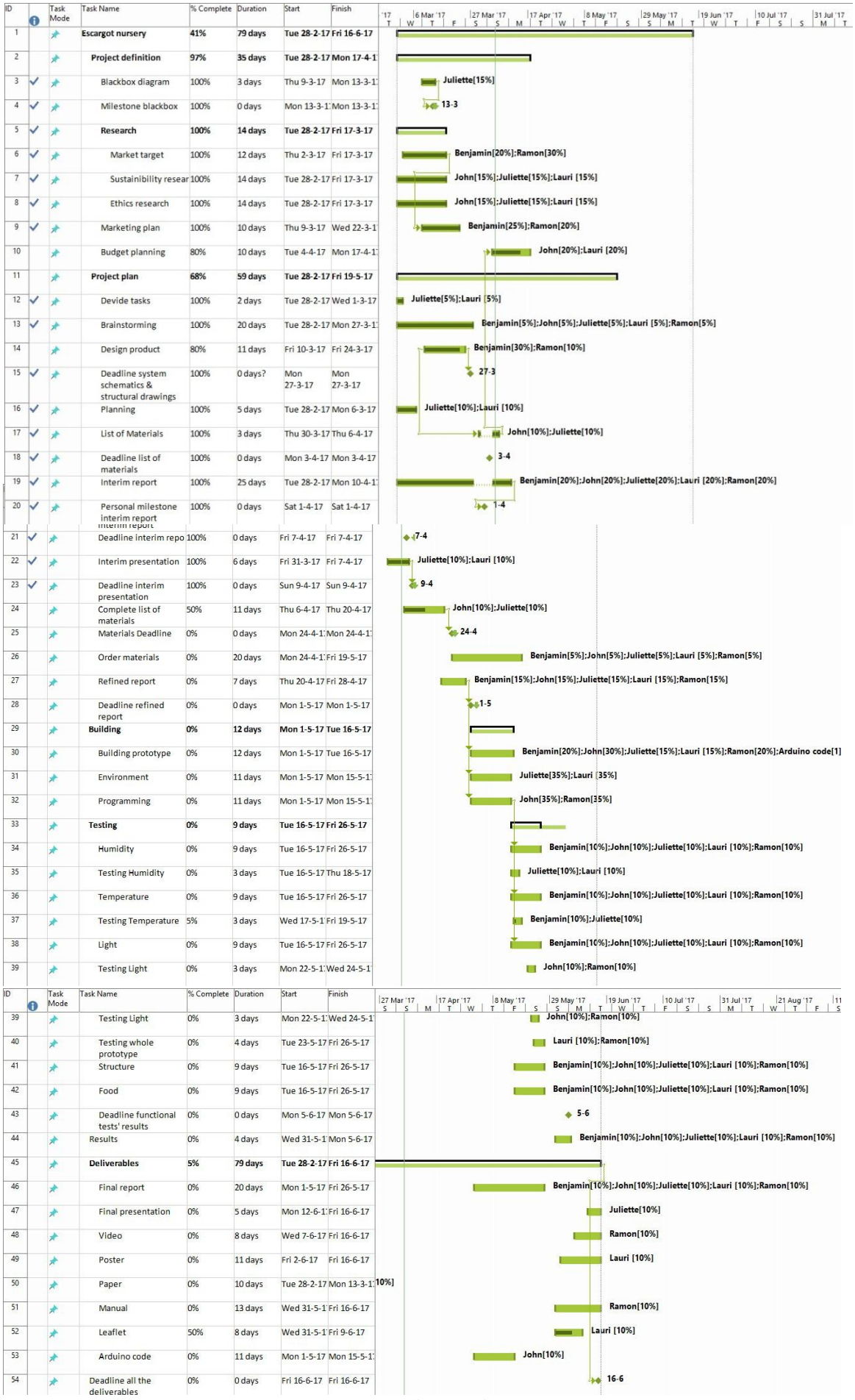


Figure 3 - The gant chartt

In Table 4 there is a summary of all the deliverables and deadlines of the project.

Table 4 - Deliverables and deadlines

Deliverable	Deadline
Gantt Chart	2017-03-06
“Blackbox” System Diagrams & Structural Drafts	2017-03-13
System Schematics & Structural Drawings	2017-03-27
List of Materials (What & Quantity)	2017-04-03
Upload Interim Report & Presentation	2017-04-09
Complete List of Materials (local providers & price)	2017-04-24
Interim Presentation	2017-04-20
Upload Refined Interim Report	2017-05-02
Upload Functional Tests' Results	2017-06-05
Upload Final Report, Presentation, Video, Paper, Poster and Manual	2017-06-18
Final Presentation, Individual Discussion and Assessment	2017-06-22
Hand in a CD with the Corrected Deliverables	2017-06-26
Hand in the Prototype and User Manual to the Client	2017-06-29
Receive the EPS@ISEP Certificate	2017-06-29

3.4 Cost

When managing a project, it is essential to monitor the costs to remain within budget. The costs relating to a project are the costs of the materials used and also the cost of the labor or the workforce (see Figure 4).

Cost management can be done through a pre-established process:

- First, the **plan for cost management** needs to be produced. This means that all the internal procedures must be established so the budget can be assigned in the correct areas.
- Next a **cost estimation** will need to be done to evaluate the cost of materials.
- Then the **budget can be determined**.
- During the project the team will need to **manage costs**. This step consists of updating project costs and managing changes affecting the base cost reference.

As the budget has been set by ISEP, which is 100.00 € to build the prototype, the principal requirement in regards to cost during this project is to manage the costs and stay within the budget.

The material resources for building the prototype are showed in Table 5.

Table 5 - Materials resources

Product	Quantity	Cost (€)
16×2 I2C LCD Display	1	8.50
Fan 12V PC Fan	1	-
Arduino Uno	1	-
Luminosity Sensor Breakout - TSL2561	1	6.50
DHT22	1	9.80
Resistors	4	0.20
NPN Transistor	2	0.98
Solenoid 12 V	1	9.40
Capacitors	4	0.60
LED Strip	3	8.88
Wiring	2	0.50
Arduino Power Supply AC/DC 230 VAC/12 V 2 A	1	7.50
ULN2003 Stepper Motor Driver Board	1	-
PVC Sheets	2 sheets of 100 cm x 50 cm	21.58
Polymethylmethacrylate (PMMA)	0.137 m^2	-
Plastico autocolante black and white	4	5.72
Clear plastic tube	1.5 meters	-
Nylon Mesh	1	-
UHU Allplast	1	4.00
Shipping costs	-	8.22
Total		**95.53**

Thus, the total cost of the materials is 95.53 €

The work resources for building the prototype are shown figure 4.

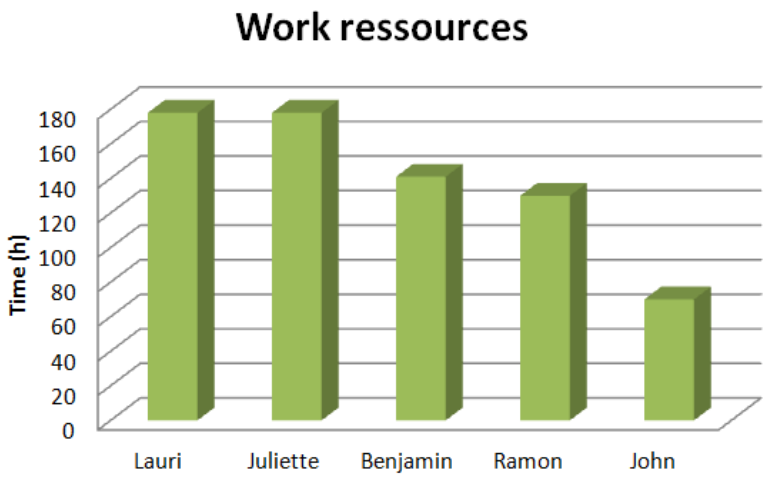


Figure 4 - Work resources

3.5 Quality

According to standard ISO 8402-1986 quality is “the totality of features and characteristics of a product or service that bears its ability to satisfy stated or implied needs.” The quality of a product is a pillar of the success of any business. If the product is of good quality, consumers will be more inclined to buy products from the company again, i.e. Brand Loyalty, but also if people experience a high quality product and service they are more likely to recommend the product to their friends and family, which has the added bonus of being free advertisement. Quality is the key indicator of the success of the project, but it’s also an obligation since companies must comply with a certain number of standards in terms of quality such as ISO 9000. With such high importance being put on quality, most big companies have a department dedicated to quality management [34].

Quality management is a process that starts at the very beginning of a product's design. When designing a product, the product designers and engineers make sure that the materials that are used are fit for purpose, for example a hairdryer cannot be made from plastic that can melt easily. Using quality management techniques such as acceptance sampling, engineers can determine if the materials that are used within the product are of satisfactory standards. For instance if a company is using a particular brand of bolts, they will test 3 % of the batch, depending on batch size, and if the bolts are not accepted then the bolts will be sent back to the supplier [35].

In the “EscarGO” project the materials will be purchased from reputable sources, and non-destructive tests will be conducted before use of the prototype. Software will be used to build 3D models, and also for the electronics. Using open source software, the design of the electronics will be carried out and simulations will be undertaken before the electronic components are built and assembled.

Testing the prototype is an important part of the quality, the team wants to deliver a product of quality. Figure 5 shows that all the parts that needs to be tested, sensor of humidity, temperature and light will be tested one by one. This is important because when a test fails, the team knows directly what the reason is. After testing the parts one by one, the whole prototype will be tested.

33	Testing	0%	9 days	Tue 16-5-17	Fri 26-5-17
34	Humidity	0%	9 days	Tue 16-5-17	Fri 26-5-17
35	Testing Humidity	0%	3 days	Tue 16-5-17	Thu 18-5-17
36	Temperature	0%	9 days	Tue 16-5-17	Fri 26-5-17
37	Testing Temperature	5%	3 days	Wed 17-5-17	Fri 19-5-17
38	Light	0%	9 days	Tue 16-5-17	Fri 26-5-17
39	Testing Light	0%	3 days	Mon 22-5-17	Wed 24-5-17
40	Testing whole prototype	0%	4 days	Tue 23-5-17	Fri 26-5-17

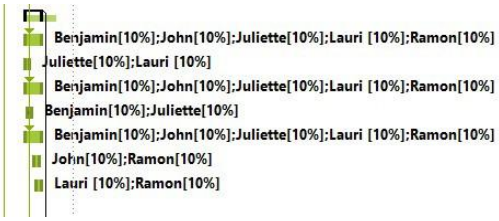


Figure 5 - Prototype testing

Quality needs to be ensured for the duration of the life of the product, by providing after sales service in case of any problems and a warranty. The after sales service is also a measure of the success of the “EscarGO” society because if customer problems are solved quickly, they will be more satisfied.

3.6 People

Human resource management or people management is an important part of project planning. It includes the activities and processes, in which each team member is involved. The tasks are assigned to a team member, but every team member assists the others with input in team meetings. The tasks are assigned on a skills basis. The team consists of so many differing backgrounds and specialism which brings something different to the team (see the following section).

3.6.1 RAM

The group used a Responsibility Assignment Matrix (RAM) (see Table 6) as an essential part of their project planning.

Table 6 - RAM

Task	Benjamin	John	Juliette	Lauri	Ramon	Supervisors
Gantt Chart				A	R	A, C
BlackBox		A	R			A, C
Structural Drafts	R	A				A, C
State of the Art	R		R	R	R	A, C
Eco-effiency Measures for Sustainability		R	R	R	A	A, C
Ethical and Deontological Concerns		A	R	R		A, C
System Schematics	A	R				A, C
Structural Drawings	R				A	A, C
Cardboard Model	R	R	R	R	R	A, C
Marketing Plan	R		A		R	A, C
Project Management	A		R	R		A, C
List of Materials		R		A	I	A, C
Interim Report	R		R	R	R	A, C
Interim Presentation	R	A	R	R	R	A, C
Building	R	R		A	R	A, C
Programming	A	R	I		T	A, C
Testing	R	T	T	T	T	A, C
Website		A	I		R	A, C
Video			R	A	R	A, C
Leaflet	R		A	R	R	A, C
Paper	R	R			A	A, C
Poster		A	R	R		A, C
Manual	I			A	R	A, C
Final Report	R	R	R	R	R	A, C
Final Presentation	R	R	R	R	R	A, C

- R: Responsible
- A: Approval
- C: Consultant
- I: Informant
- T: Tester

3.7 Communications

In order to achieve the best possible project, it is essential to ensure good communication within the group. Indeed, since everyone comes from different countries, with different languages there may be problems with comprehension. Thus, it is very important to be clear, rigorous and to repeat the explanations if necessary.

Moreover, as everybody comes from different specialties, all having differing knowledge bases, that is why it is very important to communicate in order to develop ideas, and consider perspectives from fresh eyes. In addition, communication is essential in order to resolve any problem that may arise within the group. To work in good conditions it is important that there is a good atmosphere without underlying problems.

These days there are many means of online communication that can be used to improve communication when the team not together at school.

First of all, when the team wanted to organize meetings, ask their colleges for help or divide the tasks, the team can use the Messenger application in Facebook. Messenger is very useful when several people want to work on the wiki because, since it is no possible to work at the same time on it, the team had to make sure that nobody was working on it to avoid two people working at the same time. The team also used both Dropbox and Google Drive so that everyone can upload their work to a shared online platform and furthermore, different people can work at the same time on the same document on Google Docs. The fact that everyone had access to everything, allowed the whole team to have a view on the whole project. So, everyone could express their opinion on the work accomplished.

The Figure 6 represents the distribution of the various means of communication mentioned above. Oral communication represents half the diagram because the team spent a lot of time in school working together. Google Drive was used more than Dropbox because it allowed the team to write in a shared document, several at the same time and that is more convenient. The team also used a lot of Messenger because it allowed them to talk in real time even if they are not together. At the beginning WhatsApp was used but since it was not practical for everyone, it was abandoned as a means of communication.

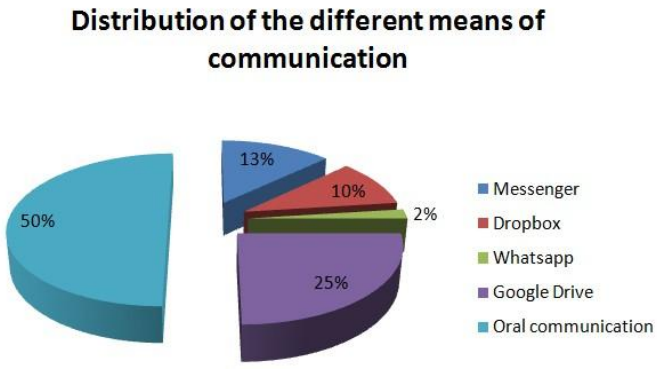


Figure 6 - Distribution of the different means of communication (4)

Table 7 shows the Communication Matrix.

