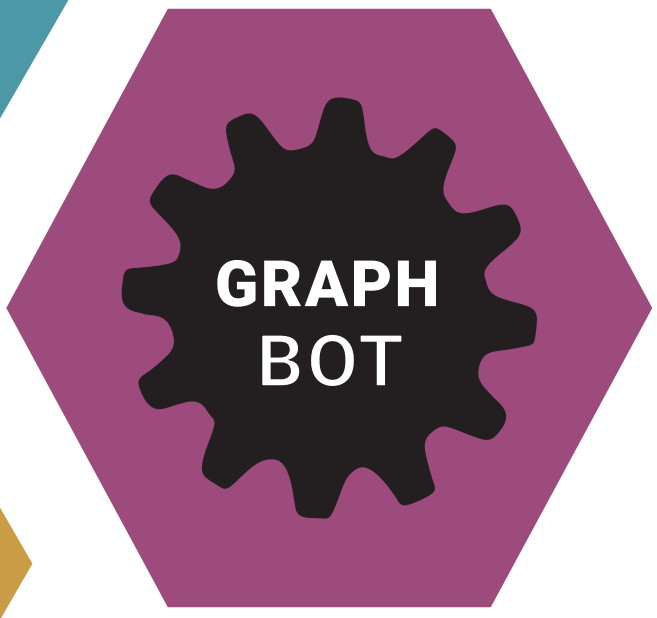
April 2016

Interim report EPS 2016



Robotic Art Team 1

IT sector

Authors:

Adam Dziomdziora, Daniel Nicolae Sin, Fraser Robertson, Mikko Mäntysalo, Nona Pattiselano

isep Instituto Superior de **Engenharia** do Porto

Acknowledgements

We would like to thank all EPS-teachers for their support, feedback and guidance of our project.

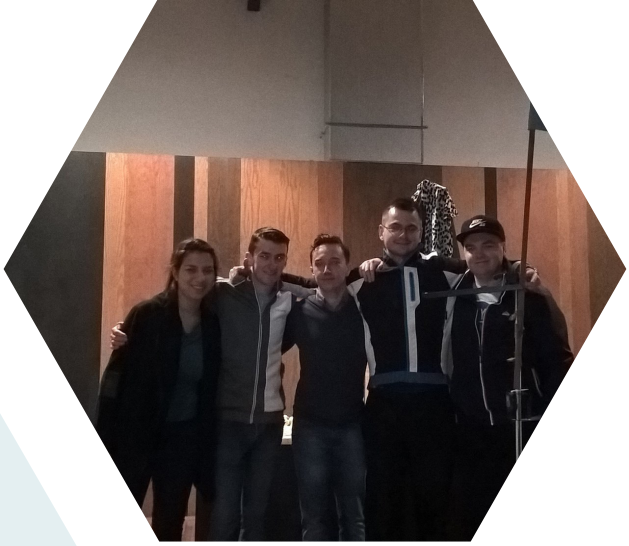
Index

List of figures

List of tables

Glossary

Abbreviation	Description
EPS	European Project Semester
STEM	Science, Technology, Engineering, Mathematics
SWOT	Strenghts Weaknesses Opportunities Threats
WBS	Work Breakdown Structure



Primeiro EPS tribo

Table 1: Introducing the team

	Mikko	Adam	Daniel	Fraser	Nona
Studyfield	Power Systems Engineering	Information Technology	Mechatronics	Electrical, Electronic and Energie Engineering	Industrial Design
Country	Finland	Poland	Romania	Scotland	Belgium

1 Introduction

1.1 Presentation

Our team consists of Adam Dziomdziora, Daniel Nicolae Sin, Fraser Robertson, Mikko Mäntysalo and Nona Pattiselano. We are five students with the following study fields: Information Technology, Electrical, Electronic and Energy Engineering, Power Systems Engineering, Mechatronics and Industrial Design (see table 1) . We are an international team coming from Poland, Scotland, Finland, Romania and Belgium. Our team name is Primeira EPS tribo. We are collaborating all our knowledge to bring this project to a good end. Our main team values are support, fun and memories.

1.2 Motivation

The development of this robot is an opportunity to learn more about robotics and programming. The team already has some limited experience with Arduino, but has never touched upon a project of this size. As future engineers this project is very interesting as robotics is an up and coming market. The specific skills acquired in our different studies comply with this project. The development of a drawing robot while regarding marketing, project management, sustainability and ethics still remains a challenge. It is never easy to work in a team. This team consists of people with different cultural and study backgrounds, making it even harder. This is however also an advantage. The team has the chance to learn a lot from each other and by sharing their knowledge work towards a common goal: bringing this project to a good end.

The main goal of the graphbot is to introduce girls to technology from an early age. This could inspire them to get into technology and later study in a STEM-field. Besides that the robot should be a creative tool to express yourself. Both girls and boys could use the graphbot. People who are limited in their movement could also use our graphbot to create art.

1.3 Problem

The task is to design, develop and build a robot that creates art. The team decided to build a drawing robot commanded by voice for children. The robot should be able to change the pen it is using in order to be able to draw in different colors. The robot has to go forward, backward and change the direction. The area of drawing is limited to the paper. The robot is intended for children to introduce them in technology

1.4 Objectives

The objective is to develop a drawing robot for children. The robot has to be able to recognize simple voice commands and respond accordingly in a timely manner. The graphbot should be user-friendly and childproof. It has to be easy and clear how one must use the robot. The drawing area should be detected automatically, ensuring the robot does not draw on the floor or table. The user should be able to change the drawing color with ease.

1.5 Requirements

The robot should:

- Move on a plane
- Work with distinct colors
- Be aesthetically pleasing
- Allow changing the drawing paper
- Have as maximum dimensions 1.00 × 1.00 × 0.80 m
- Reuse materials if they are provided
- Use low cost hardware solutions
- Use open source software
- Comply with the Machine (2006/42/CE 2006-05-17), Electromagnetic Compatibility (2004/108/EC 2004-12-15), Low Voltage (2014/35/EU 2016-04-20), Radio Equipment (2014/53/EU 2014-04-16) and Restriction of the use of certain Hazardous Substances(ROHS) EU Directives.

1.6 Functional test

In order to evaluate the work that was done certain functional tests must be performed. These have to give the team some insight in where the drawing robot can be improved.

- Test if the robot responds timely to all different voice commands
- Test if the speed is sufficient
- Test if the robot can change the colors automatically
- Test if the robot can detect the edge of the drawing area and responds accordingly
- Test the usability of our graphbot

1.7 Project planning

Any project has to be planned carefully. In order to achieve a good planning we are given some classes in project management. The first task given to the team was to make a WBS. Besides this a Gantt chart was also made in which one can see the planning and progress of our project. The project planning is discussed more thoroughly in chapter 3: Project Management.

1.8 Report structure

Chapter	Title	Description
1	Introduction	Presentation of the team, project and main goals
2	State of the art	Analysis of the existing products
3	Project management	An overview of how this project was planned
4	Marketing plan	An insight in the marketing situation and implementation of our product
5	Sustainability	How does one make the graphbot more sustainable?
6	Ethics	The ethical concerns regarding our product
7	Project development	The progress of the project
8	Conclusion	This chapter discusses the project and all future possibilities

2 State of the art

2.1 Introduction

This chapter shows the work that we did as a group when researching products already on the market which could be similar to our own final design and ultimately selecting the path that we thought would be most beneficial to us and the customer. We researched the existing products in this market and compared them. In the conclusion the choices that were made regarding our project are described.

A drawing robot is a machine that can draw. In our project we will use a pen or marker to create art. In other robots you can also find the use of paint. The robot should be able to hold a pen and move it over a surface. The input could be given by various actuators. It could be by an existing drawing, a picture or a person controlling it. In some cases the robot draws on its own.

2.2 Existing products

When researching existing types of drawing robots, we discovered that there are many of these types of devices already on the market, which are being used by artists, companies and by the public and are intended for people interested in robots or the arts.

One of the most commonly used products of this kind that is used mainly in manufacturing processes and some arts is the robotic arm. Probably the first method which comes to mind would be that of the robotic arm which, if constructed correctly, can perform drawing tasks smoothly and precisely.

Another form of robotic art which is commonly used in society is the drawing robot which travels on wheels. This consists of a robot with 2 wheels and the pen attached at the front so that the device is stable and can travel around the paper freely but has no particular precision when drawing.

An uncontrollable method of drawing on paper using a robot is that of a vibrating robot. These gadgets are used by some but not particularly by artists as they have virtually no control over what is being drawn.

One of the less well known methods of robotic art is the Egg-Bot. Although this product is not used for writing on paper on a flat surface, it allows the user to draw on objects that are almost impossible to accurately draw on.

A method that we carefully considered for our project was the spider robot which had four poles, one in each corner of the table or work surface, and string attached to each which all were attached to a pen or marker in the centre of the paper. This type of of drawing robot was considered as it would be relatively easy to construct with four motors controlling the length of the strings. The pen would be controlled by the string attached to each corner either lengthening or shortening depending on where the user would want the pen to be on the paper.

The last type of robotic art form we looked at was the printer robot. Basically, this type acts in the same way as a computer printer but would allow the user to print on any type of surface.

Another choice we had to make was the type of input we would use to command the robot to perform certain tasks. There are many ways in which humans can interact with robots, but we researched four of the most popular and easily usable command methods for our project.

The method of communication that we will use is sound. Whether it be words, tones or decibel levels, sound is the easiest way to communicate as we can easily express what are we attempting to say so that other humans or robots can understand and respond in the correct manner.

When the use of sound cannot be used effectively, gestures can be used to communicate between humans and robots if a camera is linked to the robot. This means that the camera can recognise certain gestures performed by a human and pass the information onto the robot to perform the tasks already set in the programming stage.

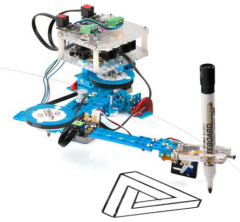
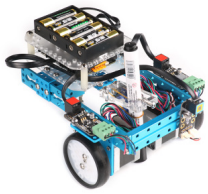
A camera which is attached to the robot can also be used to recognise colours that are placed in front of it. The different colours of paper, cardboard etc. can be used to signal a different command which will be carried out by the robot.

The last method of interacting with the robot that we investigated was the smartphone application. This is probably the most up-to-date method of communication as smartphones have only became reasonably priced for the public for around 5 years or so. The application would show several buttons on the screen with commands for the robot to perform which the user would only have to select.

2.3 Comparison

Once we had researched all available possibilities which appealed to the group in terms of the structure of the robotic drawing device and and the type of input that would be used to command the robot, we could then compare them against each other in terms of advantages, disadvantages, the parts used for construction and the cost of the materials. These construction and input methods appealed to all of us as they instantly took our interest, they were aesthetically pleasing stationery and when in motion, they were challenging so we could gain a sense of satisfaction when completing the project and they all would provide a good service to our customers. Tables 2 and 3 were created to collect all of this information for an easy comparison on all subjects.

Table 2: comparison of existing drawing robots

Method	Advantages	Disadvantages	Materials and Cost	Links
Arm 	The robotic arm would be fairly simple to construct. Many different materials can be used which gives a variety of options. The robotic arm design is aesthetically pleasing in the way it moves and performs tasks if constructed properly.	The materials that are used for the construction of the arm can be expensive to purchase from local providers. If not constructed correctly, the movement of the arm can be sudden and jittery. The arm can only reach a certain radius when in use.	Meccano, MeArm, 50/100 €	http://www.makeblock.cc/mdrawbot-kit/
Wheels 	The wheeled construction of the drawing robot can operate over a large area on a flat surface. The base would not cost very much to buy or construct along with the electronics. The base is simple to build with the correct components. The Arduino board would be easy to program for the functions the robot is to carry out. With the wheels, the device can move freely around a plane.	The wheel method can also be less precise when in use compared to the arm and other methods. One of the drawbacks of the wheel method is that changing the colour of the pen could prove to be difficult.	2 wheels, 3 motors, 30 €	http://www.makeblock.cc/mdrawbot-kit/

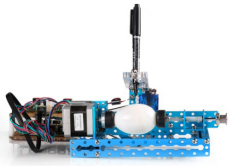
Vibration 	The vibration technique for the robot could turn out to be easy to make and relatively cheap.	The vibration of the device causes it to be unable to continue is a single direction steadily. It is almost impossible to control the movement of the device. The device has extremely random movement which would not be suitable for creating art.	Vibration motor, 13 €	http://www.instructables.com/id/Drunken-drawing-robot-/
EggBot 	The egg method allows the user to be able to print on difficult surfaces. The structure of the device allows the painting of Easter eggs to be carried out very easily.	This type of drawing machine can only draw on a limited number of objects.	Motor x2, Pen positioning system, Egg holder, Microcontroller, 20 €	http://www.makeblock.cc/mdrawbot-kit/
Spider 	The spider device can cover a vast area of a plane if long enough strings are used. This method can be used on a horizontal or vertical plane.	Drawing in the corners of the page could prove difficult. If a four string system is used then it would be hard to calculate the length that some strings would need to contract or expand.	Motor x4, Pen holder, Strings x4, System to attach at end of canvas, Microcontroller, 14 or 28 €	http://www.makeblock.cc/mdrawbot-kit/
Printer 	The printer drawing robot can provide a good level of precision. The drawing time will be decreased if many of the same drawings are to be printed.	The construction of this robot would be very complex. The cost of the materials could be increased as at least 3 motors would need to be purchased. The programming would be extremely challenging.	Mechanic materials	http://www.chinahae.com/product_yc-s25op-state-of-the-art-technology-wall-printer-for-individuality-home-decoration_13988.html

Table 3: comparison of input methods

Method	Advantages	Disadvantages	Materials
Sound	Using sound could be easier for the user as it requires little effort to give commands. Anyone of all ages can give commands easily. When using sound recognition, many different sounds can be programmed into the system.	Some accents may not be compatible with the system. The system may not be able to function properly in a noisy environment.	Microphone
Gesture	There are a lot of instruction pages online to help us with the programming. It is a fun and interactive way to give commands to the robot.	A lot of materials and parts are required to create this system. It would be very tough to make this system function properly. The materials for the structure would be very costly.	Camera
Camera	The camera can recognize the gestures given. Can recognize colours that are placed in front of the camera.	It would be very costly to make. Detecting multiple objects can be difficult for the system. Can only operate in an environment with a lot of light.	Camera
Application	The application for smartphones method would have good precision when drawing.	The app for the system would be very time consuming and complex to create and link with the drawing device. A smartphone would be needed to command the drawing device.	Smartphone, Bluetooth module for robot

2.4 Conclusion

After comparing these sets of methods of construction of the drawing robot and the way in which it receives a command, a final decision could be made on what direction the project would be heading in.

