# ‘Zoef’

## Project Smart Products

Bachelor Industrial Design

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# Summary

In Project Smart Products, our project group tried to make a smart toy car for children to use in a crowded shopping mall.

First, an analysis was done. A market research, use location research and a target group research had been done. Also a PACA analysis was made as a tool for gathering the requirement specification. Tasks were divided and meetings with the tutor were scheduled to get the best insights on the project.

After the analysis phase, the first ideas came to our minds. The first sketches of the ideas for the outside and the interface of the car were made and the first ideas of the sensors for the prototype were written down.

Out of the first ideas the best ideas were picked. These best ideas were further developed into three concepts. Discussions about certain aspects often ended in decisions everyone agreed upon and then the concepts were determined.

The three concepts were compared to each other, based on several relevant aspects. The outcome of this method showed us which one of the concepts was the best concept. This concept was further developed to a final concept. Also the appliance of the product in the shopping mall and the way how to rent the car were taken into account.

For the project, also a prototype had to be made. This prototype contains all kinds of different sensors, for which the code was made in de programme Arduino. Also a block diagram of all the electronics was made to get a clear overview of the prototype. Finally a SolidWorks model for the outside of the car was created.

When the prototype and the interface were finished, these could be evaluated. The prototype and interface were assessed by performing tests with other students. The overall conclusion was positive, but of course some aspects of the smart toy car can be improved.

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# Introduction

Project Smart Product is the fourth project of the first year of Industrial Design Engineering. In the project, students apply the knowledge gained in the different module components. For the project a Smart electric toy car, whose job it is to entertain one or two children while their parents are shopping in a crowded shopping mall, should be developed.
Project Smart Product is a group project, with groups containing six students. A group project raises challenges in how to plan things and how to make decisions. This project is divided into seven phases that each have different goals and different ways to reach those goals.

Phase 1 is all about the analysis. Which products are already on the market and for whom will we make this product? Also, the requirements for the product are made in this phase. The first contact with the project group is made in this phase, and with all the collected information the task division for the next phases can be made.

In Phase 2, first, a style analysis was made. With this analysis, the ideation of the outer appearance and the interface can be made. With this ideation, important decisions will be made with the whole project group.

Phase 3 is about the concepts, i.e. which of the ideation ideas are good enough and can be worked out. With the morphologic diagram, these decisions can be made. Productive meetings, deadlines and decision making in teams are trained in this phase.

In Phase 4 the final concept is presented. This means the looks of the toy car, but also the appliance of it in the shopping mall. The renting services in the shopping mall will be discussed too.

Phase 5 is all about the prototype. All the electronics and the codes will be explained in this phase. Also, the 3D SolidWorks model will be shown. In the end, there will be a prototype that should function.

In phase 6, the prototype will be evaluated. This is done by for example usability testing. The feedback received in this phase is very important and the group should learn how to be critical and how to receive critical feedback.

The last phase, phase 7, is all about the examination. The group will hand in a report and will give a presentation. The tutor will give feedback on the report and 2 tutors will give feedback on the presentation.

# Phase 1

## Analysis

1.1 General product information/Market research

1.2 Target group

1.3 Use location and circumstances

1.4 PACA

1.5 Requirements and Specification

# 1.1

## General product information/Market research

A battery vehicle is a small electric car in which children can drive around independently. There are a lot of different types. The differences can be found in their electrical systems like the batteries, but also in the appearances. Nowadays, even the big car brands like Volvo or Mercedes bring small electric vehicles on the market. There are a lot of different vehicles for children:

Car

The design of these cars is usually realistic and it encourages children to imitate how their parents drive. This is a creative process that enhances their cognitive skills.

Truck/tractor

Riding on trucks/tractors is incredibly popular amongst children because they like to drive through the garden and pretend to mow the grass.
Similarly, ride-on tractors help to inspire the imaginative side of the child while they copy what they see their parents doing in the backyard.

Scooters/motorbikes

Bicycles and motorcycles are very interesting for young children. Many of the available models are inspired by real ones, which means that their designs are often very slim.
Children also enjoy using the throttle and handlebars to control the speed and direction of the motorcycle. They do need side wheels or a 3 wheel design to keep them from falling over.

Jeep

Jeeps are fantastic when it comes to off-road driving. This is because their structures are usually larger and stronger than other vehicles. That is why they are resistant to the rougher nature of off-road surfaces.
The wheels are larger and can also offer the child more support.

Police car / firetruck / etc.

A lot of children and especially boys tend to like these vehicles. Driving a police car is a fantastic opportunity for children who like to play imaginatively. They can drive in a police car and present themselves as an officer on patrol.
It also leaves more options open for playing games. For example, you can be a robber and they can be the police that haunts you in the vehicle!