Table 7 - Communication matrix

What	Why	Who	When	To whom
Deliverables	To develop the project	The team	On the date of the deadline	The supervisors and the team
Weekly supervisor meetings	To discuss about the progress of the project	The team	Every Thursday	The Supervisors
Agenda	To inform supervisors about the topics of the meeting	Team member who is responsible for the agenda that week	Before every Thursday	
Brainstorming sessions	To discuss about the different ideas, project planning	The team	Multiple times a week	Other team members

3.8 Risk

Risk management is an ongoing process that identifies the risks involved with each task and provides a solution to mitigate risk to the health and safety of the individual or group that are involved in the task. In this project, to avoid risk, the team decided to identify and analyze all the potential risks that may arise and think about possible solutions.

Risk management includes the following six processes:

1. Establish objective
2. Identify risks
3. Assess impacts
4. Assess risks
5. Risk control
6. Monitoring

Table 8 shows the risk management.

Table 8 - Risk management

Risk	Cause	Effect	Trigger	Response	Impact	Probability	Rank
Broken Components	Poor Quality of the Components	It will be not Possible to Build a Fully Working Prototype of the Product	Prototype Testing Failure	Quality Check of Components on Arrival (Mitigate)	High	MediumLow	3
Not Meeting the Interim Deadlines	Bad Planning	Lower Grade	Teachers and Coordinators Bad Input	Good planning. Weekly Tasks. Communication (Avoid)	MediumLow	Low	7
Illness of the Team Members	Bacteria, Virus or a Work Accident	Slowing Down the Work Rate and Quality	Team Member Feels Sick	Follow a Healthy Lifestyle (Accept and Transfer)	Medium	Low	4
Faulty Components Delivered	Components Broken Because of Bad Protection While Transporting	Cannot build the prototype before the deadline	Material Delivery Check	Check for Shop's Reviews Before Buying (Avoid)	High	Low	5
Tests Fail	Bad or Wrong Components	A Non Working Prototype	Prototype Testing	Test All the Components One by One, Before Testing the Entire Prototype (Accept and Mitigate)	High	MediumLow	2
Inappropriate Material Selection	Bad Materials Research	Impossible to Construct the Designed Model	Prototype Testing	Ask Teachers and Supervisors for Advice (Mitigate and Transfer)	High	Medium	1
Conflict with Stakeholders	Bad Communication	Slowing Down the Development of the Project	Communication With the Stakeholders	Implement Comunication Plan and Measure and Meet Stakeholders Expectations (Avoid)	Medium	Low	6

3.9 Procurement

Procurement is the process of acquiring and buying products, goods or services from external suppliers. The process is used to make sure that the team receives products at the best possible price but also quality compared with other external suppliers, i.e. the best value.

For this project, the team was only allowed to choose suppliers from Portugal, which means that there are more restrictions on what can be used in the final product. In some countries the components that are needed to build the prototype, are cheaper, better quality than in Portugal and in some cases cannot be found in Portugal.

3.10 Stakeholders Management

Stakeholder management is an important part to make the project successful. A stakeholder is a person that has influence over the team or is influenced by the team, whether that be an investor in the business, or someone who's livelihood is tied up in the business. A part of the stakeholders management could be, making sure that the team is meeting the deadlines, making a product of good quality and that the product is going to make money.

In this project there are different stakeholders with different expectations. The stakeholders in this project are the supervisors, the team members and the university. Table 9 shows the stakeholders.

Table 9 - Stakeholders management

Who	Role	Expectations	Power	Influence
The team	The team develop the project	Learn new skills and develop a working product	High	High
Supervisors	Supervise the project	Receive an interesting project and a working product	High	High
Teachers	Give information about different subjects	Gain knowledge that is necessary and receive an interesting project	Low	Medium
Suppliers	Provide materials	Sell the materials	Low	Low
Consumers	Buy the product	Receive a good working product	Low	Medium
ISEP	Sponsor	Receive interesting projects	High	Low

The graph in Figure 7 gives another view of the influence of the stakeholders.

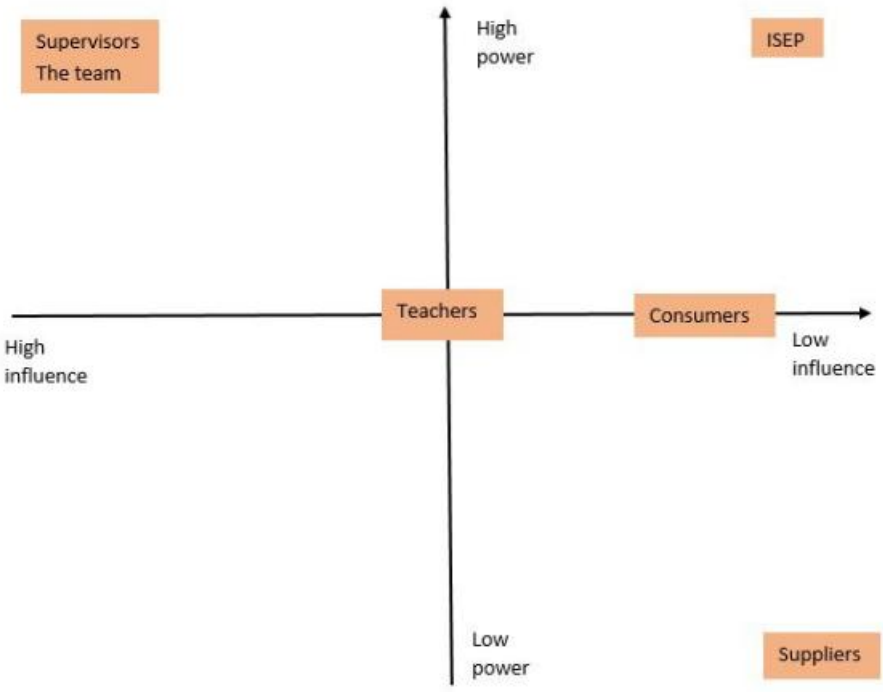


Figure 7 - Stakeholders management graph (5)

3.11 Conclusion

To conclude this chapter, project management is one of the main aspects of the realisation of a project. Project management is a useful and important tool for the team members to identify all the tasks and time limits, to guide the cost and the budget, to measure the risks and to analyse the responsibilities of the people that are involved.

The main objective was to organize the project planning in an efficient manner. The project planning ensured each team member was clear of their responsibilities, identified the time limit and the tasks that needed to be done. The team made a Gantt Chart with all the time limits and tasks highlighted for each team member. With using the Gantt Chart, the team was up to date with all the tasks and time limits.

In the next chapter the team introduces the marketing aspect of “EscarGO”.

Marketing Plan

4.1 Introduction

Marketing is the set of actions undertaken to encourage people to buy a product or service. In this chapter there will be explanation about the market situation analysis, potential customers, segmentation and target market, strategies, product, price and promotion. The analysis starts from a macro level, going closer and closer to the own business. All levels have an impact on the activities and decision making of the company. Taking into consideration this data, the team will provide a suitable marketing plan for the product, explaining the necessary actions to achieve the marketing objectives covering the first year of the product launch.

4.2 Market Analysis

4.2.1 Macro Environment

The first step of the market analysis is a Macro Environment Analysis where the team tries to define possible opportunities and threats within the industry. These factors are external and uncontrollable by the team, yet they affect the performance and decision-making. The macro environment can be divided using the Political, Environmental, Social, Technological, Legal and Economic (PESTLE) model (see Figure 8).

Figure 8 - PESTLE [36]

Political/Legal

The political/legal factor defines to which extent politicians and the government and legal directives have influence on the industry. In the case of the Escargot Nursery, many governments support the idea of home production of food. [97] Also food education is a big topic, as big budgets are spent for healthy students. The Escargot Nursery could be used at home, but also for educational purposes in school.

Since this product uses living animals and these may be used for cooking at home, care needs to be taken about norms related to living creatures as well as nutrition and health laws. In order to release the "EscarGO", the team had to comply with E.U. legislation related to selling consumer goods in Europe (see DIRECTIVE 1999/44/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 May 1999) and product safety (see DIRECTIVE 2001/95/EC OF THE EUROPEAN PARLIAMENT AND OF

THE COUNCIL of 3 December 2001), but also food contact materials regulation (see Food Contact Materials - Regulation (EC) 1935/2004).

Environmental

The carbon footprint of the food is reduced in different kinds of ways. First of all it eliminates the food transportation from the other side of the world to the dinner table. Moreover mollusks and insects are used instead of meat as protein source, because meat production spills enormous amounts of fresh water and energy. Special attention is needed when choosing materials for the product. Instead of using production techniques for assembly of a product with a linear life cycle (production to landfill), circular life cycle should be considered.

Social

The social environment analysis defines cultural, demographical and behavioral trends, values and norms. Social media is becoming increasingly important in our culture [98]. That is why the project needs to implement social media in when it comes to marketing but also improve the real life contact between the users. It has to connect the different members of the family in order to improve social cohesion. Other social trends like going back to the basics, growing your own food and food education work in favour of the home Escargot Nursery.

Technological

Technological trends focus on the change in use of technology. Automation of some processes like temperature and humidity control make maintenance much easier. Internet Of Things (IOT) is already used in a lot of products and its use is only expanding. Therefore it would be a possibility to implement it in the Escargot Nursery future development as it also improves social connection. Technology is needed to improve and optimize the life cycle of the snails (heating/humidity/light).

Economic

Economic factors describe elements of the economy that have an effect on the industry and the company itself. These factors can be the price of energy, inflation, income etc. Escargots are expensive as food and with the Escargot Nursery customers can produce the snails themselves for home use or for (small) commercial interests.

4.2.2 Micro Environment

The micro environment are factors outside and not controlled by the team, yet they are in the immediate area of the team, affect directly the decision-making and performance. These elements are: customers, suppliers, intermediaries, public, and competitors.

Customers

The consumers are the intended target group for which the Escargot Nursery is designed. The needs of the customers have to identified, implied, satisfied an anticipated. It's important not only to sell the product, but also realize a long lasting customer relationship.

There are two different customers:

- The home user: the home user wants a product to grow snails for the purpose of eating them. Snails are a delicacy and are therefore not cheap.
- The educational user: the educational user focuses more on the development of the snails than on using them for food.

Suppliers

Suppliers provide the necessary resources that enable the company to make its products or services. The Escargot Nursery contains a lot of electrical parts like sensors, user interface, controller, heating and cooling device. There's also material needed to build the casing and the interior of the terrarium. All of these components should be bought in Portugal. To get the best parts and materials at the lowest prices, extensive research is needed.

Intermediaries

Intermediaries stand in between the customers and the company. They middlemen who promote, distribute and sell the product to the users. The Escargot Nursery will be sold Business to Business (B2B), and mainly also as Business to Consumer (B2C) as well. Because the nursery is a relatively new product, potential customers will not know of its existence. The B2B market gives the company a wide reach and product visibility. In addition to the B2B market, the company can sell directly from the website. These days, internet selling is a standard practice and done by almost all companies.

Public

The public is a broader and more general term than targeted customer, but they also have actual or potential interests in the product. While designing, making and selling the Escargot Nursery the team have to take into account some groups beside the intended consumer. One of these groups are the animal protection groups like People for the Ethical Treatment of Animals (PETA). The product has to be of decent quality so consumer protection groups will not protest. Another group to take in account is the media. They have great power to make or to break the sales of a product.

Competitors

Competitors also influence the actions made by the company, because they offer similar products or services. There is a difference between direct and indirect competitors.

The one and only direct competitor is the GROW YOUR OWN ESCARGOTS by S'cargo (see Subsection 2.3.1 Products for Home Use). S'cargo is a company owned by Helen and Rachel Howard who are artisan food producers. The product has a bell shaped propagator and saucer. Additionally there is a detailed care instruction to help keeping the snails healthy and growing. Before the consumer can start, he has to send a card to receive the escargots and dry food at home. The price 35 £ Sterling and the dimensions are approximately 29 cm x 28 cm x 29 cm.
The advantage of this product is the low price and small dimensions. There is no technology included in the product which makes it easy to use and not energy consumable. Disadvantages are the high amount of attention needed to grow the snails. The dimensions are small, so only a small amount of snails can be kept inside. Temperature and humidity is not controlled so the snails can die without the right care. Carbon monoxide poisoning is also a problem as the whole structure is sealed

Indirect competitors make product that are similar to the snail farm, but are meant for other purposes. Some snail enthusiasts keep their pets in aquariums or terrariums. For these products there is a much bigger market. They exist in every price class and with different amount of technology. Professional snail farms make their own snail huts. Usually they are made from wood and/or nets and the focus is on food production, not usability, aesthetics or education. But these professional snail farms need a lot of care and attention.

4.3 SWOT Analysis

This Strength, Weaknesses, Opportunities, and Threats (SWOT) analysis was used to warn the team about the dangers that developing this product may have had, and also to help the team make the most of their possibilities. These four factors must be divided into external (opportunities and threats) and internal (strengths and weaknesses). Internal factors are those the team can control, while the ones that are out of the team's control reach belong to external factors, most likely consumers and competitors (see Figure 9).

Figure 9 - S.W.O.T. analysis (6)

The project had some weaknesses. First of all, before the start of the project, none of the team members knew anything about snails and their breeding which was an obstacle to overcome. In addition, none of the “EscarGO” components really have had any serious business experience and since the product did not have direct competitors, they could not study their marketing strategies. The team had a small advertising potential because, at the time, snails were not known to the general public as pets. Many people found snails disgusting and the idea of raising snails was really odd for them. The team members did not come from the same countries and did not speak the same first language, which could represent a weakness to communicate with one another and make their points of view clear. Everyone communicated in English, which the team spoke to differing levels.

This product also had much strength. It was an original product because it did not exist on the market. So, the idea was very innovative and would prove to be a curiosity for potential customers.

As one of their main objectives was to make the product as sustainable as possible, the product did not require a lot of power since it was intended for indoor use, reducing the need to change the atmospheric conditions of the inside of the “EscarGO”

The team needed to take advantage of the opportunity to be a leader in the market. “Caracol” had no competitors, and that could be an opportunity to develop the product and start a new and wide market. This was a project where team members came from different degree programs in their

home Universities, they could acquire knowledge from the others and improve their own skill set. Moreover, it was an opportunity to learn how to lead a team, and simulate a project in a professional environment.

Despite the opportunities, the project also had threats. First, the team had a budget of 100.00 €. "Caracol" had to make choices in order to remain under the budget. Additionally, the team had a tight schedule which the team found to be difficult to manage the time. To conclude, other potential threats were that a lot of people do not want to eat the snails they have bred. For instance, most people who raise rabbits, or any edible animals, find the idea of eating them inconceivable as they are now pets.

4.4 Strategic Objectives

In Table 10, in order to achieve the long-term success of the "EscarGO" product, the team stated the Specific, Measurable, Achievable, Realistic, Timed (SMART) objectives that were used as a reference to measure the past, present and future of the company in a realistic approach (see Figure 10).