The robot structure that the team decided on using was the wheels method in which the device can move around on a plane on wheels with a pen attached to the front of the device. We decided this was the best solution for the task as the device can draw over a large area on a plane. The base of the robot would be easy to build and relatively cheap to buy the parts for with the correct components. The programming of the robot would be easier than that of the other options and with the wheels, the device can move freely around the paper. The materials for the whole robot would be within our budget as well which may not have been the case for other options.

We also decided that sound would be the best option for the input to command the robot. This is the best option as it can be used by people of all ages and fun can be had when using the system to create drawings. Also, if we allow the user to create their own commands for the robot then this can add to the feeling that they have created something special.

The next chapter to be discussed is that of project management and how the project manager must handle all aspects of the project from defining the project scope to the planning of each part of the project.

3 Project management

3.1 Scope

In Project management defining the project scope is the most important part. If it is not clear what has to be delivered to the customers in the end and what the boundaries are, the chance of failure will be high. In most of the instances, there actually is no chance to success with this unorganized approach.

The project is to make a robot that creates art through sounds. The robot has to work by following conditions:

- Move on a plane
- Work with distinct colours
- Be aesthetically pleasing
- Allow changing the drawing paper
- Have as maximum dimensions 1.00 × 1.00 × 0.80 m
- Reuse the provided materials
- Use low cost hardware solutions
- Use open source software
- Comply with the Machine (2006/42/CE 2006-05-17), Electromagnetic Compatibility (2004/108/EC 2004-12-15), Low Voltage (2014/35/EU 2016-04-20), Radio Equipment (2014/53/EU 2014-04-16)and Restriction of the use of certain Hazardous Substances(ROHS)EU Directives.

The project deliverables are:

- Interim Report
- Interim Presentation
- Leaflet
- List of Materials & Components
- Final Report
- Final Presentation
- Paper
- Poster
- Manual
- Video

This is Figure 1, presenting the Work Breakdown Structure of the project.

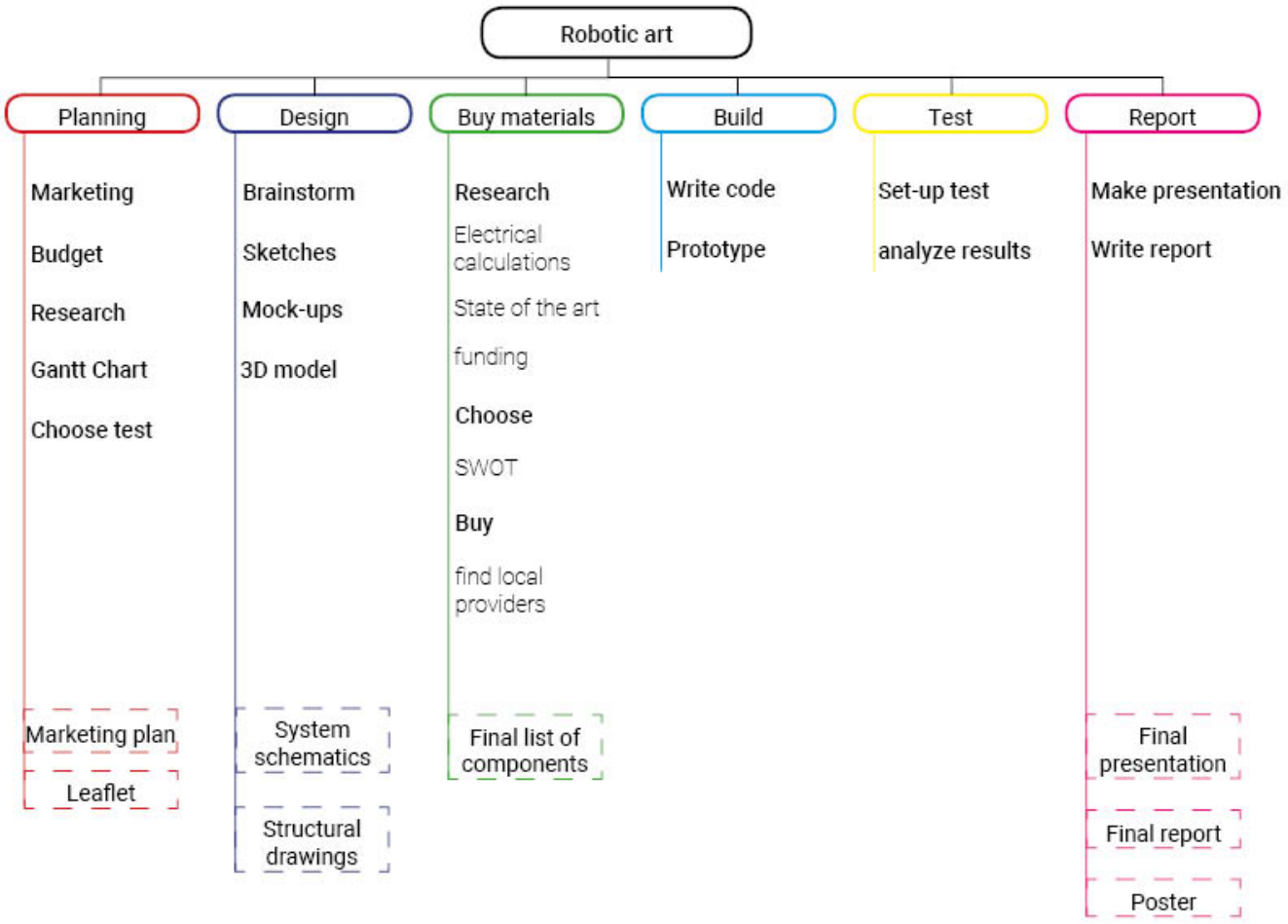


Figure 1: Work Breakdown Structure diagram

3.2 Time

In order to illustrate the project schedule, decision was made to use a Gantt chart. It is commonly used in project management to create a clear structure of the steps which have to be taken in a specified amount of time.

The Gantt chart has been created in MS Project 2016.

It shows the timeline from Mon 29.02.16, up to Tue 28.06.16, when all of the tasks will be finished.

This chart allowed the team to instantaneously check at which stage of the project team members are, if they have any delays and what our next steps are.

The Gantt chart is presented in Figure 2.

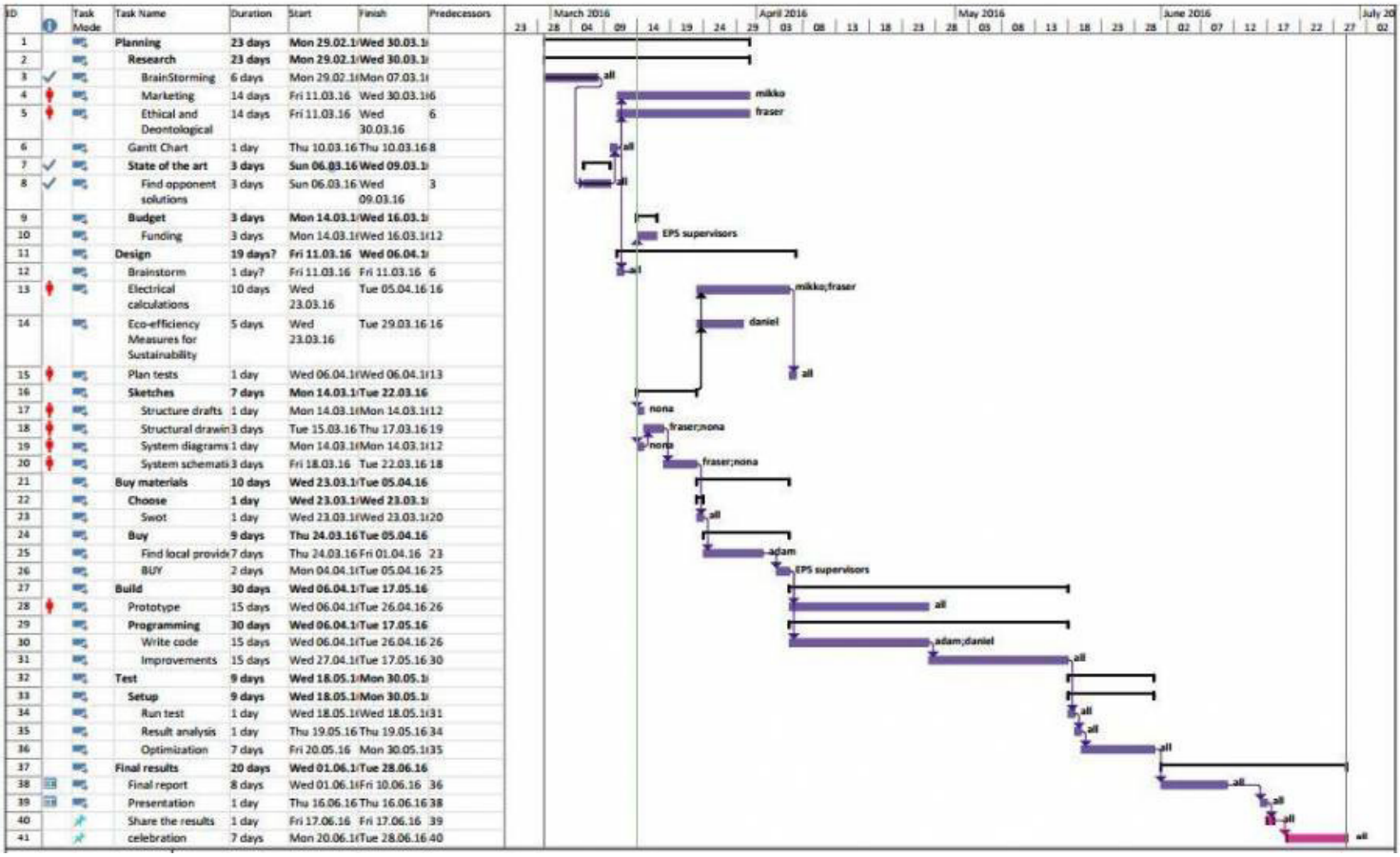


Figure 2: Gantt chart

3.3 Cost

Project Cost Management includes the processes required to ensure that the project is completed within the approved budget. There are 4 processes in this knowledge area including:

Resource planning: Resource planning involves determining what physical resources (people, equipment, materials) and what quantities of each should be used to perform project activities. It must be closely coordinated with cost estimating.
The budget for this project is 150 € which is to be used for materials and components to complete the prototype.

Estimating Costs: Cost estimating involves developing an estimate of the costs of the resources needed to complete project activities.

Cost budgeting: Cost budgeting involves allocating the overall cost estimates to individual work items in order to establish a cost baseline for measuring project performance.

Cost control: When choosing or making changes in the components to our project we have to take into consideration the quality of the products and the price so we stay within the budget limits. Also the stakeholders have to be kept informed and they have to give permission for us to go ahead with changes in cost. We do not want to make irrational decisions about cost changes without consulting everyone in the process. Then when changes have to be made we make sure to record everything correctly in the cost baseline.

A list of the components for the graphbot can be found below in Table 4.

Table 4: Component list

Component	Quantity	Description	Price
Small Reduction Stepper Motor	1pc	Motor for pen switching	6,46€
Motor Driver L298N	1pc	Driver for DC motors	3,99€
3 Wheel Robot Kit	1set	Platform for the graphbot with wheels and motors	20,17€
EasyVR Shield 3.0	1pc	Voice Recognition shield for drawing commands	59,9€
Battery holder	1pc	For battery placement and connection	5,17€
9V Battery	1pc	Power supply for the graphbot	1,85€
Bread Board	1pc	For connecting the circuit	0€
Reflectance infrared analog sensor QRE1113	1pc	Drawing area detection	3,00€
Arduino Uno R3	1pc	Motherboard for the control system	22,45€
Standard wires	1set	For connecting the components	3,99€
Force springs	4pc	Springs for the pencils	0€

3.4 Quality

In order to deliver a high quality project, following issues have to be concerned:

Customer Satisfaction

Customer must feel that the final product meets their needs and way of production fulfils his expectations.
If not, the customer is very likely to consider the project quality as poor, regardless of what the project manager or team thinks.

Inspection, testing, requirements

Monitoring deliverable to evaluate whether they comply with the project's quality standards and to identify how to permanently remove causes of unsatisfactory performance.

Continuous Improvement

Continuous improvement is simply the ongoing effort to improve products, services, or processes over time. These improvements can be even really small, not always major or breakthrough
The customer is most likely to buy a product, which is maintained and improved continuously.

3.5 People

People management or human resources is a part of every project planning. Tasks are assigned to single team member but every group member will be available to assist others if needed.

3.5.1 R&R

R & R it is relation between each process & role conducted by team members and responsibilities accordingly. It enables the team to obtain a motivation and it enhances the performances. I addition, R&R supports project management very well.

Table 5: R&R Matrix during Graphbot development

Task	Adam	Daniel	Fraser	Mikko	Nona	All	Supervisors
Brainstorm						R	A,C
State of the Art			R			I	A,C
Structural Drafts					R	I	A,C
System Diagrams					R	I	A,C
Structural Drawings					R	I	A,C
System Schematics			R	T		I	A,C
List Of Materials	R			I			A,C
Mechanical construction		R			T, I		A,C
Electrical assembly	T	T	R	R			A,C
Programming	R	R	T	T			A,C
Marketing Plan				R	R		A,C
Project Management	R			R			A,C
Eco-eficiency Measures for Sustainability		R					A,C
Ethical and Deontological Concerns			R				A,C
media & leaflet					R	I	A,C
Proposed Solution						R	A,C
midterm presentations						R	A,C
final report						R	A,C
final presentation						R	A,C
Functional Tests						R	A,C
Materials research	R			T			A,C
Bibliography chapters						R	A,C

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

3.6 Communications

Communication management takes into consideration the information flow related to every issue connected with the project between a entire team. Moreover, communication is an essential part of conducting business, and therefore the team is using various methods to communicate in a workplace.

Face-to-Face Communication

Most of the time a communication is based on meetings. This type of communication takes place at least once a week, but nowadays often everyday.
Moreover, every week the meeting with supervisors takes place on the project problems and we strongly believe that face-to-face communication is the most efficient way to work.

Mobile phone

If any urgent or important situation appears, in order to collect all the members quickly and inform about the situation, calling or sending SMS is the best method.