4 × 4 vehicle

4 × 4 vehicles are fun for taking off-road trails. This is because the 4-wheel drive gives your child more precise control over the turns.

4-wheelers

4-wheelers, such as ATVs and quads, are great fun. They are often a great solution if the child should have a toy with which they can play both inside and outside.
Their design makes them suitable for taking on more bumpy off-road surfaces.
However, they are still great for riding indoors.

Most of the electric vehicles nowadays have parental controls. A limit can be set at the top speed to ensure that it is safe for a child. Some vehicles do also have remote controls that allow taking full control of the toy. [1)]

Existing products






# 1.2
Target group

Children can walk from the age of three years old. They are often distracted and simultaneously focus their attention on other things.
Around their fifth year, children can learn to participate in traffic.
Until the age of 6, traffic is still a game for children. They do not know the concept of danger.
Children get a sense of right and wrong between the ages of 7 and 8. They will learn to be cautious and to pay attention to traffic [2)].

Young children have a narrow field of vision. They also have a diffuse hearing. That means that they hear sounds, but cannot yet determine which direction the sound is coming from.

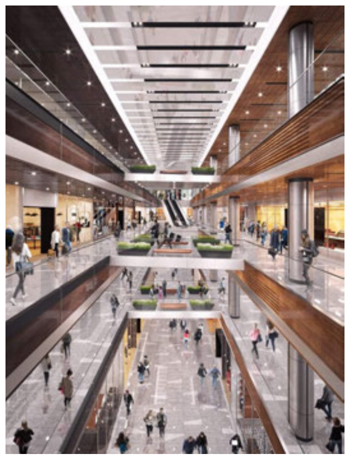
Young children can’t concentrate on anything for long. It is therefore difficult for them to continuously pay attention to traffic. They are very easily distracted by thoughts, sounds, and all sorts of things around them which makes their behavior very unpredictable.

The responsiveness of young children is in full development. They can be very shocked and primitive about loud sounds and sudden danger. Usually, they will immediately stop and look around in response.

A young child sees itself as the center of the world. Everyone takes him/her into account and takes care of him/her as well as possible. From the age of 4, a child learns that other people are also important and that not everything revolves around them. The child then begins to realize that he/she also has to take into account the wishes and behavior of others [3)].

## 1.3
## Use location and circumstances

The Smart Electric toy car will be used in a shopping mall, so there will be a lot of obstacles in the mall. Think of decoration, planters, advertising signs and benches for example, and of course the people who are shopping. They can get pretty crowded wh en a lot of people are shopping there. These people aren't always paying attention when they are looking at the shop windows. Shopping malls can be very large with a lot of floors, or can be quite modest with just a few or one floors. The size and number o f shops also vary and are dependent on the size of the mall itself. The smart toy car can be used inside all types of shops.



# 1.4
# PACA

**People**

<u>Children: 3 - 6 years</u>
Physical, anatomy, body strengths
- Small
- Not very strong
- Lot of energy

Mental capabilities
- Want attention
- Impatient
- Unpredictable
- Easily distracted
- Don't see any danger at all

Their expectations of the car
- They think that the car is really cool and that it will ensure a lot of fun

Experience
- They most likely have not driven anything car-like before
- Should learn how to use the car

Social influence
- High status among other children

Mental model
- Understand the dashboard

Parents

Physical, anatomy, body strengths

- Strong
- Average length of a man: 182.5 cm
  Average length of a woman: 169 cm

Mental capabilities

- Distracted
- Busy

Expectations

- Keep the child occupied
- Child will not wander off
- Have main control over the vehicle
- Shop peacefully

Experience

- They don't have any knowledge about electric cars, before and during renting the car. They only know that it should be, a nice experience for children.

Social influence

- Mixed feelings
- Some pare  nts will like it
- Others will think that it's superfluous
- Spoiling their child

Mental model

- Understand how to use an app
- Understand how the car works

Grandparents

Physical, anatomy, body strengths

- Are not very strong
- Not very agile

Mental Capabilities

- Like spending time with the children
- Can not handle smart products very easily
- More observant than parents

Expectations

- Keep the child occupied
- Child will not wander off
- Have main control over the vehicle
- Shop peacefully

- Want the children to be happy
- Want a simple interface

Experiences

- They really like/enjoy to spend time with their grandchildren
- Might be sceptical of the software, i.e. do they trust it with their grandch ild?