Figure 10 - S.M.A.R.T. (7)

Table 10 - Strategic objectives

Objective	Description	Time
Final product	Build the final fully-functional "EscarGO".	August 2017
Launch development	Obtain funding. Reduce production costs. Start the publicity campaign.	September-November 2017
Product launch	Sell the product through the company's website in the christmas campaign. Sell at least 20 units.	Christmas 2017
First year	Find a distributor/supplier. Increase the production and sell more than 150 units during the year.	2018
Expansion	Promote and sell the product in other european countries, like Spain.	2019

4.5 Segmentation

The team divided the market into smaller segments to be reached more efficiently and effectively. This study helped the team to be aware of the segment of the market likely to be interested in "EscarGO".

4.5.1 Geographic Segmentation

Here the team decided which countries would be their Target Markets. The "EscarGO" product would mainly be sold as an educational and recreational product, but also it would be advertised as a way to grow your own snails at home for self-consumption to another target segment. For this reason, the team did research on which countries consume the most snails, in order to find those countries where the cultural barriers related to snails would be less important, see Figure 11.

Figure 11 - Which countries consume the most snails? [37]

Snail meat, despite being healthy and nutritious, are relatively high in proteins and in addition there is high participation polyunsaturated, particularly omega-3. It is also a source of minerals (mostly Ca, P, K, Mg, and Na)) [38], due to cultural issues it was not consumed globally.

It was estimated that over 400 000 t of snails were commercialized every year around the world [39] (a higher number of them was consumed due to the large percentage that represents the hand-picked snails for personal consumption) [40].

Only 15 % (67 500 t) of the global consumption came from snail breeding units while the largest amounts of snails traded in the market came from nature (85 %) [41][42].

The largest consumer markets were located in Europe. Three countries had the highest escargot demand. These were France, Italy, Spain. The difference between France and the other two was notable though (see Figure 12).

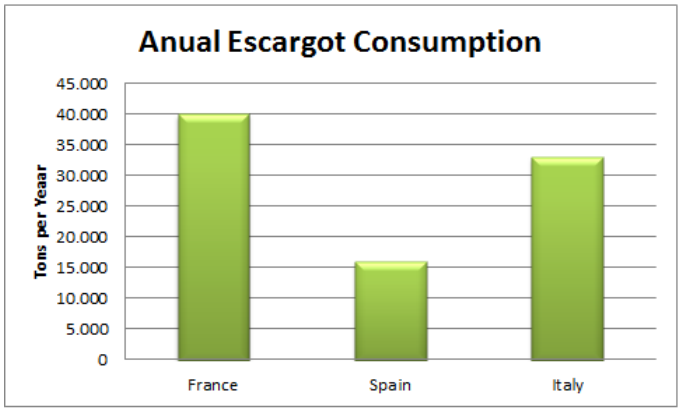


Figure 12 - Main escargot consumers (8)

In France they usually consumed more than 40 000 t of snails a year [43][44][45]. Italy ranked second in the list of EU snail meat consumer after France. Italians consumed 37 000 t of snails meat during 2010 [46]. Their usual consumption was around 33 000 t a year [47]. Spanish, in third place, consumed 16 000 t of snails a year [48].

What held true for the three of them is that all these three countries were heavily in deficit (see Figure 13). Specifically, in France more than 80 % of domestic consumption was covered by imports. In Italy about the 65 % whereas in Spain the 55 % [49].

In France, in 2010 there was a lack of 90 000 t of snails due to their high consumption that year. Based on this information, it was expected that this need for snails would not be covered even in the next 10 years [50].

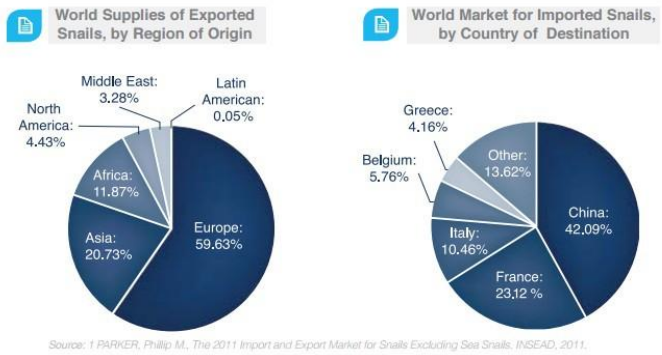


Figure 13 - Snails exports and imports [51]

The highest consumption of snails per person had been recorded in Greece; about 40 000 t in 2015, [52], though their average total consumption every year is usually lower. There, according to the Presidential Act 67/81 (FEK 43/A/ 1981) collecting snails from nature is permitted only from March until June [53].

Based on this statistics, the team decided to focus the market mainly in France for their first active year. Later on, the team would consider expanding their business to other countries like Italy, Greece or Spain.

All of these countries had a mild climate without extreme conditions allowing the grow of snails, since the Cornu aspersum is natural from this climate (see Section 2.4 Escargot Research). For this reason, the climate control of the product would not require a non-sustainable amount of power to achieve the optimal living conditions.

4.5.2 Demographic Segmentation

The product's size was meant for home use, so the marketing strategy tried to approach families living in the big cities of France, for instance Paris, Marseille, Lyon, Toulouse or Niece (see Figure 14).

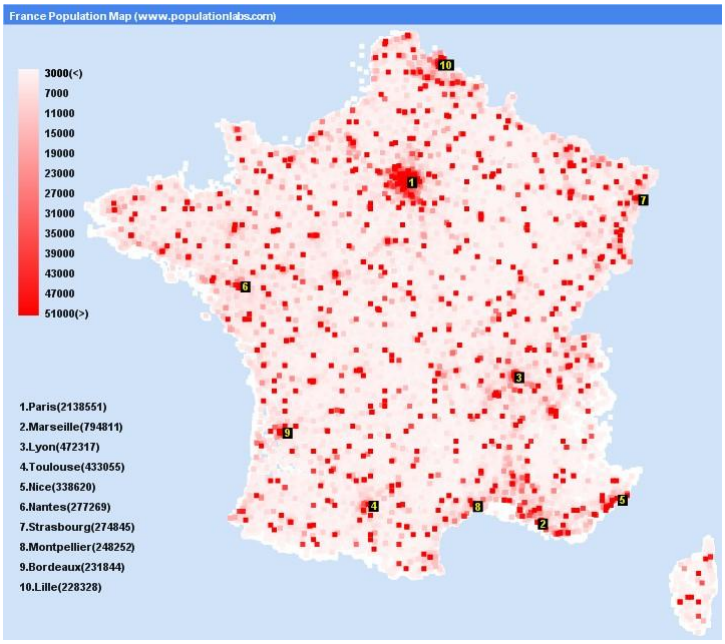
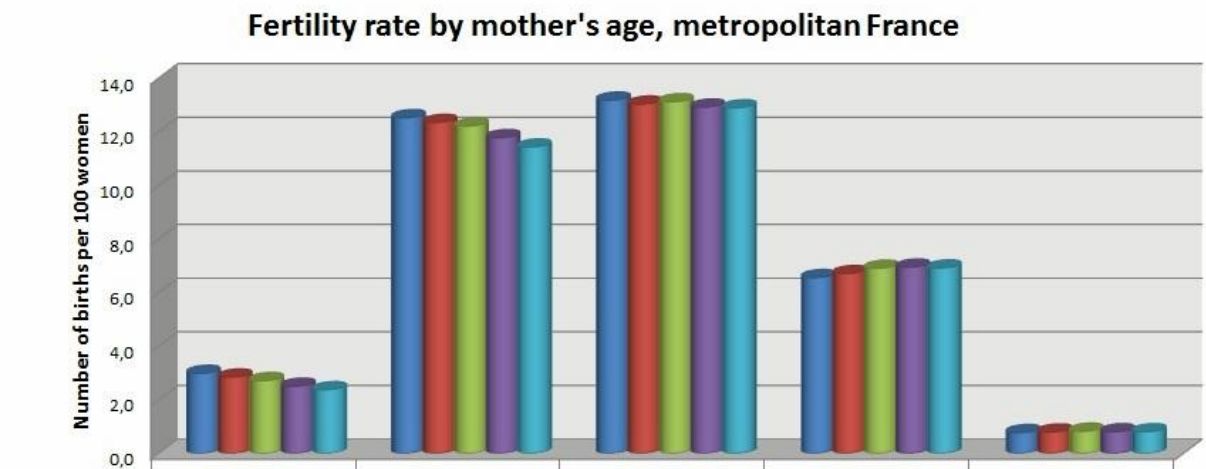


Figure 14 - Main cities in France by population [54]

Additionally, the "Caracol" team decided to focus on the population segment with the following characteristics:

- **Age :** 30 to 35 years old
- **Family size**: In a couple / married - preferably with children. For educational target purposes
- **Income**: Medium to high
- **Type of accommodation & situation**: Flat in a busy French city center, far away from nature
- **Professional situation**: Working

The team decided to advertise the "EscarGO" mainly as an educational product and chose to aim for an age range of between 30 and 35, based on statistics (see Figure 15) that showed it was the age when people in France seemed to be starting a family [55].



	15 - 24 years	25 - 29 years	30 - 34 years	35 - 39 years	40 - 50 years
2012	3,0	12,5	13,2	6,6	0,8
2013	2,8	12,3	13,0	6,7	0,8
2014 (p)	2,7	12,2	13,1	6,9	0,8
2015 (p)	2,5	11,8	12,9	6,9	0,8
2016 (p)	2,4	11,4	12,9	6,9	0,8

(p) provisional data at the end of 2016. Source: INSEE, vital statistics and population estimates.

Figure 15 - French fertility rates

At the time of writing, France had a total population of 66 990 826 people. The age sector of 30 to 35 years old population comprised a total of people 4 947 116 (7.38 %) [56]. This demographic sector of the French population seemed not to be growing or decreasing at the time of the study (see Figure 16).

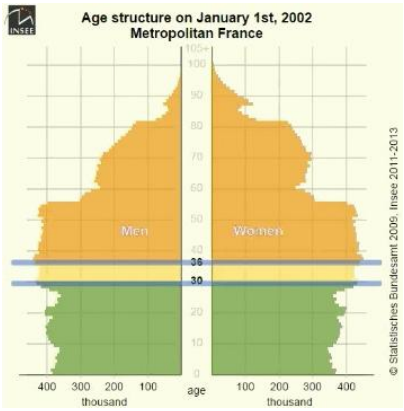


Figure 16 - French 30 to 35 age segment evolution [57]

4.5.3 Psychographic Segmentation

The team, based on the statistics introduced in Geographic Segmentation and Demographic Segmentation chapters, decided to focus on medium working class families who live in a busy environment filled with distractions and technology. Parents craving to spend more time with their children, feeling scared about their education, since they are easily exposed to many different kinds of media coming from TV and Internet. The product the team was to make, provided a solution that allowed the user to not have that much interaction with the snails as other pets do (fish, etc.), by the use of automatic humidity and temperature control systems and also because of the high resilience of snails as animals. For these reasons, the group thought this product would be attractive to families

living in a busy environment, that may not have that much free time to spend on a pet. If the children asked to have a pet, the "EscarGO" would require less work and time than a dog since it would not be necessary to take their pet out for a walk for instance. The user rate would be much lower, only requiring one cleaning every three months. The rest of the time only some care should be taken to feed the animals. The children can enjoy their pets at all times while their parents only help them to raise them during the cleaning period.

4.5.4 Behavioral Segmentation

This product aimed to attract modern families who lived in a busy environment filled with distractions and technology. Parents that craved to spend more time with their children, and felt scared about their education, since they were easily exposed to many different kinds of media coming from TV and the Internet.

The team also noticed that escargot were a common Christmas dish in France. Two thirds of the French escargot production a year were consumed during the Christmas period [58]. The imports seemed to peak just before the end of the year as a result of this traditional festive dish [59] (see Figure 17).

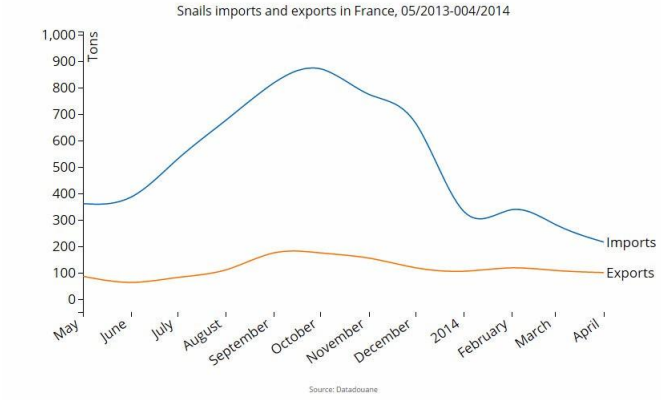


Figure 17 - French escargot Christmas import peak [60]

Customers would only buy this product once. For that reason, loyalty was not as important as user satisfaction and customer reviews were. The aim was to get parents recommending this product to their friends with children, while the children would talk with their friends from school about the fun product they owned.

4.5.5 Levels of Market Segmentation

There are four different levels of marketing segmentation:

- **Mass Marketing**: same product to all consumers
- **Segment Marketing**: different products to one or more consumers
- **Niche Marketing**: different products to one or more segments
- **Micromarketing**: products suit the tastes of individuals and locations

The team settled their mass marketing level aiming at French people aged 30 to 35 years old. The group would also apply a Niche Marketing strategy, advertising the product mainly as an educational and recreational product for families, but also as a gastronomical experience for couples or single people wanting to grow their snails for self-consumption. In the future development of the company,

“Caracol” would advertise themselves also for B2B companies that may be interested in the product, like schools and pet shops (education/recreational) or small restaurants or food shops (gastronomy).

4.6 Strategy/Positioning

A clear position in the market provides the company a competitive advantage over the rest. The positioning strategy gives the answer on what, why and who the company is different over competitors. It provided an image for the customer and is based on the segmentation part. Besides meeting the needs from the customers, it was also important to find a gap in the existing market.

Positioning the company happens in different stages:

1. Identifying Possible Competitive Advantages.
2. Choosing the Right Competitive Advantage.
3. Communicating and Delivering the Chosen Position.

The existing market consists of one direct competitor (S’cargo) and a lot of indirect ones (see Section 2.3 Existing Products). If the Escargot Nursery wanted to be different than its competitors the following requirements had to be achieved. The Escargot Nursery focused on ease of use, made possible by sensors and electronics. It was the only technological product specific for raising escargots. “EscarGO” can be used to keep snails as pets, as well as food production. The real distinction of the product is the social part of it. The Escargot Nursery brings the family together and teaches kids about nature and food production.

The perceptual map (see Figure 18) shows the connection between need for maintenance and the amount of snails the nursery can contain. These two values are important to find a gap in the existing market. All direct and indirect competitors are or in the fourth quadrant, which is the one with high maintenance and low amount of snails. The quadrant with low amount of snails and low amount of maintenance, for example the small led lighted aquarium, is to be avoided because of size matter. The professional nursery with high amount of snails and high need of maintenance is not useful for the chosen target group. The only existing competitors in the upper left quadrant are good equip terrariums for reptiles. The size had not to be very big, but enough for feeding a normal size family for two meals a year.