Email

Email is a preferred method of communication with supervisors as team can discuss with them our doubts and issues at anytime.
In behalf of portal Office 365, we have obtained a possibility to fast & easy email whoever team need to.

Facebook

It is cheap, user friendly and furthermore it is a fast way of communicating with each other. Nowadays it is the most popular online social networking service, and often most of us has it connected on our mobiles.

Here is table 6 presenting our ways of communication

Table 6: Communication matrix

What	Who	How	When	Why	To whom
Weekly supervisors meeting	Team	Meeting in F503	Every Thursday	To evaluate progress and discuss	Supervisors
Team meeting	Team	Facebook/ mobile	Every day	To discuss and develop the project	Team
Weekly performance assessment	Team	Meeting	Every week	To monitor and execute project development	Team
Contact with direct supervisor	Team	Email/meeting	In an urgent situation	To obtain additional feedback, discuss problematic situations and improvement the project	Direct supervisor
Interim deliverables	Team	Presentation/ Wiki report	22th April 2016	To present current project advancement and part of finished work	Supervisors
EPS classes	Teachers	Classes	Every day	To pass necessary knowledge and provide additional information for further project development	All EPS students
Material list feedback	Teachers	Email	Every time after sending some compulsory part of work	To show the place for an improvement and provide feedback each component	Team

3.7 Risk

The benefits of risk management in projects are huge. There is a lot of money to be gained uncertain project events are dealt in a proactive manner. This will result in minimizing the impact of project threats and seize the opportunities that occur. This allows to deliver the project on time, on budget and with the quality results that the project sponsors demand.
Project risk management in its entirety, includes the following six process groups:

- Planning risk management
- Risk identification
- Performing qualitative risk analysis
- Performing quantitative risk analysis
- Planning risk responses
- Monitoring and controlling risks

Table 7 shows the risk management.

Table 7: Risk management table

Description	Cause	Effect	Trigger	Response	Owner	Last review	Threat level
Broken components	Using in improperly way	It will not be possible to build the prototype	Overheating / bad data	Discuss with the professor of ordering new materials	Fraser	14 April 2016	Medium
Team members getting sick	Virus / Bacteria	Will slow down the work rate and possibly even cause missing deadlines	Team member feels bad	Others have to step in and take the extra work	Sick team member	14 April 2016	Medium
Not meeting interim delivery deadlines	Laziness / problems with research	The grades will be lowered	Not completing previous milestones	Plan well ahead to avoid these situations	Adam	14 April 2016	Low
Faulty components delivered	Transporting without protection / production error	Can't build the prototype on time	Obtaining bad result in microphone	Demand new parts from the sender	Mikko	14 April 2016	Low
Prototype will not work	Bad planning / lack of knowledge / bad calculations	Project failure	Bad results during the tests	Discuss with the teachers about new solutions and avoid this situations with careful planning	all team members	14 April 2016	Low

3.8 Procurement

Procurement management is designed to support an organization with saving a major part of the money spent on purchasing goods and services from outside. To achieve that, we have to compare the cost of all items against quality.

It is therefore obligatory to handle suppliers performance with precision, to ensure that they're deliverables meet our expectations. Although there may be several suppliers, who provide the same goods and services, careful research would show whom of these suppliers will give us the best deal for our project.

Due to restrictions we are only allowed to use local Portuguese providers. However, not all goods and services needed to be purchased from outside.

3.9 Stakeholders management

In Stakeholders management, we think of ways to keep stakeholders expectations satisfied. Stakeholders are those who are affected by or affect the results of the project. Making sure you meet deadlines and make a good quality product can be a part of stakeholder management. In our project there are different stakeholders in the university, with different expectations. In this chapter we introduce these stakeholders and their expectations. Our stakeholders are for this project, all the supervisors, the team members and also the university. Defining project stakeholders and making sure you understand the different expectations you can create a strategy to keep good relationships with the stakeholders. During this project our different teachers from Sustainability, Engineering ethics, Marketing & Communication and Project Management teach us how to do the reporting on the project and keep a close eye of the progress.

Table 8 shows the Stakeholders and figure 3 presents them in a graph defining power and interest.

Table 8: List of our Stakeholders with Power and Interest

Stakeholder	Role	Expectation	Power	Interest
Project team	Project planning and execution	Learn new skills and to make a product that works	High	High
Benedita Malheiro	Chief supervisor of EPS	Successful project and a good report	High	High
Teachers	Teaching important things on projects	Expecting the project teams to follow the subject guidelines on projects	Low	Medium
Supervisors	Supervise and assist the project development	That project teams meet the deadlines and complete a functional project	Medium	High
ISEP	The University	Expect that EPS students respect the rules of the university and complete the work	Medium	Medium

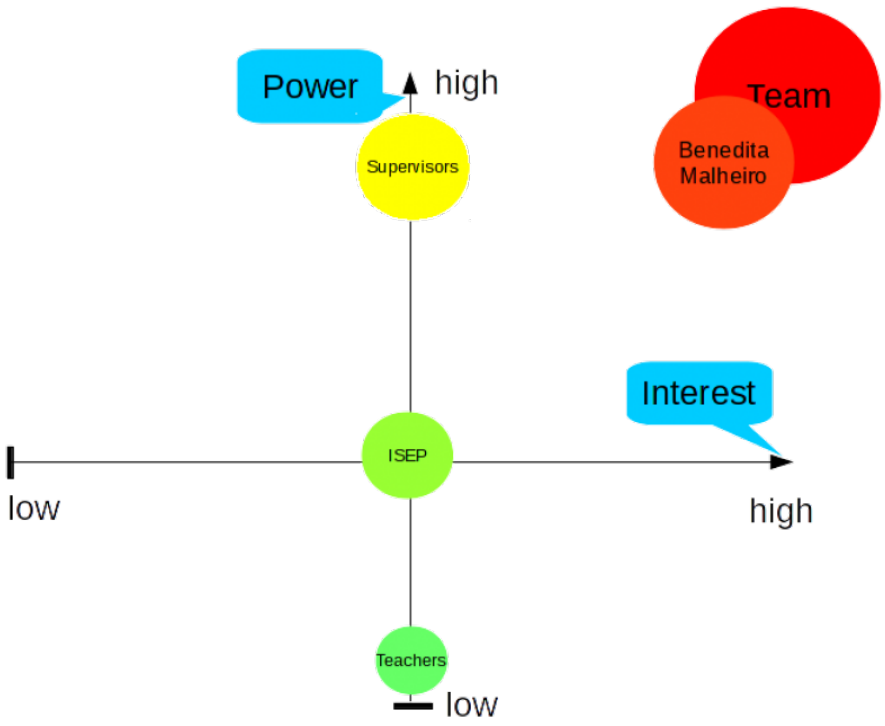


Figure 3: Stakeholders in comparing Power and Interest

3.10 Conclusion

Project Management is one of the main aspects of realization a project.

It is an important tool, which enables the team members or the project manager to

- measure the risks of a project
- analyze responsibilities of the people involved
- monitor the cost and the budget
- create the product requirements
- manage the duration and deadlines of the individual tasks

Most importantly, project management allows all of the people involved in the project to follow the daily schedule and monitor the deadlines.

Thanks to useful tools such as “Microsoft Project 2016” or a Gantt Chart, we were able to assign each task to a team member, set the proper deadlines and expected duration for each task and deliverable, and follow the completeness of our project.

This way, we are able to be up to date with all the tasks and organize our work well.

4 Marketing plan

4.1 Introduction

The decided target group and potential market are children. Within children the design is more specifically for girls. The idea behind this is to pick up on the trend to make technology more attractive for females. It is important to have more incentives for girls to get interested in technology such as robotics. The drawing robot will be sold as a toy for kids to get creative. In the following chapters you can read more about the research we have done regarding this aspect.

4.2 Market analysis

In market analysis the target group to whom the product is going to be offered to has to be specified. To do so an analysis have to be made of who would use the product and what is the competition. To start off with you should see at the latest trends in the market, general buying habits, changing technologies and competitor activity. So basically what customers want/need and what the competitors are offering.

More specifically:

- What products and services the target market is already using
- Which businesses are using the best marketing mix to provide these products and services
- If there are any shortcomings in these products and services that can be fixed to gain the attention of customers
- What external factors apart from competition and demand can affect the success or failure of the business (e.g. government economic policies)

4.2.1 Market situation

Nowadays parents are buying tablets and smartphones to children who are at very young age and they don't have as much different activities than children used to. They like to spend hours and hours playing video games and this can be a challenge in the project. Children have a lot of different choices to choose from and introducing new kind of toys to the market has to be very well marketed to gain the interest of children and their parents.

4.2.2 PESTLE - Macro Environmental Analysis

The PESTLE Analysis is a framework used to scan the organization’s external macro environment.

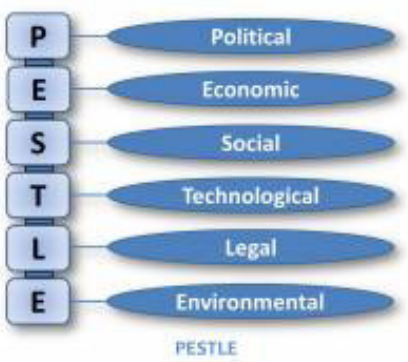


Figure 4: The PESTLE abbreviations

4.2.2.1 Political

The political aspect does not affect the production of this product much at all. The tax regulations etc. may have variations but it should not affect the sales or peoples buying habits.

4.2.2.2 Economic

Represent the wider economy so may include economic growth rates, levels of employment and unemployment, costs of raw materials such as energy, petrol and steel, interest rates and monetary policies, exchange rates and inflation rates. These may also vary from one country to another.

Even though the economic situation is relatively poor. There is a market for this product because people still can afford technology and have to have it.

4.2.2.3 Social

Represent the culture of the society that an organization operates within. They may include demographics, age distribution, population growth rates, level of education, distribution of wealth and social classes, living conditions and lifestyle.

Having in mind that the product is targeted to children, let us take a look at the social situation of children in Portugal.

In Portugal the economic crisis has halted a long-term gradual decline in both inequality and poverty, and the number of poor households is rising, with children and youths being particularly affected. Unemployment is one of the principal reasons why household incomes declined. [1]

Table 9: Age distribution

Country	People aged 0-14 (%)	Country Population
Portugal	15,9	10 427 301
Germany	13	81 459 000
Belgium	15,6	10 449 361
Finland	15,8	5 487 616

4.2.2.4 Technological

Technological factors refer to the rate of new inventions and development, changes in information and mobile technology, changes in internet and e-commerce or even mobile commerce, and government spending on research. There is often a tendency to focus Technological developments on digital and internet-related areas, but it should also include materials development and new methods of manufacture, distribution and logistics.

This is an important factor to the product since it is a new technological product for the market. There are printers etc. produced by the competition but the focus is on the voice recognition and having fun drawing for the kids. So this is a different approach with this technology than others.

4.2.2.5 Legal

There are no regulations that would deny the production of this product. But like all toys there are safety regulations and we have to take those into consideration in planning. Regulations: [2] The difference between Political and Legal aspects are that Political refers to people's attitudes and approaches and legal factors are laws and regulations.

4.2.2.6 Environmental

Can include issues such as limited natural resources, waste disposal and recycling procedures.

The graphbot's cover is made from recyclable parts and uses a 9V battery. This is important to people nowadays and in marketing this has to be told to the people. It is possible to recharge the graphbot with solar energy due to budgeting issues. Maybe newer versions of the robot could include a solar-charged one.

4.2.3 Micro Analysis

Micro environment factors, are factors close to a business that have a direct impact on its business operations and success. Before deciding corporate strategy, businesses should carry out a full analysis of their micro environment.

4.2.3.1 Suppliers

It is important to have good relationships with the material suppliers. It has to be made sure that services of the most reliable and good quality/price related components are used. Because if a supplier provides a poor service this could increase timescales or product quality.

4.2.3.2 Employees

Employing staff with relevant skills and experience is essential. This process begins at recruitment stage and continues throughout an employee's employment via ongoing training and promotion opportunities. Training and development play a critical role in achieving a competitive edge. If a business employs staff without motivation, skills or experience it will affect customer service and ultimately sales.

4.2.3.3 Shareholders

As organisations require investment to grow, they may decide to raise money by floating on the stock market i.e. move from private to public ownership. The introduction of public shareholders brings new pressures as public shareholders want a return from the money they have invested in the company. Shareholder pressure to increase profits will affect organisational strategy. Relationships with shareholders need to be managed carefully as rapid short term increases in profit could detrimentally affect the long term success of the business.

4.2.3.4 Competitors

Last but not least the competition. Competitors should be looked at carefully at all times. What they are promoting and what new are they bringing to the market and then working around that to getting the customers to buy your product instead of theirs. Competitor analysis and monitoring is crucial if an organisation is to maintain or improve its position within the market. If a business is unaware of its competitor's activities they will find it very difficult to "beat" their competitors. The market can move very quickly for example through a change in trading conditions, consumer behavior or technological developments. As a business it is important to examine competitors' responses to these changes so that you can maximize the impact of your response.

The biggest competitor for our company has to be Makeblock. They sell a 4-in-1 mDrawbot. [30] This is a drawing robot that can be assembled in different ways. The big difference is that our robot is not a build-kit. It's ready to use and will not take hours to assemble or program. Besides that the price they are asking for the kit is high ($229.99). Our product will be cheaper.

4.3 SWOT analysis

The SWOT analysis is a tool used for the analysis of a company. It consists of four points: Strengths, Weaknesses, Opportunities and Threats. The first two are internal, analyzing the company for its own strengths and weaknesses. The others, opportunities and threats, refer to the current business environment and are so external.

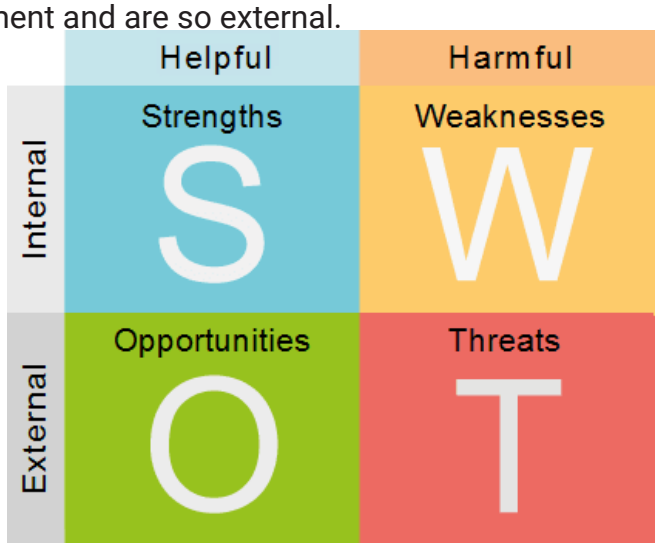


Figure 5: The SWOT analysis

The strengths of the team are innovation, diversity and ambition. The product that is under development is an innovation. There are few similar projects. This is a group of people with different backgrounds. This gives the group an advantage as it has insights in different markets. It is ambitious to prove it's skills and bring this project to a good end. The weaknesses are time and experience. The time given to complete this project is very short. Only a few members of the team have done a similar project. Furthermore the experience with robotics is limited. Fortunately there is good guidance from the teachers.