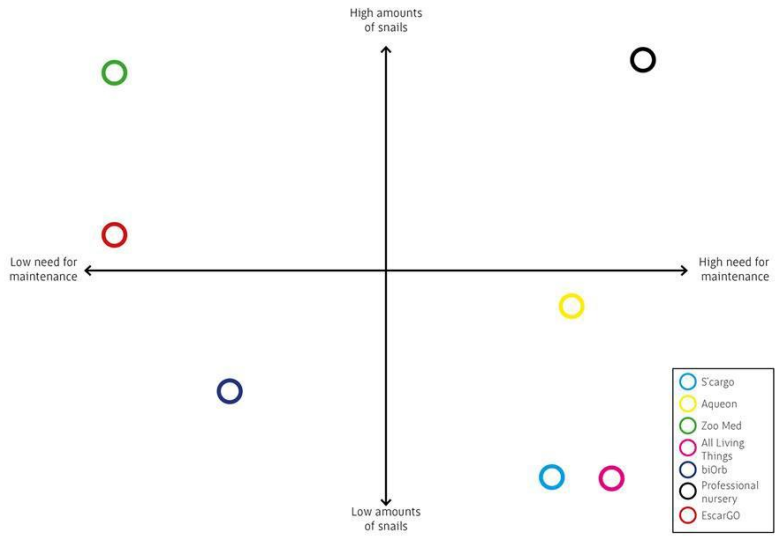


Figure 18 - Perceptual map (10)

4.7 Adapted Marketing-Mix

The team used the marketing mix to adjust their position in the market by taking into consideration the product price, promotion and place (see Figure 19).

Figure 19 - The marketing mix (11)

4.7.1 Product

The team decided to use the commercial name of "Caracol" for the brand (see Figure 20). The name of the product would be "EscarGO" (see Figure 21). The logos for this commercial name were designed to be appealing to families and kids.

Figure 20 - "Caracol" logo (12)

Figure 21 – "EscarGO" logo (13)

Thanks to the lack of competitors at the time, the team decided to sell the product using internet selling and distribution through their website: ([https://caracoleps.wixsite.com/escargo]) (see Figure 22) The "Caracol" portal is optimized for both desktop and smartphone view. It would include a customer reviews section once the product was launched. Since loyalty is not important for a product people would only buy once, the team wanted to have their clients recommending their product to others.

Figure 22 - Website home page (14)

To comply with legal requirements that all consumer goods sold in the EU had, (see DIRECTIVE 1999/44/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 May 1999), the group included a two-year warranty with the product.

4.7.2 Price

To decide the product's final price, the team had only one direct competitor to compare it with. "GROW YOUR OWN ESCARGOTS" by S'cargo cost 46.00 € (see Section 2.3 Existing Products). It was only sold online and it did not have any built-in technologies. The "EscarGO" could be sold at a higher price since it was a much higher quality product, but not that much higher that would lead customers to decide to go with the competitor.

The payment methods their internet would accept would be paypal, credit card, and Cash On Delivery (COD), in order to make the sale as easy as possible for the customers. The team did not plan to add any discounts when buying more units, since this product would not sell large quantities of units to a single buyer. The delivery taxes when sending this product to the metropolitan France would be included in the final price.

4.7.3 Promotion

The team was aware of the importance of promotion and advertisement of "EscarGO". There were a large number of different options available to promote the product, and the right or wrong choices the team made would determine the success or failure of the product's launch.

For the team's site to reach the kind of people who may had been interested in the "EscarGO", the "Caracol" group applied a digital marketing strategy.

It included a careful Search Engine Optimisation (SEO), which consisted on choosing the title of the site, an appropriate description and keywords like "escargot" "pet" or "home" so that the website was accessed through the search providers more effectively.

Another feature of the "EscarGO" site was a Frequently Asked Questions (FAQ) section, along with an explanation video. In the future, the team would also add a chat option for help. All of these actions were taken to make a more personal approach to selling the product.

The last feature of the team's digital marketing strategy was internet advertisement. It allowed the team to have a full control of the message when promoting the "EscarGO". The team decided that pay-per-click Google Ads suited best the advertisement of the product. The website was also optimized for smartphone view, to allow the visitors to enter the site throughout smartphone advertising.

The team would also consider applying a public relationship strategy that would include giving away the product to schools in France for free. The main objective would be the children testing the product at class, while the teachers would test the product as a teaching tool as well.

4.7.4 Place

In this section the focus was on the marketing and distribution channels for the "EscarGO". Here the team took the decision to sell directly to the consumer through online selling as a main distribution channel. They also considered other marketing channels like specialized pet stores, or supermarkets. These would only be located in crowded cities in France, since there was no need for this kind of product in the countryside. The group considered it was too early for the product to be sell using those channels. The product should be more known before that channels could be used.

4.8 Budget

A budget of 5000.00 € was set aside by the company as marketing budget. This amount of money was used to increase the brand awareness among the French consumers. That way, the team expected to increase their sales. It included the elements used to get the product ready to be launched to the market and customer communication related actions (see Table 11).

Table 11- Marketing budget

Action	Budget (€)
Leaflet	600.00
Flyer	600.00
Website	1200.00
Google Ads	1000.00
Social Media	1600.00
Total	5000.00

4.9 Strategy Control

Strategy control is about the current state and the state in the immediate future of the company. Rather than thinking about past decisions, strategy control controls the execution of the strategic plans. This control enables the company to improve and optimize the ongoing processes, but also feedback the ongoing plan to the original plan. The assumptions made by the company in the beginning of the development process about trends, customers and the environment are refuted or confirmed. In order to do this, after the launch of "EscarGO" consumers have to be questioned. This will give the company the right data for the strategic control.

4.10 Target Market Survey

The team used google forms to make a survey and ask potential customers about their interest in this kind of product and how would they want it to be like. The survey was translated into English, French, Spanish and Portuguese. It received 165 answers (see Figure 23) which helped the team to make some conclusions about the development of their product.

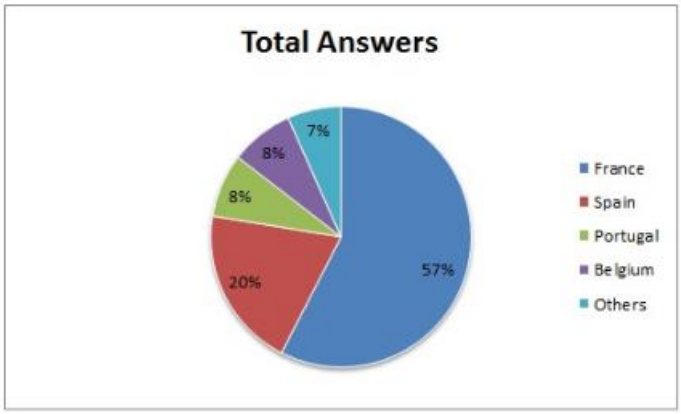


Figure 23 - Survey total answers (15)

In total, eating snails seemed not to be an attractive option (see Figure 24). But when considering only the French answers, the survey offered more optimistic results (see Figure 25).

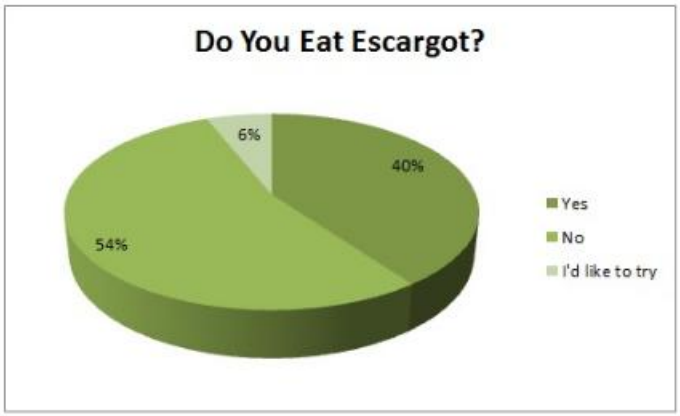


Figure 24 - Snails as a meal total answers (16)

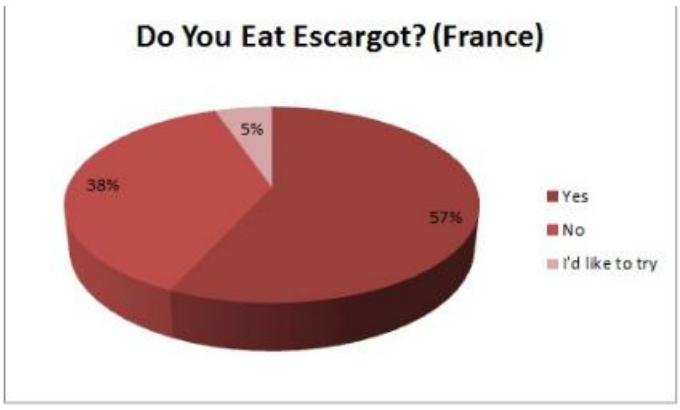


Figure 25 - Snails as a meal French answers (17)

Among the snail consumers, most of them do not eat escargot often in a year (see Figure 26). A home size product like “EscarGO” would host enough snails to satisfy the needs of those customers, since a normal snail dish in France, consists of around 15 snails for 4 people [99].

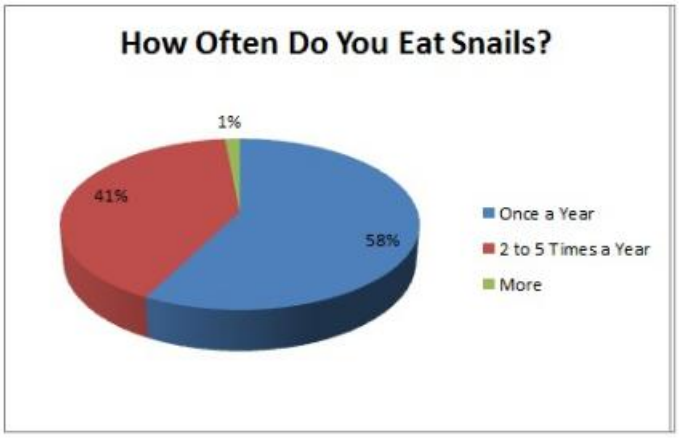


Figure 26 - Snails consumption frequency answers (18)

When asked if people would consider having snails as a pet, the survey results were not as positive as expected (see Figure 27). On the other hand, when asked if they would grow snails at home if it was possible, all the positive answers highly increased in all of the countries. This may meant there was an interest for this kind of product (see Figure 28). In both questions, more “Maybe” answers were registered. People seemed to be interested in a product like “EscarGO”, but could not visualize what it would be like with ease.

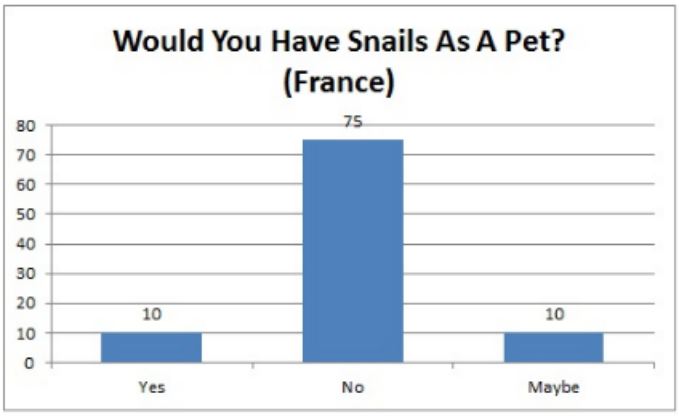


Figure 27 - Snails as a pet French answers (19)

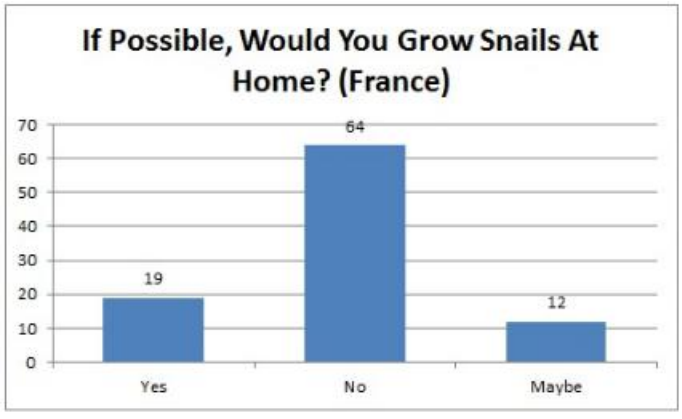


Figure 28 - Growing snails at home French answers (20)

It was clear for the team to see that their potential customers were not interested in a very technological product, but a rather simple product with just the necessary technology (see Figure 29). To accomplish that, the products design was kept clean and simple.

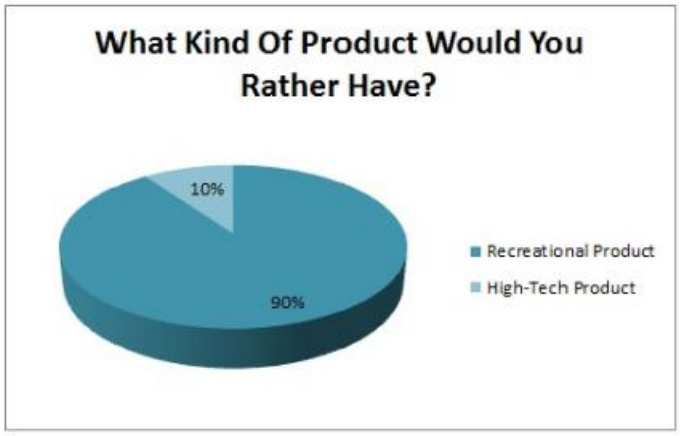


Figure 29 - Growing snails at home French answers (21)

Another conclusion extracted from this survey was the lack of competitors in the market. Few people were aware of the existence of a similar product to "EscarGO" (see Figure 30).

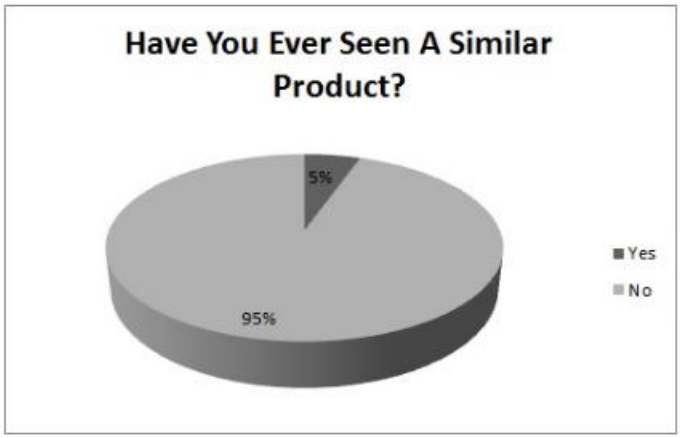


Figure 30 - Competitors awareness answers (22)

4.11 Conclusion

In this chapter the logos and commercial names were chosen and it was decided to sell on the internet. The team became aware of the difficulties the launch of this product may involve. To diminish these difficulties, the team looked for the target market of the “EscarGO”. France was decided as the country where to launch the product, since the cultural barriers related to snails appeared to be less important there for the team. They would try to reach two different kinds of customers: the gastronomic user wanting to raise snails at home for self-consumption, and mainly, also the user wanting an educational and recreational product.

Along this chapter the team developed their marketing plan and applied changes to the “EscarGO” as a result. The product was decided to be a home product and therefore its dimensions were decided not to be bigger than any other home-size product like a microwave that people could have at their kitchens. At the same time, for the ‘gastronomic’ customer to be happy with the product, it was decided that this dimensions should be big enough to host around 50 snails, satisfying this way the customers snail related eating habits.

“Caracol” had to create a product with a simple design and ease of use based on the survey done. Despite the lack of competitors in the existing market at the time of writing, the team would have to find a way to keep the production costs low enough to sell the product at a competitive price at a profit of around 50.00 to 70.00 €.

Eco-efficiency Measures for Sustainability

5.1 Introduction

The idea is to reuse as many materials as possible and up cycle for the prototype and to use sustainable materials for the product. This reduces waste but also keeps costs down. Natural materials are what are preferred where possible and natural vegetation for feed rather than synthetic man made pellets or feed. Another possibility is to use food waste from the kitchen for feed, which is very good for the sustainability aspect of the project.

This project promotes sustainability at home. The Escargot Nursery would be a fascinating way to teach children about where their food comes from and what it takes to produce food instead of throwing it in the trolley at the supermarket.

It is believed that this project fulfills a genuine need in the market, and sustainability and protecting the environment around us is becoming more and more important to people, as humans have become consumer orientated and do not produce their own food as most used to at the start of the 20th century.

As can be seen in Figure 31, sustainability is a widespread issue, with many sub-sections. Economic, environmental and social issues. It is the consideration of all these concepts that makes sustainable development more and more important and are all contribute to our understanding of sustainability.

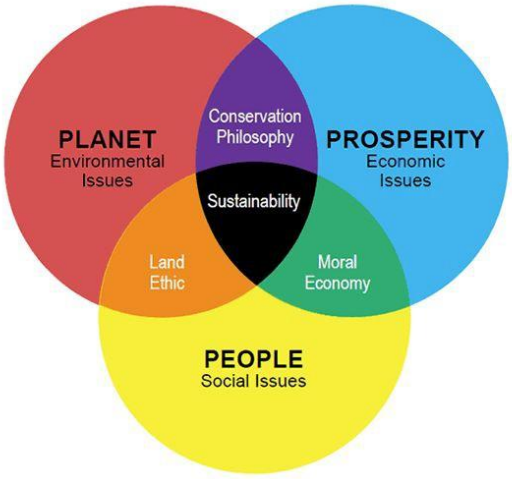


Figure 31 - Sustainability [61]

5.2 Environmental

Environmental sustainability is protecting the natural environment and its resources to protect the planet. Environmental sustainability concerns the ability to be able to reuse materials or resources indefinitely, so the use of trees, for wood and paper because trees can be grown back easily. Avoiding the use of fossil fuels as once consumed cannot be regenerated. Once we deplete the world's oil supplies then that means that we cannot create polymer plastics anymore. Recycling waste thermoplastics is essential in reducing our dependence on new production and allows for more resources to be available in future. The team can also recycle glass and metals, which limits our need for additional mining and damage to the natural environment. If the resources and materials used cannot be reused or reproduced indefinitely then they cannot be defined as sustainable [62].

Being able to recycle the product is not enough, because if the rate of yield is larger than the rate of recycling then this is not a sustainable model. Waste needs to be controlled carefully as the ability for the planet to absorb our waste is at an unsustainable level. Landfill sites are not able to handle the amount of waste humans produce, and the fact that we dispose off plastic, a non-biodegradable material, in landfill is a huge issue. Landfill sites have many pockets of harmful gases such as methane, ammonia, sulfides and carbon dioxide that get trapped when the landfill is buried, this produces another harmful effect as these gases can ignite. If they ignite this releases more harmful elements to our environment and contributes more to the greenhouse effect [63].

Therefore, in accordance with the above reasons it is essential for this project to use environmentally friendly materials such as natural materials or materials that can easily be recycled. Nevertheless the used materials should meet the expected properties to withstand humidity and higher temperatures. By using recycled and sustainable materials to build this product, the families who buy the product will be able to buy the product in good conscience.

5.3 Economical

Economic sustainability is the ability of an economy to support a defined level of economic production indefinitely. In a sustainable economy, growth strengthens competitiveness and an increase in employment is combined with better management of space, the protection of nature and a reduction in environmental impact [64].

In most countries in the developed world, if a company is a high polluter then it has pay more taxes. This means that more companies are prepared to reduce their carbon footprint and act in a more environmentally friendly way to save money if not for the environment. This kind of legislation helps to change mentalities and encourages people and businesses to act in a better way. If people are having to be more environmentally friendly at work and being educated about the issues at work, then they are more than likely to take these kind of behaviors and practices home with them and educate their families on these issues [65].

The introduction of eco-friendly and innovative products such as the Escargot Nursery benefits the market and economy, as there are more choices for consumers. Sustainability is the modern way and is a trend at the moment so people are more likely to choose such a product.

An important part of economical sustainability regarding to this project is the use of the local economy. This project will use local providers and suppliers in Portugal. This benefits the economy here and if the product is designed, built, and produced here and then exported, this model benefits any local economy, producing jobs, addition of taxes to the government, which is then able to spend the extra funds on additional services for the people.

5.4 Social

Although for most people sustainable development means only the protection of nature but, an additional pillar of this concept is the social dimension. The social dimension aims to promote and improve the social equality. Sustainable development should enable everyone to have equal access to concepts such as: food, housing, health, human rights [66].

There are generational, and social obstacles surrounding sustainability. For example if a person has been used to never recycle their household waste, it can be a challenge to persuade them to change their habits. There are also those who do not believe in Climate Change which becomes a problem if they are in positions of power, such as in large companies or in government where they can affect real damage if they are not held accountable. To affect change in attitudes in regards to sustainability and the environment is, above all, a matter of education. The goal for the future is for everyone to participate in sustainable development so we can create a better world together and save our environment from the damage humans have inflicted upon it [67].

Refreshingly, there are more and more people who make sustainable development and respect for the environment a lifestyle. People try to minimize their "carbon footprint" by favoring local products, which reduces the carbon footprint of the food by not having to travel. In a way, sustainable development is becoming trendy and fashionable [68].

Following on from this point, the Escargot Nursery project fits perfectly into the social aspect of sustainable development because it promotes education and bringing people together. The project promotes education because it teaches children where their food comes from and it also teaches them the process of raising animals. It teaches children that nowadays, it's essential to protect nature and animals for the continued use of planet earth. In addition, this project allows families to come together and enjoy time together taking part in a project that the whole family will be involved in, which is a fantastic opportunity for family bonding. Lately, children are playing more and more computer games, spending less time with family, and more time on their smartphone and social media. This project breaks the mold and reunites the family.

5.5 Life Cycle Analysis

From a sustainable development perspective, it's important to study the whole life cycle of the product and not only its production. Nowadays, contrary to what was thought before, the recyclability and the disposal of a product is one of the most important aspects of the product's life. In Figure 32, is demonstrated the life cycle of most products. These types of studies often allow designers or buyers to compare multiple products environmental impacts. This analysis can also be used as a means of communication for businesses, lawmakers/government, or consumers [69].

Figure 32 - Sustainable life cycle [70]

The life cycle can be summarized in three phases. First, “cradle to gate” that includes three parts of the life cycle from Figure 32. The first stage is the extraction of raw materials, then, the materials are taken for processing, and eventually the construction of the final product in various factories. Then, there is the “cradle to grave” aspect in relation to the utilization of the product and its useful life. For instance, during the distribution, of the product, companies pack the products in packaging that generates waste, and more often than not the packaging is plastic and non-recyclable. In addition, when the consumers use the product, they consume resources like energy or water and this has an impact on the environment because of the pollution generated and the carbon emissions produced. These days consumers are demanding more energy efficient products, and because we have so many electrical products around the home their continued use is expensive. This is why you are seeing more A rated energy efficient products, and more and more Light-Emitting Diode (LED) lighting used in new homes. The final stage is “cradle to cradle”, the reuse of the materials. Engineers and designers, when they are conceiving a product, are more aware than ever of the end of life of the product, and how the product will be disposed of at the end of its useful life [71] [72].

France does not produce enough snails to meet demand (see Figure 33). In fact from May 2013 until March 2014 there was 6000 tons of snails declared as imports into France. The peak time for consumption is over the festive period, as escargot is considered a festive tradition for example during Christmas. Therefore the Escargot Nursery meets a huge demand for anyone willing to produce them at home. It also reduces the transport costs and therefore the carbon footprint of the food [73].

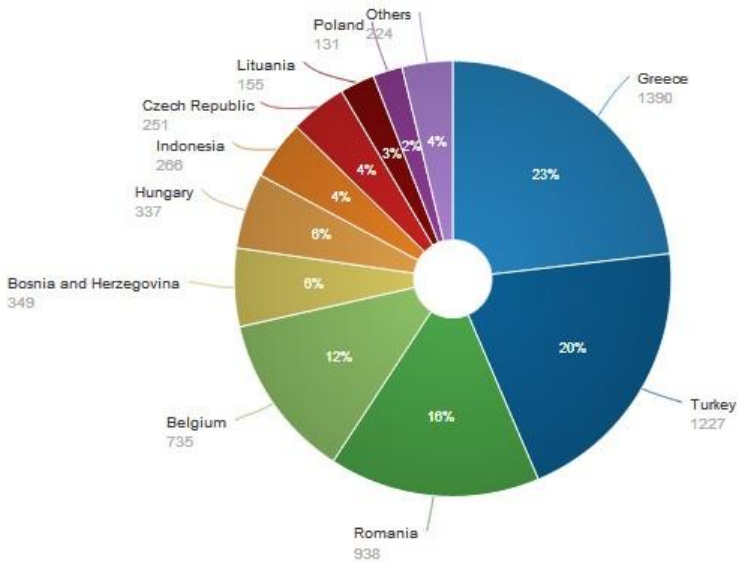


Figure 33 - Origin of French snail imports [74]

5.6 Conclusion

To conclude this chapter, nowadays sustainability is crucial and the team must take it into consideration when designing the product. Sustainability is a concept which includes the environmental, economic and social concepts. To make “EscarGO” sustainable, the team need to take these three concepts into account with equal importance. Based on this study, the team chose to use PP for the structure for the final product, because its impact on the environment is lower compared to other plastics and it is resistant to the growth of bacteria. Thus, its impact is 73 mPt/unit while the impact of polyamide, another widely used plastic, is around 700 mPt/unit that is really unsustainable [75]. Due to the budget, the team chose to use Polyvinyl Chloride (PVC) for the prototype.

Then, to comply with the social aspect, the team has decided to make education for children and cohesion of family one of these main concerns. To conclude, based to this study the team decided to use the curtain method in order to increase the surface where snails can live. As it increases the efficiency of “EscarGO”, this method is really sustainable.

Ethical and Deontological Concerns

6.1 Introduction

Ethics is the set of values that can be applied personally or professionally which dictates a person's actions. On the other hand, deontology is the set of rules and duties that govern a profession, the conduct of those who practice it, the relationships between them and their clients and the public. For instance, under article 3.04.01 of the code of deontology of engineers, an engineer must apply his or her signature to any document or plan prepared under his or her management. Engineers can decide to refuse a signature, which them values and the code of ethics allows them to do if the work is not of satisfactory quality or not done in an ethical or sustainable way [76].

Thus, the project must respect all the aspects of ethics and deontology in the following areas:

- Engineering ethics
- Sales and marketing ethics
- Environmental ethics
- Liability

6.2 Engineering Ethics

Since the beginning of the industrial revolution, the profession of engineering, science and research has developed in leaps and bounds and has become a pillar of respectability within companies. It was therefore necessary to introduce rules and regulations to govern the professional ethics inherent in this profession. The first ethics code for the engineer appeared in 1910 and it was promoted by the Institution of Civil Engineers in the United Kingdom. During the 20th century, numerous codes of ethics were published in the United States and in others countries [77]. Today, there are several codes of ethics and deontology governing the profession of engineering in most countries.

This project has to respect engineering ethics. In each of those codes, there are some common concepts that the team has to respect. The team chose to focus on France because that is the target market for this project. In France, there is an ethics charter for engineers which was drafted by CNISF (Conseil National des Ingénieurs de France) in 2001 [78] [79] [80].

The team has chosen to present this one because France is the largest market for snails. In this charter the team finds the following concepts [81]:

- First, there is the concept of engineers in society. Engineers are highly educated, and their specialist knowledge means they are in a unique position to be trusted to use their education and specialist knowledge. The engineer must use their knowledge and understanding in an ethical way and a way that protects the environment as much as possible.
- Another aspect is engineering competency. Engineers are source of innovation and progress. They develop products, manufacturing processes, research problem solving and much more. In addition, engineers have to adopt a rigorous, systematic way of working. They must admit when they are wrong, take the advice of others and correct any mistakes.
- Engineers have to be open minded, they must be fair without discrimination and listen to the opinions of everyone and take on board criticism but also be able to assert themselves if the design concept is not safe, or not achievable. They have to respect the culture and the values of the company they work for and the people affected by the work of that company. They

must work ethically i.e. engineers must not plagiarize, make signatures out of convenience, deliberately use harmful materials, etc.

- To conclude, there is the section referring to engineering and their mission. The engineer must respect the constraints imposed on them while integrating economic, human, financial, social and environmental factors. They must also anticipate risks and hazards in order to limit negative impacts.

During the process of the project, these values need to be adhered to. This project responds perfectly to the different points because the team works towards sustainable development. Furthermore, the project promotes innovation because, at the moment, there is no similar product on the market.

6.3 Sales and Marketing Ethics

In today's world, markets present a battle of interest between different players, such as competition for resources, customers and price. People want to have a product of good quality at the best price, which doesn't always mean the cheapest price, and companies want to increase their gain [82].

Given that the purpose of the project is to build a product that can be sold, the team also has to respect sales and marketing ethics. Sales and marketing ethics are particularly important for the image of the company. Indeed, the credibility of the company as well as the confidence that the customers have in the company, are at stake. It's also essential to respect sales and marketing ethics in order to avoid sanctions, fines or even legal issues [83].

The team wants to develop a long-term relationship with the customers, so one of the most important points that the team has to take in consideration is not to lie about the benefits of the product. Indeed, during the advertising the team has to promote only the real advantages of the product and not to invent or overstate the products benefits. This point is important for the customers trust and also on a legal level [84].