Opportunities in this project are plenty. The group is following up on a trend in selecting girls as the target audience. There is only a limited existing market for toys strongly linked with technology specifically for girls. There are similar drawing robots on the market, but none with voice control. This is a unique advantage. It also opens another possible market consisting of people with disabilities or injury's. The robot would make it possible for them to draw. The robot market is divided in industrial and service robots. The robot would be a service robot. This market has grown with 11,5 % from 2013 to 2014. [1] Since then it has only enlarged itself. Robots are more and more invading the daily life. They are no longer considered strange or something from the

movies. Threats are seen in the existing companies that sell drawing robots. They are however not very known to the big audience. Besides that there are some existing tutorials on how to make a simple drawing robot yourself. There is a certain skill necessary to be able to build a robot like this yourself, besides the time someone would have to invest.

4.4 Strategic objectives

Marketing objectives could be for example to raise the selling of a product by 5 percent in a target area where the company first campaigns product awareness to the public.

The objectives are simple. We want to find the children who like to get creative when they play. Have interest in new inventions and especially get girls more interested in engineering. This can be done by catching peoples attention and interest towards our product. This is intended to achieve by innovative advertising and introducing our graphbot as simple and fun as possible. The leaflet is an example of this. [3]

4.5 Segmentation

A segmentation of the market divides the market into segments, smaller groups of people with similar profiles. This makes targeting people with the same needs and wishes possible. Segmentation criteria vary for the product and main goal of the company. After segmentation the existing competitors can be easily divided over the market and see which groups they serve best. This enables the team to position the project on a segment that has not yet been spoken for. To fill this gap in the market the team must find the specific needs and wishes of these consumers and anticipate them. Other new products are also easier defined and positioned to fit in the existing market. Segmentation can be done based on demographical, geographical and psychographical aspects.

4.5.1 Demographical

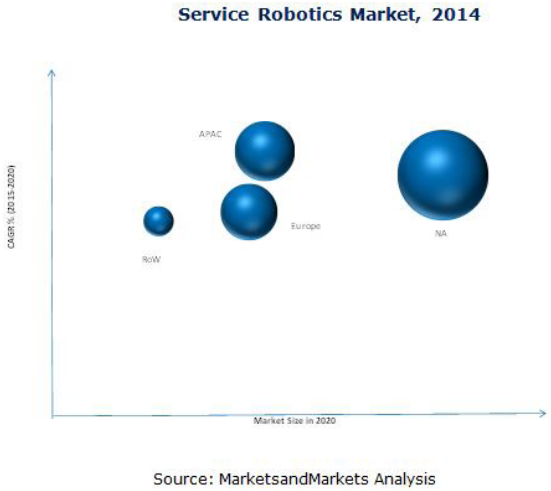
The main target group is girls aged from 6 to 11 years old. The goal is to combat the low proportion of women in technical occupations. A study has shown that more exposure to technology as a child will increase the chances of ending up in a STEM career. [2] Boys are of course not excluded but the main aim remains girls.

4.5.2 Psychographical

The aim is at a creative user group. Children that love creating things or drawing will be the primary goal. Children that like technology already will also be attracted to the product.

4.5.3 Geographical

The biggest share of the robotics market lies in industrial robots. Household robots are however starting to be more common. Think about automatic vacuum cleaners, mowing machines, medical assistance… The consumer-robot market is the fastest growing. Robots are less scary nowadays and will continue to conquer the daily life. Our product will be most successful in North America. The market in the U.S. is expected to grow tremendously.



Source: MarketsandMarkets Analysis

Figure 6: Service Robotic Market

APAC = Asia Pacific NA = North America RoW = Rest of the World

4.6 Strategy/positioning

A well-positioned company will beat the competition that has a comparable offering. The company that clearly articulates what it does, why it's relevant and how it's different, helps customers make better and faster buying decisions. Market positioning strategy can be based on following points:

- Identify advantages of the brand in relation to competition
- Choosing what to focus on
- Advertising these advantages in the most effective way

Let us take a look at the SWOT analysis. The team identified the strength of the brand being that it is unique through it's voice recognition controlling. It also opens a market to people who are disabled or with injuries to draw and have fun. But the main focus are young girls.

Pricing strategy research would focus on finding technological toys from the market that already exist and think about the pricing. Will the Graphbot be cheap enough and still entertain the buyers. The ideal pricing position would be there where the market has a gap. This is demonstrated in a picture below. The final price of the product is still to be determined.

Figure 7: Position research example

4.7 Adapted marketing mix

The adapted marketing mix means one must adjust the elements of the marketing concerning a certain product to reach an international target market. These elements consist of product, price, promotion and placement. Based on research one can adapt these to ensure the best sales in a certain region, such as Asia. Different cultural backgrounds, wages, needs… ask for a different marketing approach. This strategy will achieve a larger market share but in return it will also add to the costs.

4.7.1 Product

A product can be seen as the sum of different components. These components together construct an added value for its consumers and meet certain needs. Components are core values, additional features, look, packaging, service, warranty, size… The product is a robotic drawing toy. Its main features are comprehending voice commands, translating these commands to movement, moving on a surface, changing the pen, detecting the edge of the paper. The product is a drawing robot. It is designed to have two main settings. In the first mode the robot will draw random sketches and serve a pure entertainment function. In the second mode the user can control the robot with his/her voice. One can create images in different colors without having to touch anything. Consumers have the opportunity to draw anything that comes to mind using the robot. Drawing a straight line was never so easy.

4.7.2 Price

The price policy of the product is very important. It has a high impact on how the brand is perceived by the consumers. The team must consider several internal and external factors that influence the price. Internal factors are the marketing objectives, the fixed costs, the variable costs, the marketing strategy. External factors are the nature and demand of the market, the competition, the government policy, the economy, social concerns.

The best strategy for the product is Market Penetration. By setting a low price the robot will quickly enter the market. By the increase of sales volume, production and distribution costs will lower. This enables us to make a profit.

4.7.3 Promotion

Another part of marketing is promotion. How does the team make the target market aware of the existence of the graphbot? What message do the team wish to send the clients and what is the best method to get the message across? When targeting children it is very important to understand that most likely other people will buy it and not the child self. This is an important thing to keep in mind during the promotion process. Besides children the team must target parents, grandparent, aunts, uncles… The methods to reach people these days are very broad. Most effective is mouth-to-mouth promotion. Print promotion is the second option. Flyers, posters and so on could be very effective as the team can show some of the work. Radio promotion on the other hand will not be very effective. A television commercial could be very effective but costs a lot. Online marketing will also be very important. The team could organize drawing contests online. Promoting the product and challenging the existing customers. This is a new trend called “STATUS TESTS” [4]. The product already has a page on facebook [5]. The team could organize an online community where people exchange tips and show drawings. The product will definitely need a web page. An application that is compatible with (kids-)tablets could also ensure some promotion. Advertisement in magazines for children are also a good method. Direct marketing is another very effective approach. The team could organize events where people can test the product. This would also gain lots of attention. The team could give them the drawing they made with the logo or contact on it to ensure visibility.

4.7.3 Place

The distribution of the product is discussed in this subsection. The distribution policy should be carefully thought through as it has a major impact on the costs. It is obvious that besides online direct sales, the team should distribute the product through toy stores. Using indirect Sales has pro's and con's. Two pro's are the capability of mass-distribution and less organizational effort from the teams own company. A negative aspect of this is that the team don't control the sales activity and out dependent on the partners. It is however the best way to reach the target market.

4.8 Budget

The budget for marketing is 5000 €.

The first step to creating a solid marketing budget is to calculate the current financial situation. If the team works with estimates, the marketing budget will not be realistic.
Understanding the finances starts with organizing the revenue information. It needs to be known how much money the company makes each month and the variations that might exist. Even tough income can vary significantly throughout the year, the team must organize the information based on reliable revenue.
"Reliable revenue" is the minimum amount of money the company makes each month. Lowest monthly revenues should be used because the extra money that is made on another month is not reliable.
After organizing the total reliable revenue that can be expected to earn each month, expenses need to be substracted. The business expenses can include renting a space, the cost of materials, the cost of paying employees and advertising.
When the amount of disposable income available for the company has been determined, next should determined where the money will go. Marketing is only one area of focus that needs to be incorporated in a budgeting plan.
Divide up the money based on the goals. For example, if the primary goal is attracting clients and hiring is put on hold until the client base is stronger, then more money can be put into the marketing budget.

4.9 Strategy control

When setting any goals it is very important to also be able to monitor these goals. This is also the case for the marketing goals. One must check if the used strategy has the expected sales result. And if expectations aren't met one must find the cause and try to fix it. These inspections should be planned and reviewed. Most important is to control the efficiency of a certain method. Are the costs worth the benefit we receive from it?

4.10 Conclusion

As stated before the Graphbot is a unique technological toy for children and specifically for girls. There is nothing just like this on the market currently so a gap will be filled in the market. The Graphbot is a somewhat affordable and interesting toy for children to get creative and hopefully get interested in engineering.
For a long term possibly one can look at possibilities on developing the Graphbot further to get more functions for new models. In order to be the leading manufacturer of these type of technological inventions in the market.

In the next chapter Eco-efficiency Measures for Sustainability the reader will find information on the sustainability of the manufacturing of the Graphbot.

5 Eco-efficiency Measures for Sustainability

5.1 Introduction

Measure of sustainability generates value in technology and process changes whilst reducing resource use and environmental impact of the product life. Sustainability applies to all aspects of the project, from purchasing and production to marketing and distribution. Linking environmental and economic performance, sustainability is the first management concept. Implementing sustainability measures gives to the project a greater understanding of their activities. To use in the project eco-efficiency principles are profitable as they use less resources, energy and water, generate less waste, improve production methods, develop new products and use existing materials.[6]

The main issues of sustainability in the project are:

- To use low cost materials in small quantities;

- Choosing the best solutions of components to achieve the prototype;

- Using recycle materials like glass, rubber and plastic or wood;

- To implement a Life Cycle Analysis.

The aspects which are discussed in this project are:

- Environmental;

- Social;

- Economical.

5.2 Environmental

The environment must be a friend for everyone, so it should be kept as clean as possible. To achieve that in this project, it must be careful what materials it is going to use and what quantity. Energy saved is energy produced. This is a important detail to remember while speaking of conservation. To produce electricity is one of the most polluting activities. In this project it should to use materials which must be recycled, e.g. glass or rubber. Anyway, if it pay attention a little bit of conscientious saving energy, it could do an sustainable project friend with environment. Green electricity is electricity produced from sources that don't harm the environment.

The mobile robots is a good chalange for each engineers. The mobile robots is a young field. It is the roots include many engineering like mechanical, electrical, electronic and industrial design. Each of these fields are shared to all members of the team.

Below it is explaing advantage and disadvantage of proposal choise. The wood has many advantages and disadvantages as an engineering material. Firstly, wood is an environmentally friendly material and it is a renewable. Also, it has a high specific strength, that could be useful for the robot. Everyone knows as well that wood is not electrically and thermal conductive and that is good because it work with electronic components. Why it has decided to not use wood is that

the wood can’t be used at high temperatures because it is highly inflammable and whenever it is happening a short circuit of electronic components and the risk to burn is high and nobody want to happen something wrong with the costumers.[7]

As choise, the glass fiber could be as well for caseing. The glass fiber is high temperature resistance and it is non flammable. It has high resistance of corrosion but the disadvantages are: it is brittle, weak abrasive-resistance and it is expensive, for that, it has decided to not use it.

The cork, like wood, it is an environmentally friendly material and cork extraction process doesn't harm trees.[8] It can be installed on uneven surfaces. The great dissadvantage is that the sharp objects can punctuate or damage cork flooring surfaces and it has high costs to buy it as well and this is the reason why it is not using in this project.

The best chosie is plastic caseing. In this project it is going to use plastic because it can be easily moulded, high durability, it is recyclable and it is easy to have access on the 3D printer to create any shape which is necessary. That is the reason for which it has chosen the plastic as a material.

Save energy is important for environment and for that it discuss about energy conservation which means to decrease energy consumption using less of electrical energy. For example, if it useing the technology of solar panels instead of the battery, it will save the energy, but the costs will be quite different, this thing means that it will increase it. Even if energy conservation reduces energy services, it can result in increased environmental quality. It is at the top of the sustainable energy hierarchy. Preventing future resource depletion can reduce energy costs as well. In the result of calculations, using 9 V battery help to use the robot only for a limited period of time, but if it implement technology with solar panels it can fix it, but the cost will be higher to achieve that, but the customers will not have to change batteries so often.

It is important for the costumers to know how to use the graphbot. What it should do is to implement a user manual for this prototype such that the customers use it in a safe manner as to not overload the robot, because the risk of overheating and damaging it exists. Therefore it must be careful what it is going to use for casing materials.

5.3 Economical

The economic aspect of sustainable development can be seen as part of teaching and everyday during of the project. The greatest potential of this project consist in the saving of energy and other natural resources such as using woodcasing, also to learn principles of economy it become conscious to do what it want in the project. Economic and ecological sustainability in the classroom they may well support each other. For example, to decrease raw material or energy consumption is ecological and economical way to do sustainable action. Economical labels give information on low economical impacts of this product at the moment. The target of sustainability courses of these classroom is to teach how it should to identify the issues of these principles, attitudes and values, habits of consumption. It should to learn how to recognise motives behind advertising and it should to be able of interpreting, analysing and observing advertisements and other commercial messages in a critical way.[10]

Robotics has achived it is the greatest success nowaday in the engineering world. With this project it wish the econimical developement and raising the standards to deliver this prototype properly. The robots are the future and this project can help you to work further on this field because it is more applications in robotic domain.[11]

5.4 Social

Social sustainability is important to meet customer needs and the goals of the graphbot is to achieve this thing. It believe that the customers opinions are useful to develop this prototype and to increase the number of customers satisfied by the product it want to take a sounding of point of view which will contain the questions regarding of the product, and through that it mean the quality and what improvements should be made. The customers can contact on this facebook page: 'https://www.facebook.com/graphbot1/?fref=ts' and to improve the prototype is important clients feedback.