Then the price is a concern of sales and marketing ethics. First, the price has to be fair. The customer needs to know exactly what they are going to pay for the product. The team wants to offer a high quality with fair prices. The price has to be clear. It is important not to hide charges in the price or services that the product will need to work. So any additional parts or replacement parts after use need to be made clear to the customer [85].

In addition, the marketing of the product has to respect the cultural diversity and it has to be nondiscriminatory towards all people.

During marketing and sales activities companies use surveys, focus groups, and specialists to gather information. To behave ethically the companies have to respect the privacy of the customers and inform them why they are collecting data, and the data needs to be kept relevant and not asking more than what is needed for the particular application. Furthermore, the companies can't sell the gathered information on and they have to destroy it after the data is no longer needed [86].

6.4 Environmental Ethics

Environmental ethics is a part of the environmental philosophy and is not just about the relationship between humans and environment, but it is also about the value and the moral status of the environment and its nonhuman inhabitants [87].

There is a product on the market called molluscicide. This product is used by people to exterminate snails from gardens and vegetable gardens to prevent that the snails eat all the plants and vegetables. Molluscicide is a chemical product so it is not very ethical. Instead of killing the snails with harmful products, snails can be used for useful purposes. To increase the consumption of snails it is useful to use the "EscarGO". So the snails will be used as pets, for growing and breeding and for eating. It means increasing the harvesting of garden snails and reducing the use of molluscicide.

The study of environmental ethics focuses on the impact of the product on the environment. Humans can't help using and modifying parts of the natural world, since we depend on the nature for food, clothing and shelter, for our water supply, and for the air we breathe. But the unforeseen impacts of human actions are now creating problems like global warming and the elimination of multitudes of species [88] [89].

With environmental ethics, the team can ensure that we are doing our part to keep the environment safe and protected. The design of the "EscarGO" will be created to be as environmentally friendly as possible by using only materials that aren't harmful for the environment for the final product, like PP, which is more sustainable than other plastics.

For the production of the "EscarGO" environmental energy is used, like solar energy and wind energy. The water consumption is reduced to the minimum and the use of harmful chemicals is avoided.

During the use, energy is used in a smart way. Only when the temperature drops below 15 °C, the heater will start to work. Above 25 °C the fan will blow air in the nursery, without heating from the heating device. Led lights only work when the amount of light emitted by the sun is not enough. The humidity sensor measures the humidity level so water is added only when needed. The screen where the temperature and the humidity can be seen will mute when it is not used by the user.

After the use of the "EscarGO", the product can be recycled. The smart manufacturing of the" EscarGO" makes it possible to disassemble the nursery easily. Used materials, like PP, are reusable because of thermoplastic properties.

6.5 Liability

Liability law determines when someone in general or liability suffers in a particular case for damage or injury suffered by another person [90]. Team "Caracol" needs to take responsibility in case something harmful happens because of the product or the use of the product.

Legal liability concerns both civil law and criminal law and can arise from various areas of law, such as contracts, torts, taxes, or fines given by government agencies. The primary goal of civil liability is to restore or to compensate for damage suffered [91] [92].

Product liability is an important part of this project. The team is responsible for the product, also for the injuries this product may cause. It is important to take responsibility towards supervisors and the customers. If something unfortunate happens, the consequences of which are the fault of the team [93].
To complete the creation of the Escargot Nursery, is it necessary that the team comply with the following EU directives:

- Machine Directive (2006/42/CE 2006-05-17);
- Electromagnetic Compatibility Directive (2004/108/EC 2004 12 15);

- Low Voltage Directive (2014/35/EU 2016-04-20);
- Radio Equipment Directive (2014/53/EU 2014-04-16);
- Restriction of Hazardous Substances (ROHS) in Electrical and Electronic Equipment Directive (2002/95/EC 2003-01-27);
-

According to the previous directives:

1. When designing the product, the team must create a product that does not compromise the safety and health of users.
2. Our electronic part must be designed with the aim of limiting electromagnetic emissions from equipment in order to ensure that, when used as intended, such equipment does not disturb radio and telecommunication, as well as other equipment.
3. The "EscarGO" electrical equipment within certain voltage limits provides a high level of protection for European citizens
4. The team does not need to use hazardous substances in the "EscarGO" electronic equipment.

6.6 Conclusion

To conclude, the team has to respect all the codes of ethics mentioned above, the team has to take care with the sales and marketing of the product to make sure it is done in an ethical way. The team needs to be ethical in every aspect of the construction of the Escargot Nursery to be sure that the product meets with the ethical requirements and European directives that were set. Due to this study, the team will work to promote only the real benefits of the product and to show the value of these aspects. Furthermore, the team will particularly pay attention to the respect of environment, using sustainable materials both for the prototype and the product.

In the next chapter the team will explain the development of the product taking in ethical and deontological concerns.

Project Development

7.1 Introduction

In this chapter, the team shows the development process of the “EscarGO”. The team describes the architecture of “EscarGO” with 2D and 3D drawings. The team also describes the control system and the system schematics to show how the system is connected.

With the control system, the requirements are as follows. The enclosure needs to be able to maintain a comfortable temperature for the snails, but also it should not require much energy. It is recommended that the enclosure will stay inside the home, so what has been proposed is a heating element that will turn on if and when the temperature drops below 15 °C, and a cooling fan that will turn on if the temperature rises above 25 °C. The reason for this is that the market research suggests that people want as simple a system as possible that rarely uses any energy
.
Humidity is another aspect that will need to be controlled. A moisture sensor will be inserted into the enclosure, and there will be a sprinkler hose pipe, or an atomizer, inside to release water if the environment is not humid enough. This must be short bursts as over watering or flooding may drown the snails, and also there is a possibility of a small water tank on the system for the humidity control so that the tank does not need to be fed with a constant water supply.

Another requirement of the system is to display the temperature and humidity on a small LCD screen. Humidity and temperature are easily controlled using Arduino boards and software, which is a great benefit of using Arduino. One of the concerns with the project is that because there needs to be a humid environment for the snails, and they also require oxygen, there is the issue of dampness and humidity getting into the room that the terrarium is stored in. This needs to be carefully controlled and monitored because dampness can cause damage to the room around the enclosure.

The team considered using solar panels on the top of the nursery to provide some energy, but because the tank is designed for use indoors this was no longer an option as there would be no direct sunlight or very little, for the solar panels to work efficiently. The cost to benefit ratio proved this option was not feasible.

The product had to have an aesthetically pleasing design and be easy to use. The dimensions that have been chosen is 400 mm x 300 mm x 375 mm for the enclosure, this is to provide an efficient design that combines a compact design which can fit on a work surface, and also allows for more snails to be housed with the curtain method. Finally, the team reports on the functional testing.

7.2 BlackBox

The BlackBox diagram (see Figure 34) was the diagram used to describe the main functions of the Escargot Nursery in an early stage.

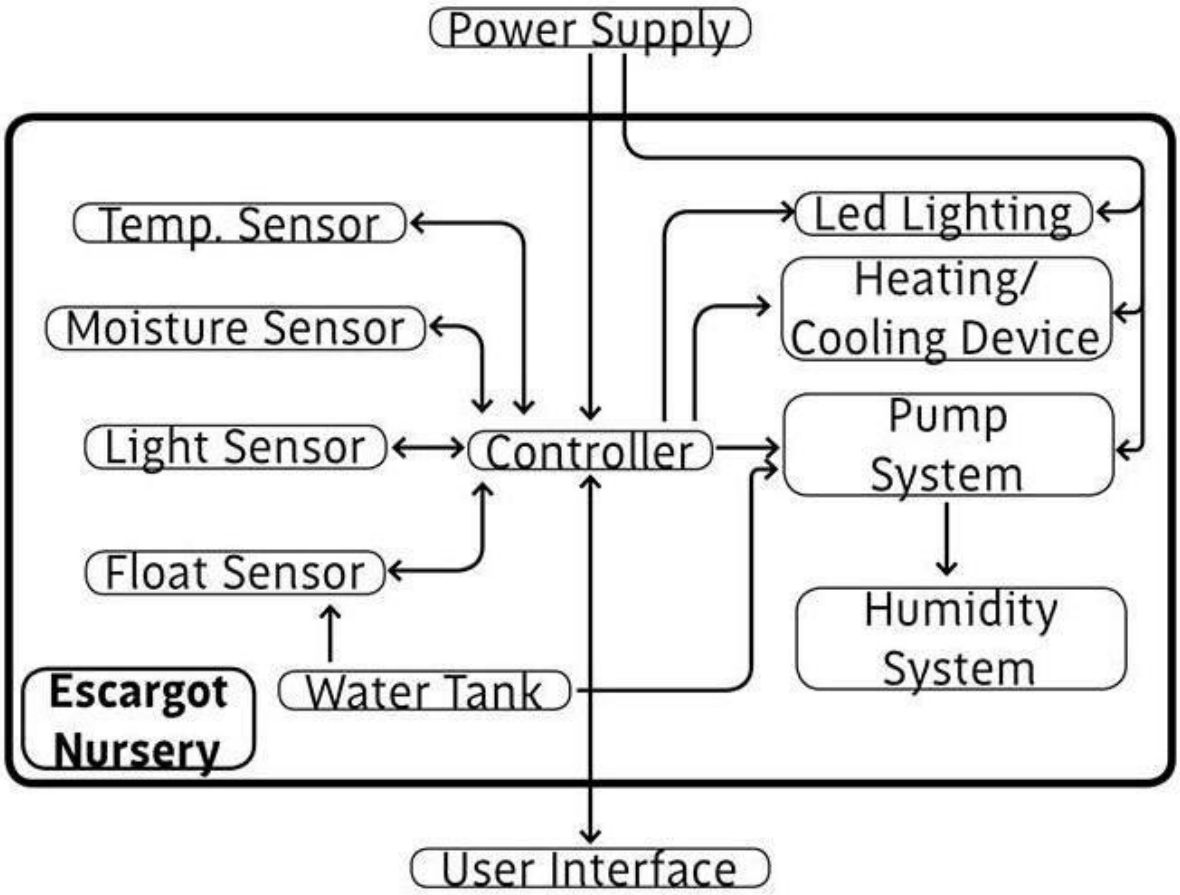


Figure 34 - The BlackBox diagram (15)

7.3 Architecture

7.3.1 First Structural Drawings

Figures 35 and 36 show the first structural drawings of the "EscarGO". These drawings were meant to be refined in a later stage, but they served as a good view of how the team wanted the Escargot Nursery to look like.

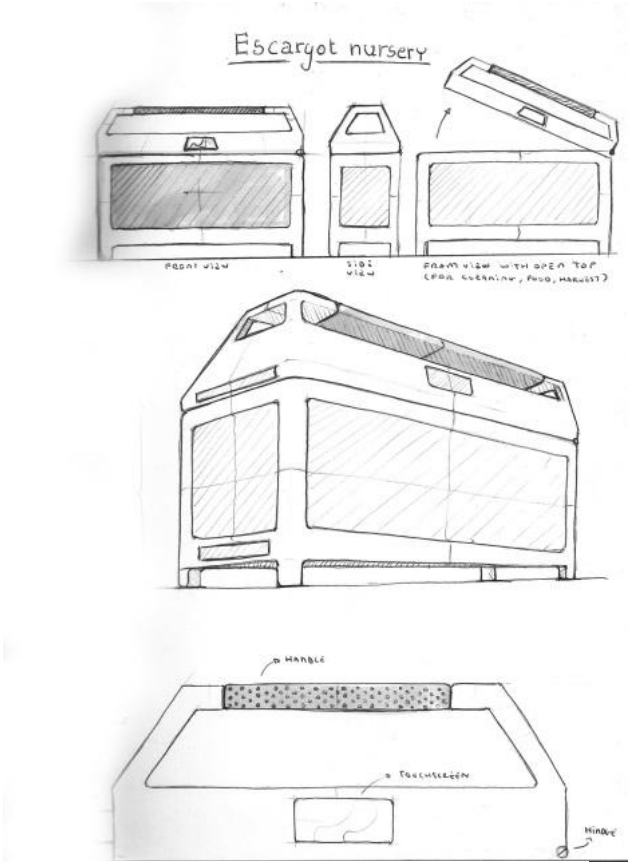


Figure 35 - First drawing (16)

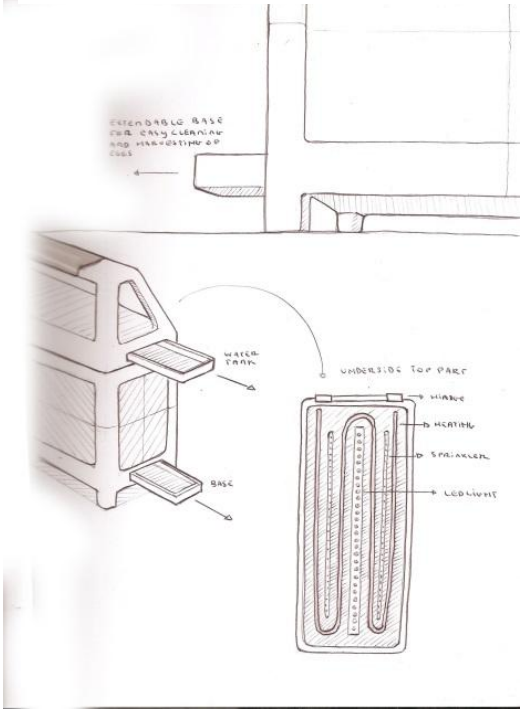


Figure 36 - Second drawing (17)

7.3.2 Cardboard Model

To begin with the architecture of the prototype, a cardboard model was made as a first approach to find out the optimal dimensions and opening system of the “EscarGO” that did not require an extra amount of free space around for its movement. The team also used it to show the curtain system. It can be seen in Figures 37, 38 and 39.

Figure 37 - Front and left sides of the cardboard model (18)

Figure 38 - Back and right sides of the cardboard model (19)

Figure 39 - Inside of the cardboard model and the curtain system (20)

7.3.3 Initial 3D Model

The team made some first three-dimensional (3D) models to see how the product would be like at the end of the project.

At this stage, it was decided to remove the feet of the structure, since it did not add anything to the product, and using a plastic rubber band to keep the product from touching the furniture directly.

Figure 40 and Figure 41 show the front view of the product. Curtains were placed inside the cage, so that the snails could climb them increasing their living surface that way. This permitted to host a bigger number of snails in the same space, reducing the energy consumption and increasing the product's usability.

Figure 40 - Front view 1 (21)

Figure 41 - Front view 2 (22)

The cover is shown in Figure 42. It includes a LCD screen where the user can read the temperature and the humidity inside the “EscarGO”. There was also a handle in the cover to make the cage easy to move to another place.

Figure 42 - The cover of the product (23)

Figure 43 shows some different colour options for the cage. The team chose these colour possibilities to make the product more attractive for the target customers.

Figure 43 - Different colours for the product (24)

Figure 44 shows how the product opens by using a pivoting system.

Figure 44 - How to open the “EscarGO” (25)

The different components included in the product are shown in Figure 45.

Figure 45 - The components (26)

7.3.4 Final Structural Drawings

The team had to do some brainstorming in order to fix the flaws found in the first design. The original pivoting opening system was not very likely to be long lasting, and therefore sustainable. In order to keep the cover removal simple, the group decided not to host the technologies inside the cover and add a chamfer instead for that purpose. These changes in the product (see Figure 46) were intended to make the “EscarGO” more user-friendly.

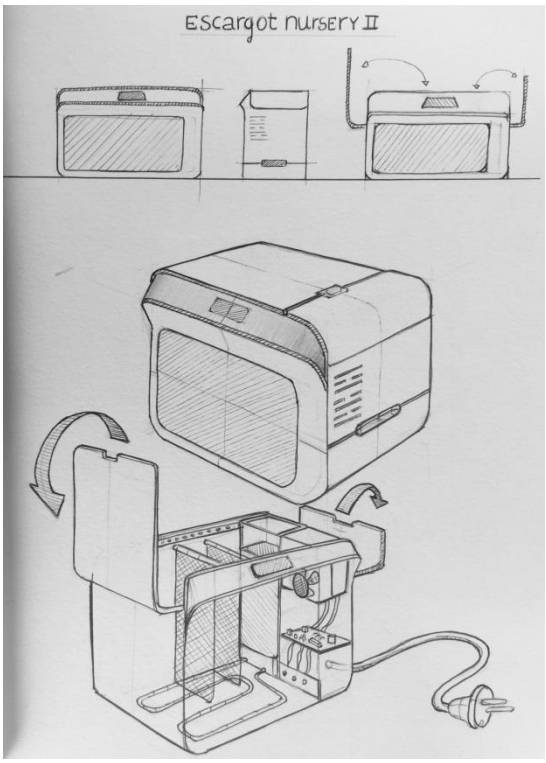


Figure 46 - The final structural drawing (27)

7.3.5 Final 3D Model

In this sub-section, the final 3D model is shown. The team decided to use another technique for opening the terrarium instead of the pivoting system. The dimensions of the “EscarGO” will be 400 mm x 300 mm x 350 mm. Figure 47 shows an overview of the whole product.

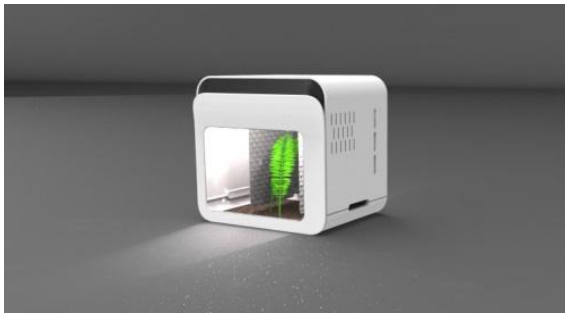


Figure 47 - Whole view of the product (28)

Figures 48 and 49 represent the front view of the product.

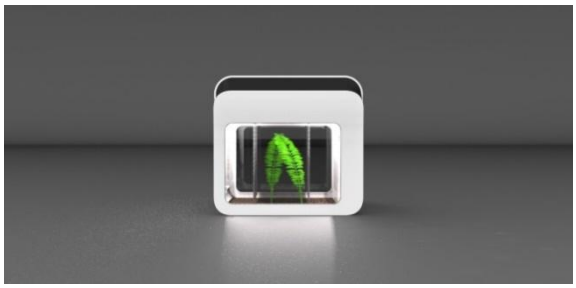


Figure 48 - Front view 1 (29)

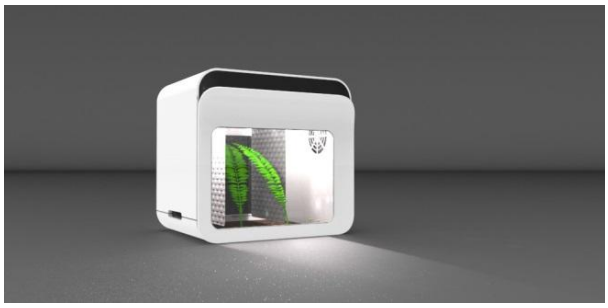


Figure 49 - Front view 2 (30)

Figure 50 displays a front view and a view of some parts that will be inside the terrarium. The figure shows the curtains and the water tank.

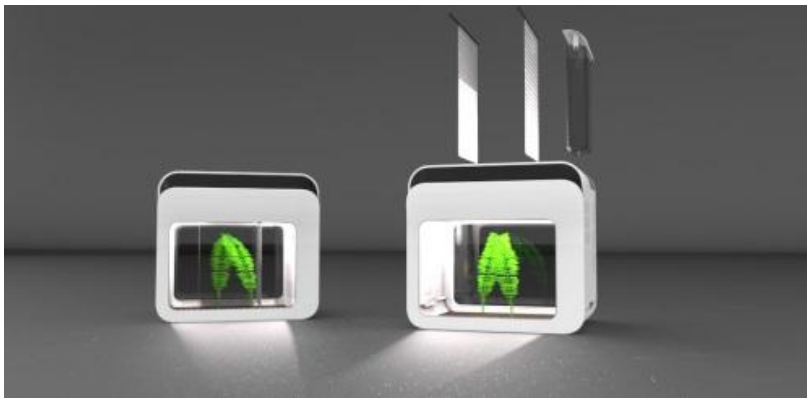


Figure 50 - Front view and some parts (31)

Figure 51 represents the inside of the terrarium. There will be a drain system in the soil and a water tank on the side. On the same side as the water tank, there will also be the technological part with all the sensors (humidity, temperature and light). In this figure are the curtains also well displayed.

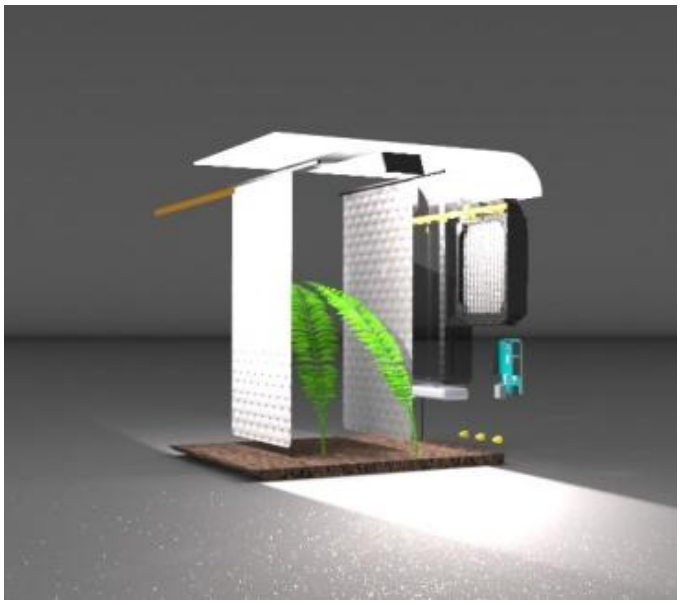


Figure 51 - The inside of the "EscarGO"(32)

7.4 Packaging

The "EscarGO" is assembled in factory so the customers don't have to build the product. The packaging has to protect the nursery while transporting, but has also additional value for user experience. Additionally to the box, foam blocks prevent damage. The packaging has to be attractive and make the customer curious about the product inside. The material of the packaging is corrugated fiberboard because of its strength and ecological impact. This kind of fiberboard is easy to recycle and reuse.

7.5 Functionalities

The Escargot Nursery was expected to achieve certain functions. It had to keep the climate inside at a comfortable level for the snails. For this the humidity needed to be controlled, so a liquid spray system needed to be used to keep the soil moist, the temperature also needed to be kept within the safe range, i.e. between 15 and 25 °C. Lighting in the form of LED also needed to be controlled to ensure the snails had enough light to thrive. The system measures the temperature and humidity inside the nursery and measures the light level outside the nursery. The program stored in the Arduino board then controls each aspect to ensure automation of the climate.

7.6 Components

In the following section, the team will explain the reasons behind the choices of materials.

7.6.1 Controller Boards

Table 12 shows some of the controller boards which the team could use to build the prototype of the product.

Table 12 - Possible options for the controller board

Controller board	Picture	Microcontroller	Size (mm^2)	Voltage input (V)	Voltage output (V)	Price (€)
Arduino Uno	 [94]	**ATmega38**	**68.6 x 53.4**	**7-12**	**6-20**	**22.90**
Arduino Nano	 [95]	Atmel ATmega168 or ATmega 328	18 x 45	7-12	6-20	23.37
Arduino Micro	 [96]	ATmega32u4	48 x 18	7-12	6-20	22.14

The team chose Arduino Uno as the micro controller board because it blends perfectly (size, functionality and cost) to suit the project. Arduino Uno is very commonly used in online forums so it makes it easier for inexperienced people to use. Arduino was chosen because it uses open source software which is the software requirement from the brief.

7.6.2 Sensors

The “EscarGO” needs a light sensor because the *Cornu aspersum* needs 16 hours of light per day. The light sensor is used to detect the ambient light level in the room and switch on a bank of LED lights if the light level gets too low. In Table 13 are possible light sensors presented for the prototype.

Table 13 - Light sensors

Light sensor	Power (mW)	Resistance (Ω)	Voltage (V)	Current (mA)	Price (€)
LDR GL5528	100	100	150	Not provided	0.50
Analogue Ambient Light Sensor	70	up to 10 KΩ	3.3 - 5	14 to 21	6.30
ADVANCED PHOTONIX NSL 19M51	50	max of 20 MΩ	>100	max of 20	0.92
Luminosity Sensor Breakout - TSL2561	1.8	5 KΩ	3	0.6 m	6.50

The team decided to use the “Luminosity Sensor Breakout - TSL2561” because it is a digital sensor and therefore easier to connect to the control system. Other sensors the “EscarGO” needs are a temperature sensor and a humidity sensor. In Tables 14, 15 and 16 are the possible sensor choices.

Table 14 - Temperature sensors

Temperature sensor	Voltage (V)	Current (uA)	Accuracy (°C)	Temperature range (°C)	Price (€)
LM35DZ	4 - 30	<60	0.5	-55 to 150	1.85
MCP9808	2.7 - 5.5	200	0.25	-40 to 125	6.89
DS18B20	3 - 5.5	not given	0.5	–55 to 125	5.10

Table 15 - Humidity sensors

Humidity sensor	Voltage (V)	Price (€)
Soil Moisture Sensor	3.3 - 5	4.90

Table 16 - Humidity + temperature sensors

Humidity + Temperature	Voltage (V)	Current (mA)	Accuracy	Temperature range (°C)	Humidity range (%)	*Price (€)*
DHT11	3-5 DC	200 - 500	±5 %, ±2 °C	0 to 50	20 to 90	*4.95*
DHT22	3-5	2.5	2 - 5 %, ±0.5 °C	-40 to 80	0 to 100	*9.80*
RHT03	3.3-6	1 - 1.5	2-5 %, ±0.5 °C	-40 to 80	0 to 10	*14.76*

After the team did research about the temperature and humidity sensors, the team decided to choose a humidity + temperature sensor. The team chose the DHT22 temperature and humidity sensor because it measures both humidity and temperature into one sensor which streamlines the programming and soldering of parts, and also reduces cost and encroachment into the terrarium. The DHT22 had a better range than the DHT11, so therefore was the better choice.

In Table 17 are water level sensors displayed which can be used to measure the water level in the water tank. If the water tank is almost empty, there will be a notification on the LCD screen.

Table 17 - Water level sensors

Water level sensor	Power (W)	Resistance (mΩ)	Voltage (V)	Current (mA)	Price (€)
Water Depth Sensor	not given	not given	3 - 5	<20	3.95
10W Liquid Level Sensor	10	<200	100	0.5	6.20

The team decided to avoid using the water level sensor for a few reasons. The programming was going to be more time consuming and therefore the time taken for the project would be longer, and the team decided it would be the best to use that time in other areas. There is also the cost aspect, to stay in budget there had to be some cost saving measures.

7.6.3 Heating/Cooling

For the snails to have the optimal living conditions, it is necessary to use a cooling and heating system. When the temperature drops below 15 °C, the heating system will switch on. If the temperature rises above 25 °C, the fan system will turn on. Tables 18 and 19 display different heating and cooling systems.

Table 18 - Heating systems

Heater	Power (W)	Voltage (V)	Size (mm^3)	Price (€)
DBK HP04-1/04-24 HEATER	10	30	35 x 40 x 8.5	15.67

Table 19 - Cooling systems

Cooling fan	Power (W)	Current (A)	Voltage (V)	Size (mm^3)	Noise Level (dB)	Rotation speed (RPM)	Price (€)
Fan 50 mm x 50 mm x 10 mm Sunnon	1.32	0.11	12	50 x 50 x 10	29	5000	3.65
Fan 12 V 40 mm x 40 mm x 10 mm Velleman	1.2	0.1	12	40 x 40 x 10	25	6000	3.70
SUNON MC30060V2-0000-A99 Axial Fan	0.36	0.072	5	30 x 30 x 6.9	24	7500	11.25
MULTICOMP MC36256	0.9	0.18	5	40 x 40 x 10	27	5800	6.44

The team decided to use the Fan 12 V 40 mm x 40 mm x 10 mm Velleman because it can be run on 12 V and therefore is more powerful, and is not as loud. It is also more cost effective than fans running on 5 V.

7.6.4 LCD Display

To know if the temperature, the humidity and the heating/cooling are optimal for the snails, the "EscarGO" needs to use an LCD display to display these values. In table 20 are the possible LCD displays presented.

Table 20 - LCD display

Heater	Voltage (V)	Type	Size (mm^3)	Price (€)
Display LCD 16 x 2	5	parallel	80 x 36 x 12	6.10
ITEAD 1602 LCD Shield	5	parallel	83 x 57 x 1.6	10.50
Display LCD 16 x 2 Bot'n roll ONE A	5	parallel	80 x 35 x 11	6.00
MIDAS MCCOG21605C6W-FPTLWI	3 - 5	I2C	74.2 x 25.2 x 6.3	10.97

Display LCD 16 x 2 I2C	5	I2C	80 x 36 x 12	8.50

The team decided to use the Display LCD 16 x 2 I2C from electrofun because it uses an I2C display so has less interference, also it is cheaper than the other I2C display that was found.

7.6.5 Lighting

"EscarGO" needs to use lighting when the light level is too low. In table 21 are the possible LCD displays presented.

Table 21 - Lighting

Component Name	Voltage (V)	Power (W)	Price (€)
OPTEK TECHNOLOGY OVM12F3G7 LED Strip	12 DC	9	2.96
Single white LED	2.4 - 2.7	Not given	0.35
OPTEK TECHNOLOGY OVQ12S30W7 LED Strip	12 DC	1.6	12.86
OMC FFSB1 LED Strip	12 DC	Not given	15.30

The team has chosen the "OPTEK TECHNOLOGY OVM12F3G7 LED Strip" because it is the most cost effective option and does not require as much work connect compared to using single LED and creating a mount for them.