The product is addressed to certain types of customers such as families with children. It want to attract more children to be passionate about technology and his creation, so if children will be attracted of this product in the future, they will be passionate about electronic parts which it has been built this project. The success depends very much by the customer satisfaction, and customer satisfaction is the motivation to improve the competences in engineering as high as possible and to bring improvements to the product which we conceive it. To do that, it is going to develop the communication skills with the costumers so that this project will be sustainable from social point of view. Because it has a limited budget, it need to brainstorm about a starting price of graphbot to be accessible for everyone.

Social relations should not be established only between team members and customer, it must keep good relations with the local providers, so it has decided to operate with local suppliers, because the electronic components will reach us in time quickly and it's very important to save time.

Other type of social relations is between team members. It must to avoid any kind of misunderstanding and to keep a good relation because it is important to work together to achive this project like a team.

5.5 Life Cycle Analysis

To cover all issues of sustainability, it must implement a Life Cycle Analysis. At this chapter, it is going to analyse the whole product from how it has been created to recycling. For the beginning, it should to start with first stage. On the first stage it has focus on raw materials. The product is formed by electronic parts, chassis, wheels, pens and mechanical parts. All these components must be bought from Portuguese providers. It must to pay attention to report of quality and price and for that it has been decided to use low cost materials in small quantity.[12]

Design process

On the next step it gonna speak about design process. First of all, it should to draw the robot and to create a unique design made by self. It is going to try using less material because this robot should to be light to not drop from children hands. It should to have a beauty appearance to be attractive for kids and maybe it gonna use two choice of colour (one for boy and other one for girl). All design processes are mainly done by 3D software because it's easier to see on the computer how the graphbot model is looking.

Manufacturing and assembly

Let's go further to discuss about manufacturing. The term may refer to a range of human activity which it call teamworking. On this phase it should to take care how it is going to assemble all components to result final product. Assembly is the last phase before packaging and it must to take care how to connect electronic components inside in order not to be damaged when the children shake it.

Packaging

On the next phase it should to package the product and to send to the costumers. It must to be careful how it is going to package the final product to be transported safety. For that, it is using cardboards for pack and the robot is put on the protection foil to avoid being scratched. And how it said above, the robot will come with manual for user.

Use the product

Finally, the final product depend by the intensity of usage. In fact, this product is like toy for children. They need only few voice commands like forward, backward and something like that for play with it, but it will be mentioned in manual user. This step in the life of the graphbot is important, because if the costumer do not follow the correct instructions of the manual for user, the graphbot will not work properly.

End of life

In the end of the life of the product, it should to be recycled. Once the users decides that the robot is faulty, it can help them to fix the damaged components or to replace the faulty component without having to buy a new graphbot, just buy a new electronic part from local provider and bring the damaged part to be recycled.

5.6 Conclusion

This project can be a sustainable project because to build this prototype it is using low cost materials in small quantities but the final product is amazing and it can be attractive. If the robot is going to have a wood casing it will be more sustainable. In the next version of this project it can implement the solar panels instead of the battery but this version of the robot will have a rechargeable battery.

6 Ethical and Deontological Concerns

6.1 Introduction

Ethical concerns are problems which may arise that require a person or organization to choose between options which can be considered right or wrong in terms of how it affects people. Deontological concerns are similar in the way that they are defined by the morality of a choice by a person or organization over their duty to carry out specific actions. Both of these fields must be considered for every decision made by the team throughout the development of the project.

If each of these factors is considered throughout the process and carried out correctly, then the group can create and market a product which is attractive to customers. There are 5 main areas involved in the process of our project in terms of ethical and deontological concerns, and these are:

- Engineering ethics
- Sales and Marketing ethics
- Academic ethics
- Environmental ethics
- Liability

Each of these sections includes many different humanitarian and economic variables which must be taken into consideration when making decisions.

6.2 Engineering Ethics

Of all of the categories that are covered in the ethics topic, Engineering ethics is probably the most important and relative in terms of our project that we are creating and has the most effect on the public and their lives. All engineers and workers in related fields must ensure that their work is safe and complies with all health and safety standards related to their country.

Engineers are expected to fulfill these 4 acts when carrying out and planning tasks according to the Code of Ethics from the National Society of Professional Engineers[1]:

Ensure the highest level of safety, health and welfare of the public remains intact.
Perform tasks only in which they are qualified to carry out.
Carry out tasks set by employers or clients to the best of their ability.
Carry out tasks set in a responsible, ethical, lawful and honourable manner to ensure the reputation of the profession is heightened.
Each one of these acts has several rules which engineers and employees in related fields must abide by which can guide them to being ethical and lawful in every task they carry out.

Each member of the team contributed to the project in our own fields as we are most experienced within them and are comfortable working with the materials. This allowed the group to carry out the tasks set by our customer to the best of our ability to ensure they are happy with the final product whilst also sticking to the guidelines set for us.

In our project, the group had to ensure that the safety of everyone involved was of paramount importance when performing every task such as designing, building and testing our robot. Whenever the client or customer required something to be altered within the project either before or during the process, we had to do our best to accommodate their needs but also inform them if we thought it was not possible or there was a simpler, more effective way to achieve the same outcome.

6.3 Sales and marketing ethics

Within the sales & marketing section, there are six main categories in which ethical reasoning should be applied[2].

The first of these sections is the first step that should be taken in the marketing process which is research. The customers' details from the research stage must be kept private and destroyed when not needed anymore. Also, when researching other products, it is vital that none of the ideas or designs from previous products are used within our project as that would be plagiarising.

The professional conduct between the group and the customer must be performed in an ethical manner. Honest and respectful interactions must take place with the customer or client to ensure that they are receiving the product that they agreed to pay for.

In terms of competition within the market sector in which our product is placed, we must be ethical in the way that we promote fair competition with our competitors and fulfilling our obligations towards our competitors and customers in good faith.

Probably the most important aspect of the sales and marketing ethics subject for the customer is that of pricing. We must, when deciding on a price for our product, select a price which will give the group a profit but also will give the customer a sense of value for their purchase. As this product is aimed at children, it is very unlikely that they will purchase this product for themselves, therefore their parents will be the ones who decide to buy the product so we must give a sense of value to them as well as their children.

For the product that we produce from the project, we must ensure that it is safe to use for it's intended use. A set of instructions for the intended use of the product must also be provided to the customer to help them make the product function correctly.

Once the product has been created, the promotion of the product can begin. The product must be promoted honestly with no misleading statements or promises and only be promoted by highlighting the product's strengths and benefits to the customer.

6.4 Academic ethics

Academic ethics is the ethical code present in the field of Academic study. There are several fields within the ethics of Academia which include;

- The maintenance of Academic standards within a business or institution.
- The avoidance of cheating and plagiarism.

The definition of plagiarism is intentionally or unintentionally using someone else's work or thoughts without reference to the original author. The definition of cheating is attempting to present as someone's own work that one has not created by the person who is required to carry out the task or using improper means to pass an examination[3].

To prevent our team being accused of cheating or plagiarism, we had to all make sure that when we were researching ideas for the product, that we did directly copy another idea that had already been put into practice or to the market. Our aim is to be as original as possible when developing every stage of our project and product so that we are able to stand out from our competitors.

6.5 Environmental ethics

The subject of Environmental ethics refers to the relationship between human beings and the natural environment[4]. The issues that have been reported in the media worldwide in the past few decades are that of pollution of the air we breathe and the water in which our fellow creatures live due to the rise in global population, and the rapid depletion of the natural resources we use to power our planet[5].

For our project, we will do our utmost to ensure that we minimise our pollution levels when designing and creating our product. We will also attempt to reuse as many materials as possible to construct the robot to reduce the need for companies to create new components for projects such as this. In terms of the packaging for our product, we will attempt to create a fully recyclable design which will also be attractive for the customer. For the base of the structure, we will use plastic as it is 100% recyclable and therefore very sustainable for the environment.

The directive that must be followed in order to ensure the safety of the customer is that of Restriction of the use of certain Hazardous Substances(ROHS). This directive states that several hazardous substances are forbidden in the manufacturing of electronic and electrical components that may be used in a product like ours.

6.6 Liability

The last but not least of all of the categories of ethics is that of liability. Liability can be described as someone's responsibility for their acts or omissions which are against the law in in certain countries and also comes into effect in the instance that a member of the public's health or property is damaged by a company's actions or products.

In light of this, the group must make sure that we take care of everyone's health and welfare that are involved in the process of the project including:

- Group members
- Customers
- Supervisors

There are three types of liability that we must take into consideration throughout our project which are Civil, Criminal and Professional liability. These are used to ensure that the children using the product cannot be harmed so we had to make sure that there are no sharp edges or small loose pieces on the robot that the children could harm themselves with. The professional liability was our responsibility as we had to make sure that everyone in the group and involved in the process was safe when designing, creating and testing the product.

For our robotic art project, we have four directives which we must comply with to make sure that every section of the planning, designing, constructing, testing and delivering the product to the customer. These four directives are as follows:

- Machine (2006/42/CE 2006-05-17), which applies to machinery, interchangeable equipment, safety components, lifting accessories, chains, ropes and partly completed machinery.
- Electromagnetic Compatibility (2004/108/EC 2004-12-15), which regulates the electromagnetic compatibility of the equipment by ensuring the internal market functions by making sure that the equipment being used meets the required level of electromagnetic compatibility.
- Low Voltage (2014/35/EU 2016-04-20), which refers to guidelines relating to electrical equipment which operates between 50 V and 1500 V.
- Radio Equipment (2014/53/EU 2014-04-16), which establishes guidelines for putting into service and on the market in the Union of radio equipment.

6.7 Conclusion

After taking into account all aspects of ethics and deontology, the group as a whole now have a much clearer and broader perspective on how we should deal with decision making and the people involved with creating the finished product, especially the customer or client. The directives given in the specification that are to be followed have given us a guideline on how to conduct ourselves throughout the process of project. Each of the sections applies to everyone in the team including Engineering, Sales and Marketing, Academic, Environmental and liability ethics so we are all aiming for a common goal. If all of these aspects are adhered to, then the drawing robot that we create will be able to go on the market without any problems.

7 Project Development

7.1 Introduction

In this section the progress regarding the development of the prototype is discussed. The design process described here gives the reader a quick insight in how the team conceived a solution for the given problem. A lot of brainstorms about possible designs and weighing advantages and disadvantages of these designs took place before chosing the best possible solution for the graphbot.

7.2 Blackbox

The blackbox is a rough diagram describing the main functions of the robot. This diagram is presented in figure 8.

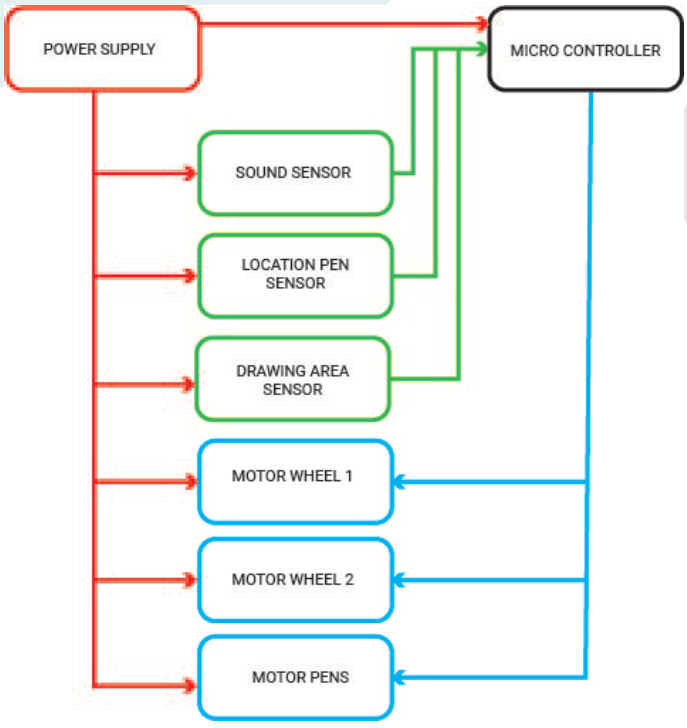


Figure 8: diagram with main functions

The power supply (red) is connected to every other component. They all need power to be able to work. The input consists of a signal from the infrared sensor, a signal from the microphone and a signal from the pen location sensor. These inputs (green) are connected to the micro controller. In the micro controller the data from the different input sensors is processed. The result of this data is translated to commands for the output (blue). So for example if someone says ‘forward’ the sound sensor will pick this up. It will send a signal to the micro controller. This signal will be translated and the micro controller will signal both motor wheel 1 and motor wheel 2 to start working.

7.3 Structural drafts and system diagram

The structural drafts and system diagrams are a search for possible solutions for the different design challenges. The structural drafts are drawings indicating different ways to form the structure of the robot. The system diagrams are schematics that show how the graphbot works regarding the electronic parts.

7.3.1 To enable the robot to change color

One of the commands that the robot must follow is to change the color it is using. A decision has been made regarding the drawing tools. The graphbot will use pens or markers with different colors. Pencils and crayons would need to be adjusted each time one draws with them. They would need to be sharpened after every use. This makes them unsuitable for this project. Paint is another option but causes a high risk of spillage, even more so because the robot is intended for children. The parents would most likely not be glad about this. The pens have to be placed on and off the paper. In the blackbox diagram 8 this is described as the pens motor.

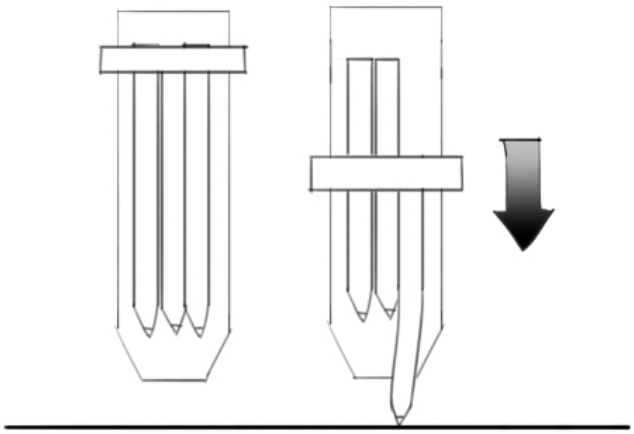


Figure 9: Four color pen method

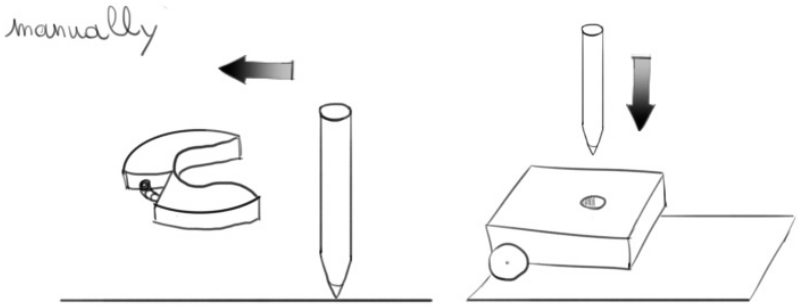


Figure 10: Manually change color

The first option (see figure 9) seen here is switching the pens the same way as the existing four color pen. The pens would have to be bendable. Besides that one could also choose to change the pens manually by attaching them to a clamping system (see figure 10). This is an easy solution, but also quite boring.

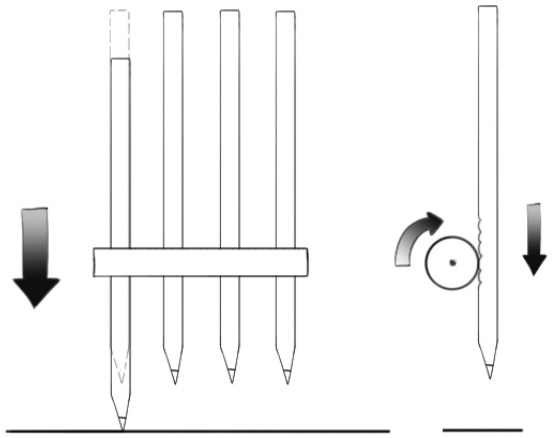


Figure 11: Roll down method

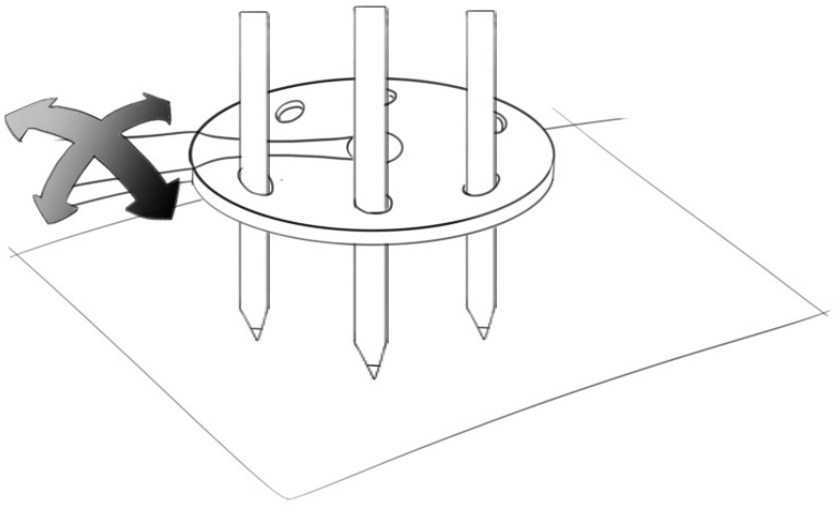


Figure 12: Rotation method

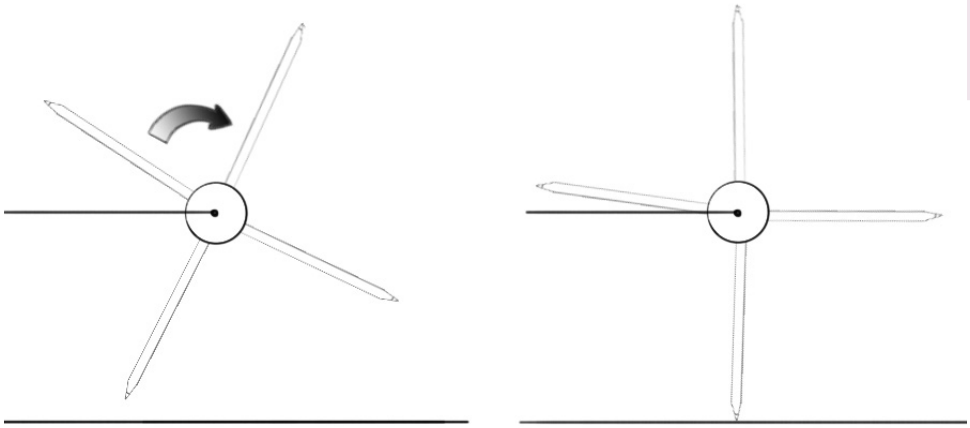


Figure 13: Wheel method

Another method (see figure 11) would be to have every pen rolled down at its turn. It would require at least one motor for every pen. Then one could also attach the pens to a system that can rotate in every direction as seen in figure 12. This would be difficult because one would have to get every pen to touch the paper at a good angle. The last option (figure 13) is a wheel with different pens on rotating to switch the pen. It would only require one motor.

In the following table (table 10) a trade-off between these different methods was made. The team has decided to pursue the last method (figure 13).

Table 10: Trade-off color change

Method	Description	Advantage	Disadvantage
1	4 color pen	It already exists, so it certainly works.	It's hard to implement. The pens have to be bendable.
2	Clamping system	Easy and cheap	Boring
3	Roll the pens down	Straightforward	It would need 4 motors
4	Rotating system	Looks cool	Hard to ensure the right angle on the paper
5	**Wheel**	**Innovative**	**Hard to ensure tight pen pressure on the paper**

7.3.2 Type of wheels

This paragraph discusses which type of wheels would be most suitable for the graphbot. In the blackbox diagram (figure 8) this is described as motor wheel 1 and 2. A comparative table was made (table 11).

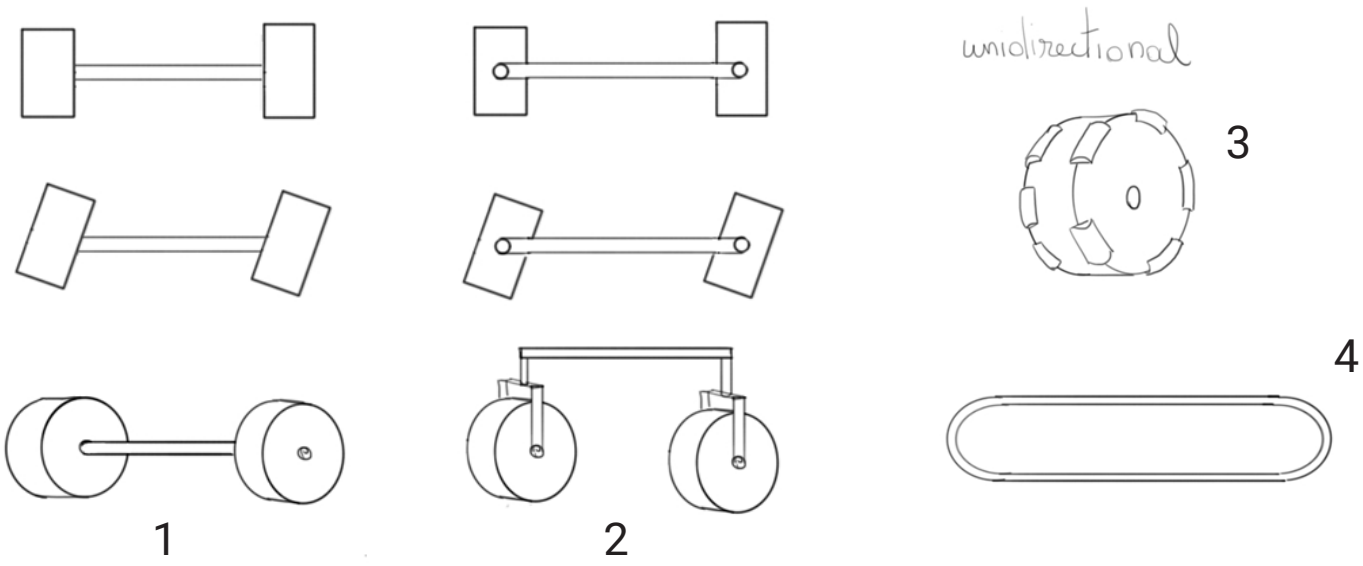


Figure 14:Type of wheels

Table 11: Trade-off type of wheels

Number	Description	Advantage	Disadvantage
1	**normal**	**common**	
2	universal		not so stable
3	unidirectional	easy to use	expensive
4	caterpillars	very stable	hard to turn

There has been decided to use the first type of wheels (marked as 1 in figure 14). Because the second wheels are less stable. Unidirectional wheels are too expensive and caterpillars are hard to turn. During the progress of our project it became clear that an extra turning mechanism was not necessary. By powering only one wheel we can make the robot turn.

7.4 Structural drawings

The robot is equiped with three wheels. Two are connected to a motor, the other is merely there for balance. The infrared sensor is place at the front side to detect the edge of the paper (see figure 15). The wheel with pens on is the system to change colors. It is connected to a stepper motor and, by rotating it, a different color will touch the sheet of paper.

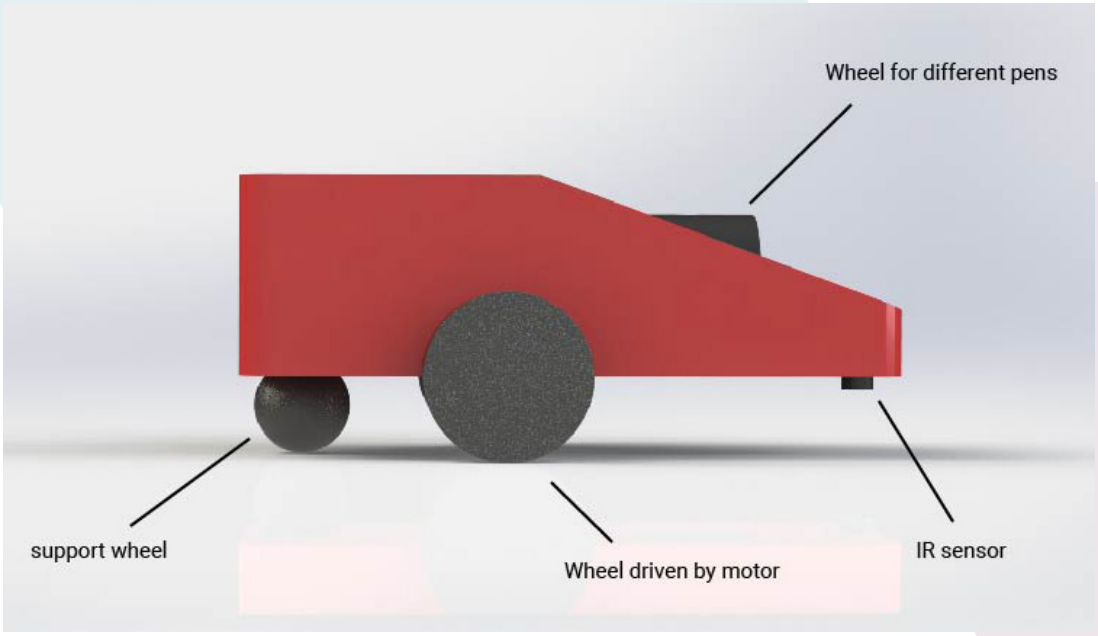


Figure 15: Side view of the graphbot

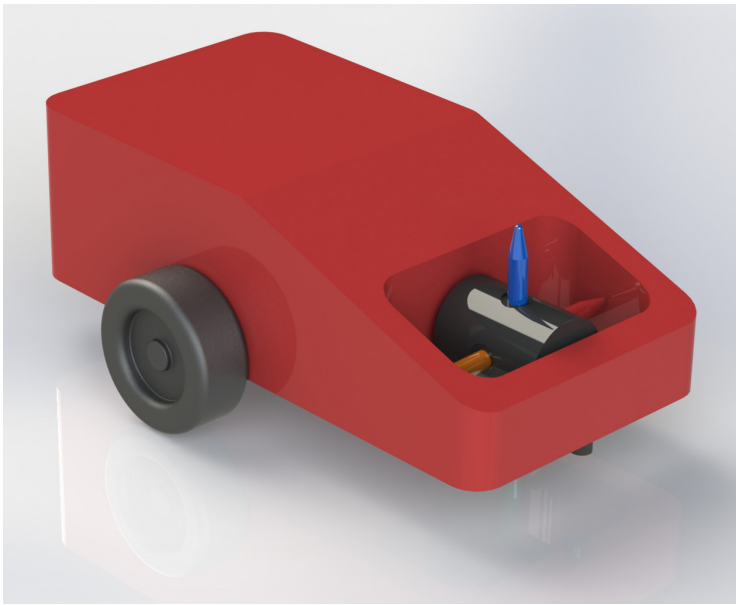


Figure 16: 3D view of the graphbot

To secure the different colors to the wheel there is a turning mechanism in the penholder, as shown here in figure 17. The pens will be developed especially for this robot. As explained in the marketing chapter they will be sold as collectables.

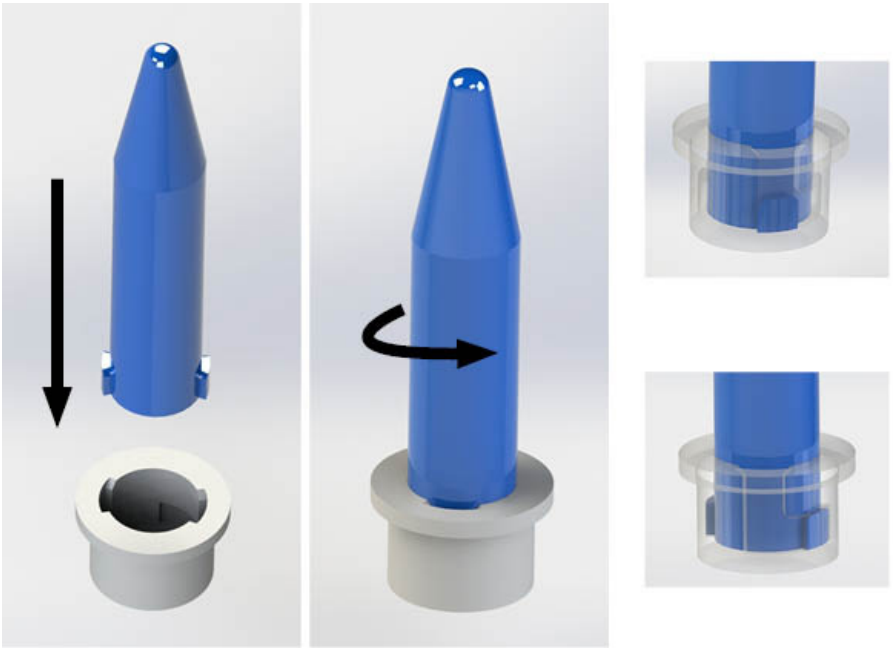


Figure 17: Penholder mechanism

To ensure the right amount of pressure while drawing there is a spring attached to the penholder. This will push the pen against the paper, as shown in figure 18. This wheel with pens on is connected to the stepper motor. The motor that will be acquired, has a flattened shaft and this fits into the wheel.