7.6.6 Power Supplies

In Table 22 there are some power supply choices.

Table 22 - Power Supplies

Component Name	Voltage (V)	Current (A)	Price (€)
Arduino Power Supply AC/DC 230 VAC/12 V 2 A	12 DC	2	7.50
Power Supply 230 VAC/12 VDC 1,4 A	12 DC	1.4	7.50
Power Supply AC/DC 12 V 3 A	12 DC	3	8.50

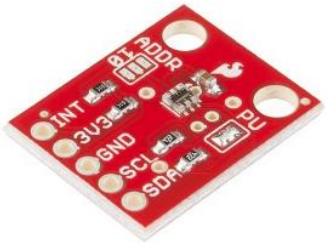
The team decided to choose the Arduino Power Supply AC/DC 230 VAC/12 V 2 A.

7.7 List of materials

Table 23 - The list of materials (external)

Material	Quantiy	Price (€)	Source
PVC sheets	2 sheets of 100 cm x 50 cm	21.58	http://www.leroymerlin.pt/Site/Produtos/Madeiras/Vidro/Acrilico/11517310.aspx
PMMA	0.137 m^2	Provided	Manuel (ISEP)
Plastico Autocolante Black and White	4	5.72	http://www.mundoescolar.pt/catalogo.aspx?id=1904&idcat=216&pag=1&pesquisa=
Nylon mesh	1	Provided	Abel (ISEP)
Clear plastic tubing	1.5 meters	Provided	Abel (ISEP)
UHU Allplast	1	4.00	Papelaria Nova Técnica

Table 24 - The list of electronic components

Component	Quantity	Image	Price (€)	Source
16 x 2 I2C LCD Display	1		8.50	https://www.electrofun.pt/display-lcd-16x2-com-i2c-verde
Arduino Uno	1		Provided	ISEP
Luminosity Sensor Breakout - TSL2561	1		6.50	http://www.botnroll.com/en/sensors/942-luminosity-sensor-breakout-tsl2561.html?search_query=TSL2561&results=2
DHT22 Temperature & Humidity Sensor	1		9.80	https://www.electrofun.pt/sensores-arduino/sensores-termicos-e-humidade/sensor-humidade-temperatura-dht22
12 V PC Fan	1		Provided	ISEP
Resistors	4		0.20	http://www.botnroll.com/en/resistors/929-resistor-1m-w.html?search_query=resistor&results=85
NPN Transistor	2		0.98	https://www.electrofun.pt/transistor-tip120-npn
Wiring	2 spools		0.50	http://www.botnroll.com/en/cables/199-fio-laranja-02mm.html

Capacitors	4		0.60	http://www.botnroll.com/en/capacitors/1326-condensador-electrolitico-220uf-10v.html?search_query=capacitor&results=45
LED Strip	3		8.88	http://pt.farnell.com/optek-technology/ovm12f3w7/led-3-strip-white/dp/1840458?ost=OVM12F3W7&searchView=table&iscrfnonsku=false&ddkey=http%3Apt-PT%2FElement14_Portugal%2Fsearch
Arduino Power Supply AC/DC 230 VAC/12 V 2 A	1		7.50	http://www.botnroll.com/en/power-supply-ac-dc-12v/477-alimentador-ac-dc-12v-2a.html?search_query=12V+POWER+SUPPLY&results=57
ULN2003 Stepper Motor Driver Board	1		3.40	http://www.botnroll.com/en/dc-motors-actuators/2137-uln2003-stepper-motor-driver-board.html?search_query=ULN2003&results=7

Table 25 - Shipping costs

Supplier	Costs (€)
Bottnrol	3.70
Electrofun	3.20
Mundo Escolar	1.32

Table 26 - Total costs “EscarGO”

Total	95.53 €

7.8 Electronic Architecture

The electronics schematic is shown in Figure 52.

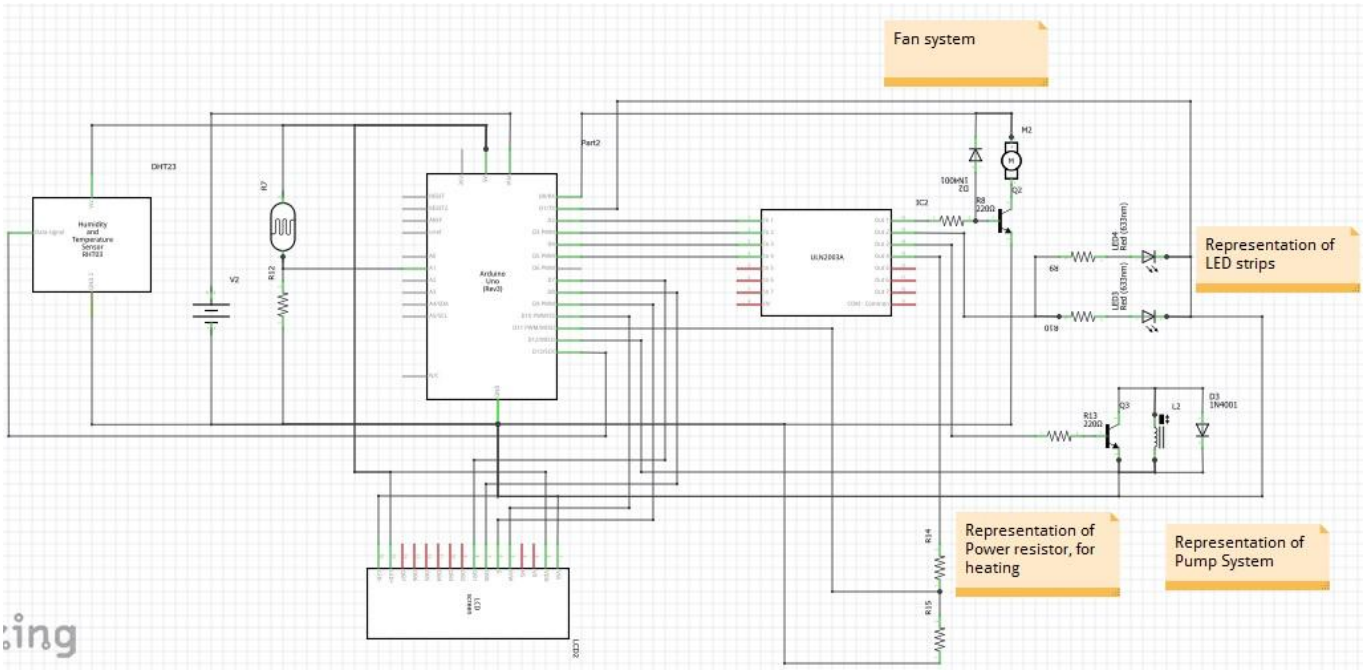


Figure 52 - Electronic schematic (41)

7.9 Conclusion

The product development section is the most important part of the project. This is where the design of the product is produced. The team has created various 2D and 3D designs, as well as produced a 3D model out of cardboard. This section is where all the materials have been narrowed down and chosen. The team did research on the materials that have been chosen to make sure that the materials are fit for purpose, and also to make sure that the electronic components are capable of what is required of them.

Bibliography

[1] World Health Organization, 2014. *Frequently asked questions on genetically modified foods.*
[2] June Eric Udorie, 2015. *Social media is harming the mental health of teenagers. The state has to act.*
[3] USDA, 2016. *Giant African Snail FAQs.*
[4], **[15]** Croque bourgogne, 2016. *Quelles sont les différentes espèces d'escargots comestibles?.*
[5] Firebox, 2017. *Grow Your Own Escargot.*
[6] Aqueon®, 2017. *Aqueon® Glass Aquarium.*
[7] Zoo Med™, 2017. *Zoo Med™ ReptiHabitat® Bearded Dragon 40 Gallon Terrarium Kit.*
[8] All Living Things®, 2017. *All Living Things® Hermit Crab Habitat Kit.*
[9] biOrb®, 2017. *biOrb® FLOW 4 Gallon LED Aquarium.*
[10], **[12]** Joseph R. Cobbinah, 2008. *Snail Farming in West Africa, A Practical Guide.* CTA, pp.31-33.
[11], **[13]**, **[14]** ChangeTHIIIIIS®, 2017. *biOrb® FLOW 4 Gallon LED Aquarium.*
[16] T.R. Fasulo G.W. Dekle, 2014. Brown Garden Snail, Cornu aspersum. *Entomology and Nematology Department*.
[17], **[19]** Plant Pest Surveillance Unit, 2014. *Cornu Aspersum.*
[18], **[20]**, **[21]**, **[23]**, **[24]** Annie Guillier Luc Madec Armelle Ansart Robert Cowie, 2015. *Cornu aspersum (common garden snail).*
[22] Ben Onwuka Adri Vink Dr J.R. Cobbinah, 2008. *Snail farming, production, processing and marketing.* CTA, pp.39-46.
[25] Ben Onwuka Adri Vink Dr J.R. Cobbinah, 2008. *Snail farming, production, processing and marketing.* CTA, pp.25.
[26] Ben Onwuka Adri Vink Dr J.R. Cobbinah, 2008. *Snail farming, production, processing and marketing.* CTA, pp.62.
[27] A. John Arnfield, 2016. *Köppen climate classification.*
[28] David Lubell, 2004. Are land snails a signature for the Mesolithic-Neolithic transition?. *Department of Anthropology*.
[29] B. Murphy, 2001. *Breeding and Growing Snails Commercially in Australia.* RIRDC, pp.9.
[30] Ben Onwuka Adri Vink Dr J.R. Cobbinah, 2008. *Snail farming, production, processing and marketing.* CTA, pp.50.
[31] B. Murphy, 2001. *Breeding and Growing Snails Commercially in Australia.* RIRDC, pp.21.
[32], **[33]** Touchstone snails, 2016. *Curtain method.*
[34], **[35]** ISO, 2015. *ISO 9000 – Management de la qualité.*
[36] Akuma Geijutsu, 14 February 2016. *MSSTRAM Session 3: PESTLE Analysis.*
[37] Caracooles, 26 July 2013. *¿En qué paises se consumen caracoles?.*
[38], **[40]**, **[41]**, **[49]** Piraeus Bank, 2017. *Snail Farming Economic Analysis Unit and Sales Piraeus Bank.*
[39], **[42]** Aristotle University of Thessaloniki, 2013. *Feasibility Study for snail breeding units 2013.*
[43] M. Z. Balti} Olgica Dragicevic, 2005. *SNAIL MEAT – SIGNIFICANCE AND CONSUMPTION.* pp.473.
[44] *The Living World of Snails - Snail Cultivation (Heliciculture).* 2017.
[45], **[47]** AGRO-SERVICES / APIA, Frebruary 2005. *Etude sectorielle : l'élevage d'escargots.* pp.203.
[46] Economic Rome Embassy of Greece, Commercial Affairs Office, 2011. *The industry of heliciculture Italy 2011.*
[48] Alimentación y Medio Ambiente - Gobierno de España Ministerio de Agricultura y Pesca, 2015. *Informacion del Sector Ganadero Helicicola.*
[50], **[51]** Touchstone Snail Franchise, 2017. *Touchstone Snail Franchise.*
[52] School of Agricultural Technology, 2011. *Technological Educational Institute of Crete.*
[53] Ministry of Rural Development, Food Directorate General of Animal Production, 2012. *Snail*

farming in Greece 2012.
[54] PopulationLabs, 2017. *France Population Map.*
[55] The National Institute of Statistics, Economic Studies (INSEE), 01/17/2017. *Demographic balance sheet 2016 - Fertility indicators, metropolitan France.*
[56] The National Institute of Statistics, Economic Studies (INSEE), 01/17/2017. *pyramide-des-ages-2017, metropolitan France.*
[57] The National Institute of Statistics, Economic Studies (INSEE), 01/17/2017. *Age structure on January 1st, 2017 - Metropolitan France.*
[58] *La consommation française d'escargots.* 2017.
[59], **[60]**, **[73]**, **[74]** FrenchKPI, 2014. *Snails Production And Trade In France.*
[61] Joshua J. Yates, 2012. Abundance on Trial: The Cultural Significance of "Sustainability". *THE HEDGEHOG REVIEW*, 14.
[62] Twink, 2014. *Environmental Sustainability.*
[63] Center for Environmental Health, 2012. *Important Things to Know About Landfill Gas.*
[64] Twink, 2014. *Economic Sustainability.*
[65] *Growing a Sustainable Economy.* 2016.
[66] Loiret, 2014. *Les trois piliers du développement durable.*
[67] Université de Versailles, 2011. *Les piliers du développement durable.*
[68] *Tour d'horizon des enjeux des 3 piliers du développement durable.* 2016.
[69] Olivier Réthoré, 2011. *L'Analyse du Cycle de Vie (ACV), outil préférentiel de quanification des impacts environnemtaux.*
[70] ChangeTHIIIIIS, 2014. *Snails Production And Trade In France.*
[71] VNG, 2016. *Levenscyclus analyse.*
[72] Les Cahiers du Développement Durable, 2016. *L'Analyse du cycle de vie d'un produit ou d'un service.*
[75] OVAM, 2017. *Ecolizer.*
[76] Gouvernement du Québec, 2017. *Code of ethics of engineers.*
[77] Christelle Didier, 2007. *Le dilemme éthique de l'ingénieur : loyauté ou alerte ?.*
[78] *Distinction entre éthique et déontologie.* 2001.
[79] AAPQ, 2016. *L'éthique et la déontologie.*
[80], **[81]** CNISF, 2017. *Charter d'Ethique de l'Ingénieur.*
[82] MSG, 2016. *Ethics in Sales and Marketing.*
[83] Willis Turner, 2016. *Ethics in Sales and Marketing.*
[84], **[86]** *Ethical Marketing.* 2016.
[85] Chron, 2016. *Ethical Practices in Sales & Marketing.*
[87] Rinkesh, 2016. *What are Environmental Ethics?.*
[88] Robin Attfield, 2014. *Environmental Ethics: An Overview for the Twenty-First Century.* Polity Press.
[89] Andrew Brennan, Yeuk-Sze Lo, 2015. *Environmental Ethics.*
[90], **[92]** *TFD.* 2016.
[91] *Civil liabiliy.* 2016.
[93] Denis W. Stearns, 2001. *An introduction to product liability law.*
[94] *Arduino UNO Rev3.* 2017.
[95] *Arduino Nano.* 2017.
[96] *Arduino Micro.* 2017.
[97] Government of the Netherlands, 2017. ***Government promotes sustainable food production.***
[98] ANDREW PERRIN, OCTOBER 8, 2015. Social Media Usage: 2005-2015. Pew Research Center - Internet, Science & Tech.
[99] *ESCARGOTS À LA BOURGUIGNONNE - Gourmet.* AUGUST 1949.

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