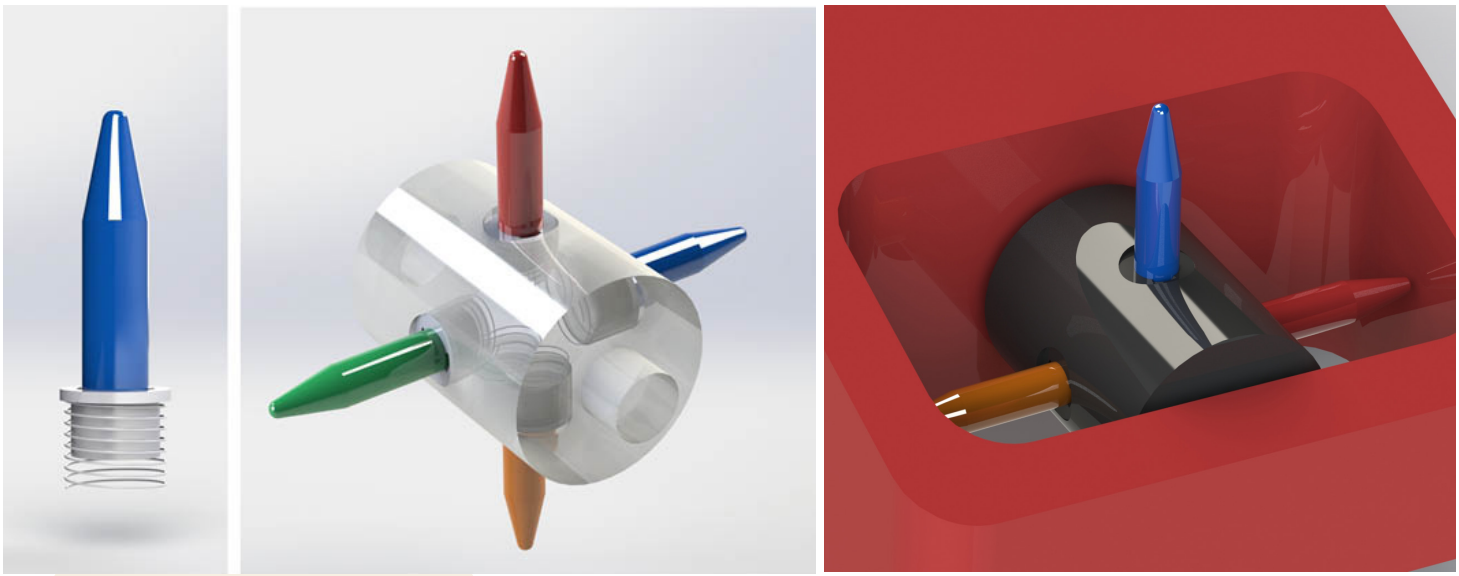


Figure 18: Pen color changing mechanism

For the support wheel a simple universal wheel has been chosen, as seen in figure 19.

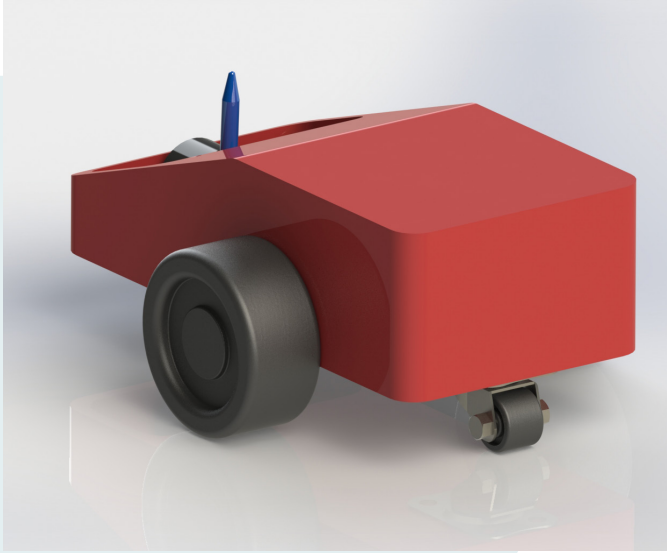


Figure 19: Support wheel

7.5 Architecture

To begin with Architecture of the project, handmade cardboard is presented in figure 20, showing future design of a Graphbot.

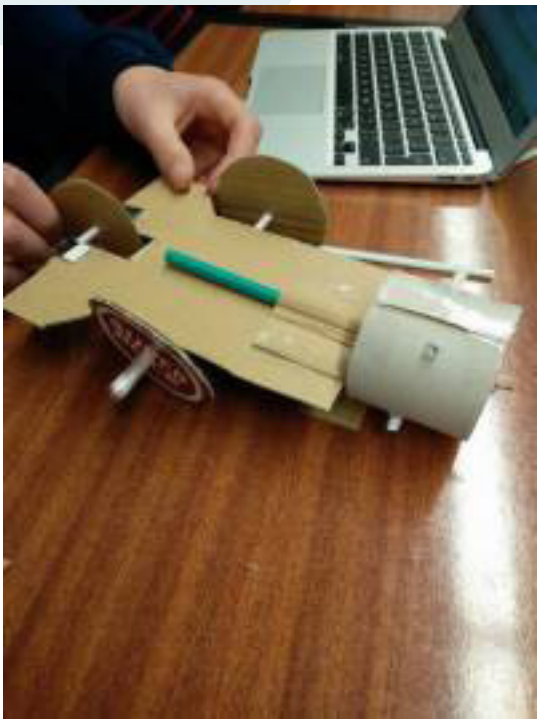


Figure 20: Cardboard model of graphbot

7.5.1 System Schematics

As far as the the EasyVR shield used to voice recognition is not available in the Fritzing program, ArduMoto has been used as it contains the same pins and layout as the EasyVR shield.

The breadboard, schematic, and PCB diagrams all show all of the electronic components that will be used in the construction of the Graphbot and how each component will be connected to allow the robot to function correctly. The 5 V stepper motor on the right side of the image is used to control the colour change of the pens in the Graphbot as it allows the pen wheel to rotate by a specific angle. The 9 V battery is being used as it allows to power all of the components that are being used when they are needed. The ULN2203A that the stepper motor is connected to is used to control the stepper motor just as the SN754410 is being used to control both of the DC motors which control the wheels. In the case that the Graphbot reaches the edge of the paper, the IR sensor on the bottom left of the breadboard will detect when the nose of the robot reaches the edge paper and give a signal to the motors to tell them to stop or reverse. The microphone that is located above the stepper motor on the breadboard schematic is used for the input to the system from the user. All of these components are connected to the microcontroller shield which is placed on top the Arduino Uno microcontroller. These microcontrollers can then be connected to a PC to allow the programming of the the components to carry out specific tasks within the Graphbot.

Here all the schematics are presented, one can find the Breadboard on Figure 21, System Schematics on Figure 22 and PCB on Figure 23.

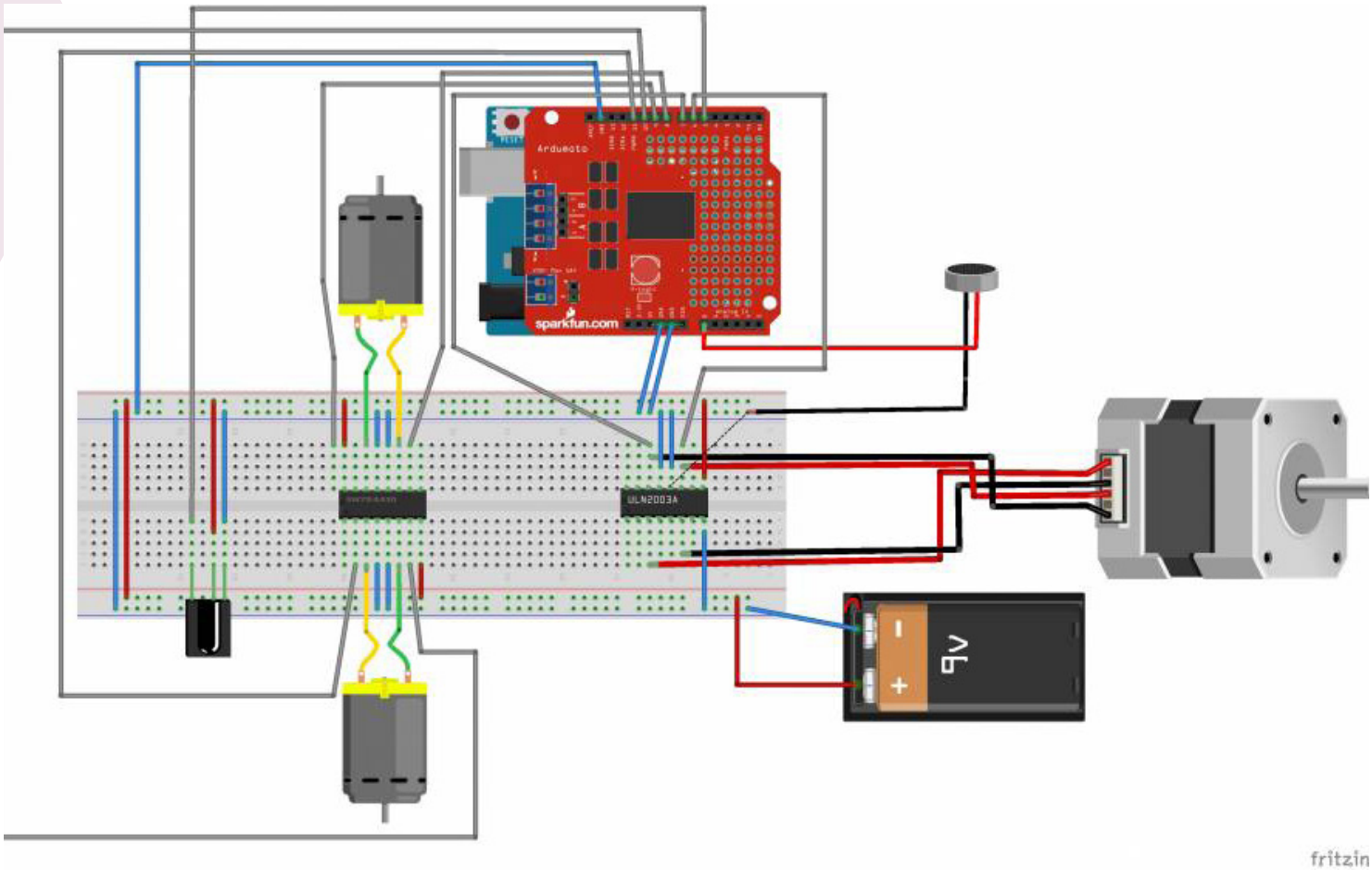


Figure 21: Breadboard schematic of a Graphbot

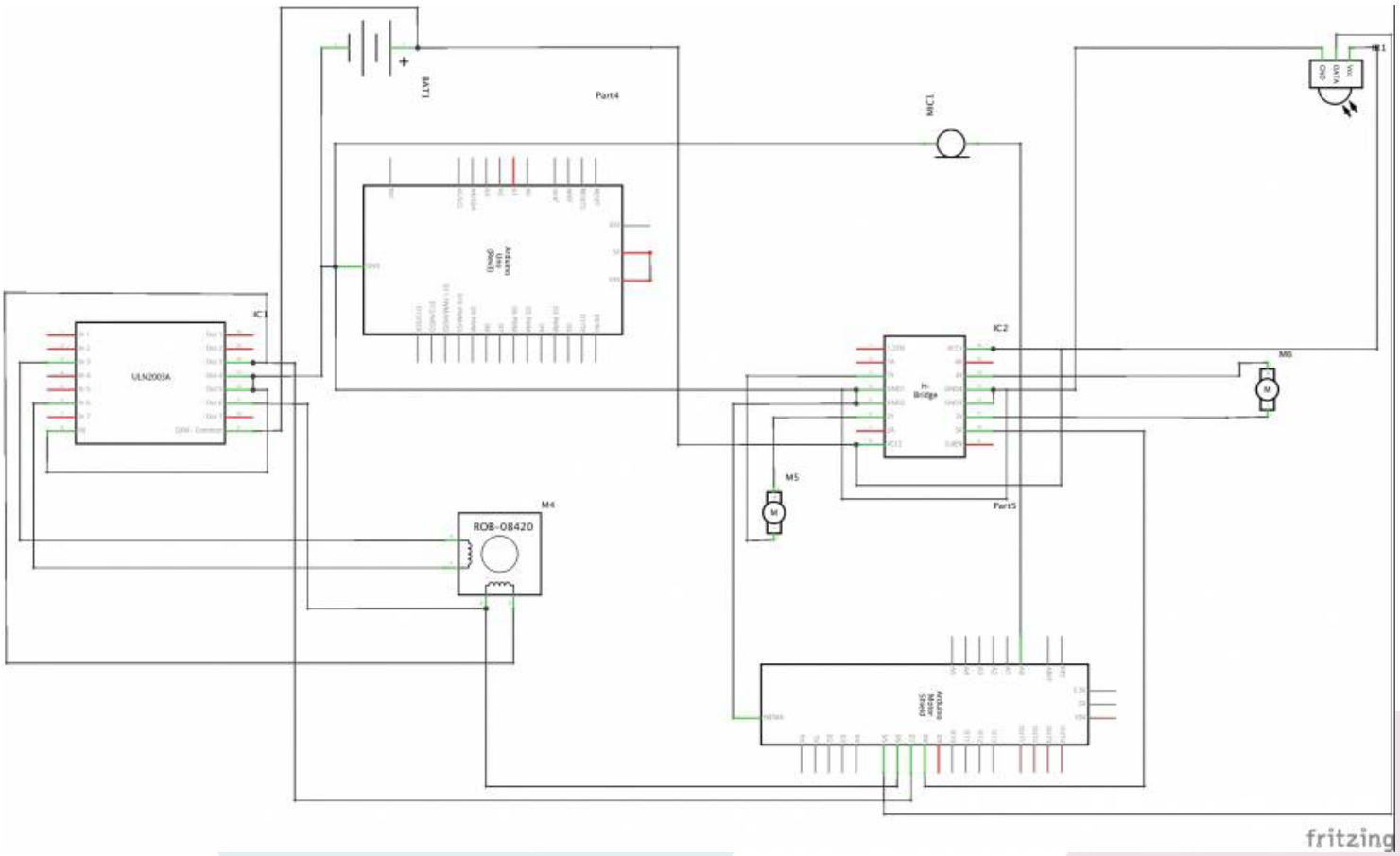


Figure 22: System schematics presenting electrical connections of Graphbot

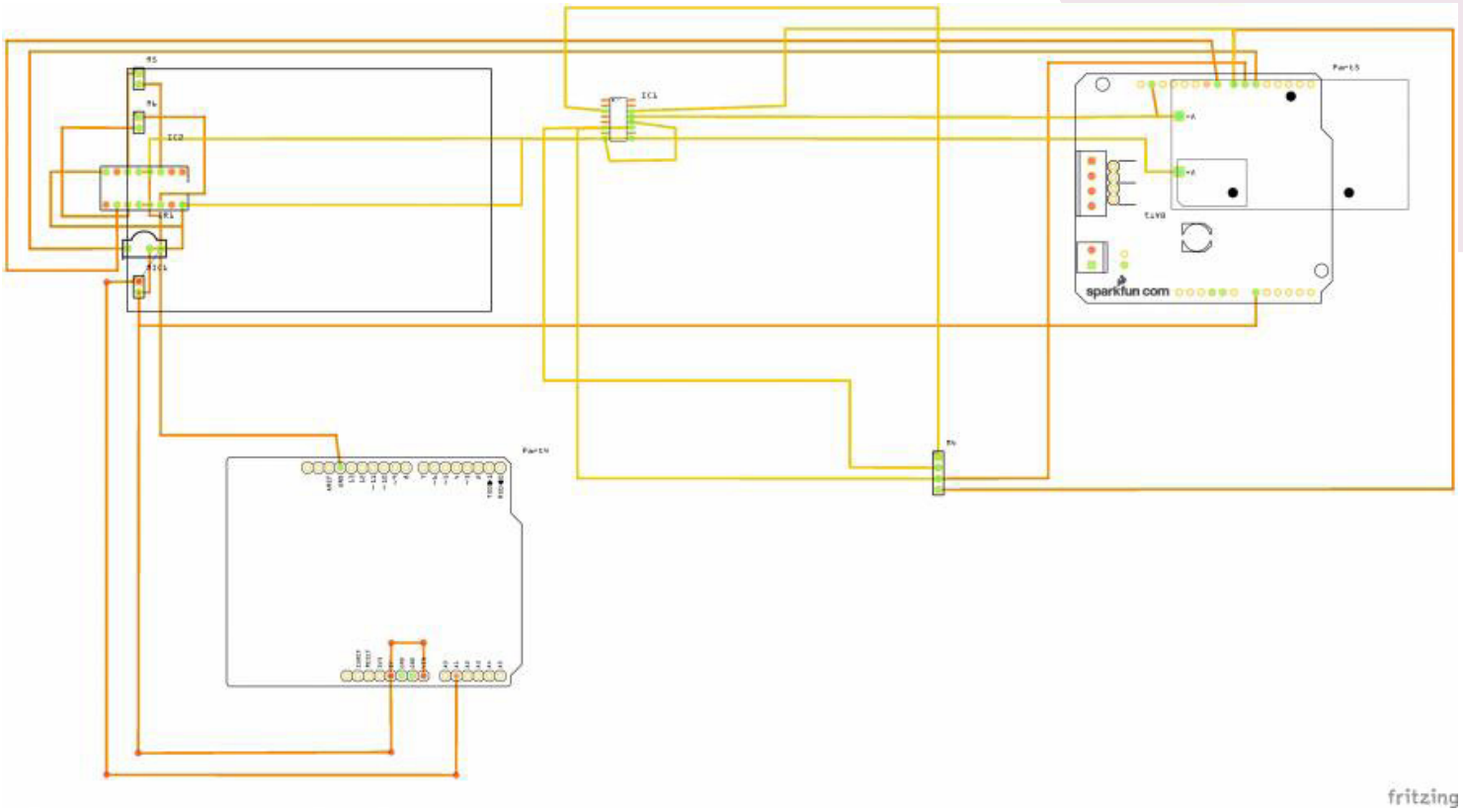


Figure 23: PCB schematics of the Graphbot

7.5.2 Components

Here a table containing all components is provided with some calculations. The proposed 9 V battery for this schematics will be enough to use the Robot for 20 minutes. This is not sufficient. Another 9 V battery with better specifications will be used.

Tabel 12: Component list

VOLTAGE [V]	CURRENT [A]	NAME	EUR	LINK	**POWER [W]**
5	0.400	Small Reduction Stepper Motor	6.46 €	http://www.ptrobotics.com/motores-steppers/2784-small-reduction-stepper-motor-5vdc-32-step-1-16-gearing.html?search_query=stepper&results=67	2.000
5	0.013	Motor Driver L298N	3.99 €	http://pt.mouser.com/ProductDetail/STMicroelectronics/L298N/?qs=gr8Zi5OG3Mj6jDtNclcF9Q==	0.065
6	0.240	3 wheel robot kit	20.17 €	http://www.ptrobotics.com/chassis/3210-3-wheel-robot-kit.html	1.440
5	0.012	EasyVR Shield 3.0	59.90 €	http://www.botnroll.com/en/sensors/345-reconhecimento-de-voz-easyvr-shield.html?search_query=easy+vr+shield&results=42	0.060
0	0.000	9 V battery	14.60 €	http://www.botnroll.com/en/rechargeable-batteries/30-bateria-96v-ni-mh-800mah-wwwbotnrollcom.html	0.000
0	0.000	bread board	0.00 €		0.000
5	0.017	Reflectance infrared analog sensor QRE1113	3.00 €	http://www.botnroll.com/en/infrared/370-sensor-de-linha-analogico-qre113.html	0.085
7	0.100	arduino uno r3	22.45 €	http://pt.rs-online.com/web/p/kits-de-desarrollo-de-procesador-y-microcontrolador/7697409/	0.700
0	0.000	wires standard 2x 30	0.00 €		0.000
5	0.000	ULN2003 Stepper Motor Driver Board	2.40 €	http://www.ptrobotics.com/motor/4184-uln2003-stepper-motor-driver-board.html?search_query=ULN2003&results=2	0.000
0	0.000	4x force springs	1.00 €	from standard pencil	0.000

133.97 €

V Max	7
A Max	0.400
P total	4.350

In next sub chapters tables comparing different components will be shown.

7.5.2.1 Single-board micro controller

It has been decided to use an Arduino board because the team has some experience using and programming those micro controller . Besides this team members had participated in a crash course at ISEP on how to use Arduino.

From the available different Arduino boards Arduino Uno R3 has been choosen. This micro controller“ meets the requirements indicated by team calculations.

7.5.2.3 Stepper motors

Stepper motor is needed in order to change the pen used by our robot. The stepper motor should have a voltage lower then 7 V in order to work in project configuration. The last stepper motor fits this. Although the resolution of this stepper motor is lower it is still sufficient. Here is provided a comparison in table 13.

Tabel 13: Stepper motors comparison table

Name	Price	Rated Current	Rated Voltage	Stride Angle (degrees)
Small Stepper Motor	6 €	0.4 A	12 V	7.5 °
Stepper Motor with Cable	13 €	0.33 A	12 V	1.8 °
Small Reduction Stepper Motor	**6,46 €**	**0.4 A**	**5 V**	**11.25 °**

7.5.2.4 Infrared sensors

The infrared sensor is used to detect the end of the drawing area e.g. the sheet of white paper, by calculation the amount of a reflected light. To follow the requirement of our project, the simplest IR sensor is enough to meet up the guidelines. A brief comparison is included here in table 14.

Tabel 14: Infrared Sensor comparison table

Name	Price	Rated Current	Rated Voltage	Link
Infrared Line Tracker Sensor	10.9 €	17 mA	5 V	http://www.botnroll.com/en/infrared/798-infrared-line-tracker-sensor.html?search_query=infrared+sensor&results=31
QRE1113 Line Sensor Breakout - Analog	**3 €**	17 mA	3.3 V - 5 V	http://www.botnroll.com/en/infrared/370-sensor-de-linha-analogico-qre113.html
QTR-1A Reflectance Sensor (2-Pack)	3.72 €	17 mA	5 V	https://www.pololu.com/product/2458

7.6 Functionality

Regarding the project development, it was figured out that our Graphbot has to obtained the following functionalities, in order to work properly, according to the guidelines and requirements.

List of Functionalities

- Recognise a following voice commands: “Start”, “Stop”, “Up”, “Down”, “Left”, “Down”, “Change”
- Recognise a white paper area surrounded by black paper
- Move on a plane
- Change colours
- Start / Stop to work

7.7 Tests and results

Our first test procedure was a Human Test. One team member had to pretend to be a robot and at the same time another one was giving random voice commands.

We used the floor as a drawing area, with previously drawn boundaries using a white chalk. The test procedure is available here in figure 24 and the results are provided here in figure 25.

Figure 24:The procedure of the Human Test

Figure 25: The result of the Human Test

7.8 Conclusion

The Project Development is the most important part of work connected with a Graphbot. In this chapter the following phases of developing our prototype has been introduced, and it will be extended in in future, during practical assembling all the components and the programming.

In the final report another chapter will be added containing the conclusions regarding the entire project.

Bibliography

[1] http://www.ifr.org/service-robots/statistics/ [Accessed in March 2016]
[2] N. S. P. E, “Code of Ethics,” Code of Ethics, Jul-2007. [Online]. Available at: http://www.nspe.org/resources/ethics/code-ethics. [Accessed: 30-Mar-2016].
[3] B. Markgraf, “Ethical Practices in Sales & Marketing,” Small Business. [Online]. Available at: http://smallbusiness.chron.com/ethical-practices-sales-marketing-64319.html. [Accessed: 28-Apr-2016].
[4] P. M. College, “Academic Ethics and Integrity,” Pine Manor College. [Online]. Available at: http://www.pmc.edu/academic-ethics-and-integrity. [Accessed: 10-Apr-2016].
[5] Rinkesh, “What are Environmental Ethics? - Conserve Energy Future,” ConserveEnergyFuture, 27-Jan-2014. [Online]. Available at: http://www.conserve-energy-future.com/environmental-ethics.php. [Accessed: 1-Apr-2016].
[6] A. Cochrane, “Internet Encyclopedia of Philosophy,” Internet Encyclopedia of Philosophy, 3ADAD. [Online]. Available at: http://www.iep.utm.edu/envi-eth/. [Accessed: 30-Mar-2016].
[13] http://www.instructables.com/id/Drawings-Robot [Accessed in March 2016]
[14] http://trendwatching.com/trends/5-trends-for-2016/ [Accessed in April 2016]
[15] http://www.bus.iastate.edu/nilakant/ProjectMgmt/pmbok7.pdf [Accessed in April 2016]
[16] https://www.projectsmart.co.uk/10-golden-rules-of-project-risk-management.php [Accessed in April 2016]
[17] http://www.forbes.com/sites/davelavinsky/2013/06/07/three-steps-to-a-solid-marketing-budget/#6ed446f11178 [Accessed in April 2016]
[18] http:www.gdrc.org/sustdev/concepts/04-e-effi.html [Accessed in April 2016]
[19] Daly, H.E. (1990). “Toward some operational principles of sustainable development”. Ecological Economics 2: 1–6.doi:10.1016/0921-8009(90)90010-r. [Accessed in April 2016]
[20] Soederbaum, P. (2008). Understanding Sustainability Economics. London: Earthscan. ISBN 978-1-84407-627-7. [Accessed in April 2016]
[23] Blewitt, J. (2008). Understanding Sustainable Development. London: Earthscan. p. 96. ISBN 978-1-84407-454-9.. [Accessed in April 2016]
[24] ISO 14040.2 Draft: Life Cycle Assessment - Principles and Guidelines [Accessed in April 2016]
[25] “Cork in Portugal,” [Online]. Available: http:www.cork.pt/cork-industry-in- portugal.html. [Accessed in April 2016]
[30] http://www.makeblock.cc/mdrawbot-kit/ [Accessed in April 2016]
[31] “Energy conservation vs. energy efficiency”. Natural Resources Canada. [Accessed in April 2016]
[32]http://europeanprojectsemester.eu/info/Introduction [Accessed in May 2016]

Appendices

[1] Portugal social situation and employment. European Parliament, 2015, pp.35.
[2] European safety regulations. European Comission.
[3] Pattiselano,Nona. Leaflet.
[5], Erich Gamma, Richard Helm, Ralph Johnson, John Vlissides, 1994. Design Patterns: Elements of Reusable Object-Oriented Software. Reading, Mass.: Addison-Wesley, pp.395, ISBN 0-201-63361-2.
[6] Daly. Natural Capitalism: Creating the next Industrial Revolution. Creating the next Industrial Revolution.
[7] Blewitt. Understanding Sustainable Development. Understanding Sustainable Development.
[8] How to Install Cork Flooring. How to Install Cork Flooring.
[9] Soederbaum. Understanding Sustainability Economics. Understanding Sustainability Economics.
[10] Life Cycle Assessment. Principles and Guidelines.
[11] N.S.P.E, Jul 2007. Code of Ethics. Code of Ethics.
[12] Bert Markgraf. Ethical Practices in Sales & Marketing. Small Business, Demand Media.
[13] College, Pine Manor, 2010. Academic Ethics and Integrity. Pine Manor College.
[14] Rinkesh, Jan 2014. What are Environmental Ethics? - Conserve Energy Future. ConserveEnergyFuture.
[15] Cochrane, Alasdair. Internet Encyclopedia of Philosophy. Internet Encyclopedia of Philosophy.
[17] Donald Knuth, Jan 1985. Deciphering a linear congruential encryption. IEEE Transactions on Information Theory, 31(1), IEEE, pp.49-52, ISSN 0018-9448.