Mental model

- Understand how to use the app/controller
- Understand how the car works

Other people in the shopping mall

Physical, anatomy, body strengths

- Can be other children, parents (adults) or grandparents

Mental Capabilities

- Busy
- Not paying attenti on to the environment
- Quickly overlook children
- Quickly irritated

Expectations

- Don’t want to be hit by the car
- Don’t want noise disturbance
- Want to be able to walk well past the vehicle

Experience

- Annoyed by other children
- Too much noise by other children

Mental model

- Should know that the cars are in that mall

Shop owners

Physical, anatomy, body strengths

- Parents (adults)

Mental Capabilities

- Busy
- Not paying attention to the environment
- Quickly overlook children
- Quickly irritated

Expectations

- Don’t want to be hit by the car
- Don’t want noise disturbance
- Want to be able to walk well past the vehicle
- Don’t want the shop or products damaged
- Don’t want o ther customers to be annoyed

Experience
- Annoyed by other children
- Too much noise by other children

Mental model
- Should know that the car is in the mall
- Should know how the car works

**Activities**

Children

Frequency
- Daily use is possible

Available time; pressure; response time
- Can rent the time you want, depending on the battery

Pace & rhythm
- Drive through the mall

Cooperation
- Interact with the interface inside the car
- Interact with the environment

Complexity; specifi c or generic
- Intuitive interface
- Not too much buttons
- Generic

Safety -critical; consequences of errors
- Stuck
- Injuries (Due to sensors that are not working, Steering wheel or pedals doesn’t work etc
- Lost

Contents & required data
- Needs to understand the interface

Parents/Grandparents

Frequency
- Daily use is possible

Available time; pressure; response time
- Can rent the time you want, depending on the batty

Pace & rhythm
- Put the child inside the toy car and getting it out again
- Renting the toy car

Cooperation
- Interact with the controller
- Interact with the environment

Complexity; specific or generic
- Easy interface and external controls

Safety -critical; consequences of errors
- Lost child
- Getting hit by the car, injury

Contents & required data
- Needs to understand the controller

Other people in the shopping mall

Frequency
- Undetermined

Available time; pressure; response time
- Undetermined

Cooperation
- Interact with the children in the car

Safety -critical; consequences of errors
- They will be hit by the car
- Fall over the car
- Get scared

Shop owners

Frequency
- Daily

Available time; pressure; r esponse time
- Opening hours

Pace & rhythm
- Many small actions to be taken by the staff

Cooperation
- Interact with the customers
- Interact with the toy cars

Safety -critical; consequences of errors

- Hit by the car
- Fix the broken cars
- Fall over the cars

**Context**

Children, Parents, Grandparents

Physical Context

- Indoors, in the shopping mall

Social Context

- Public

Organizational Context

- Bring back the toy car

Physical or Digital Context

- The toy car and the controller

Other people in the shopping mall

Physical Context

- Indoor, in the shopping mall

Social Context

- Public

Physical or Digital Context

- Danger of toy cars

Shop owners

Physical Context
- Indoor, in the shopping mall

Social Context
- Public

Organizational Context
- Charge the toy cars
- Clean the toy cars
- Renting the toy cars
- Repair when necessary

Physical or Digital Context
- The toy car and the controller

**Artefacts**

Hardware
- Slippery floors
- Uneven floors

Devices
- Controller/app
- Docking station

Infrastructure
- Walls
- Stairs
- Glass walls
- Wet floors
- Elevator
- Gutter

Shapes & affordances
- Advertisement panels
- Flower pot
- Miscellaneous products

Sensors & connectivity

- Wifi
- Bluetooth
- Sonar
- Camera
- Electronics store

Energy

- Battery

# 1.5
## Requirements & Specification

Calculations used in the requirements specification:

Moment steer the car

To calculate the moment for steering the car, the following formula is used: M = F * d. The arm of the steering wheel that will be used is 10 cm. The maximum force children can use is 27 Newton [4)]. A couple moment will occur on the steering wheel. Both moments will be equal.
F = 27 N, d = 10 cm = 0,1 m > M = 27 * 0,1 = 2,7 Nm.

Power average walking speed

To calculate the minimum amount of power needed for the maximum speed of the car, the rolling resistance has to be calculated. With that the total power needed can be calculated. The formula is : $F_r = C_r \times F_n$[5)]. The maximum mass in the car is 90 kg and the maximum weight of the car is 23 kg. This adds up to a total mass of 113 kg. The average walking speed of a guardian is 5 km/h. The friction coefficient is 0.010[6)].

$Fn$ = 113 x 9,81 = 1.108,53 N
$Fr$ = 0.010 x 1.108,53 = 11,10 N
P = $Fr$ x v = 11,10 x 5 = 55,5 W

<u>Power average walking speed while shopping</u>
The calculations for the power needed for walking speed while shopping are similar to the calculation of the average walking speed. The average walking speed of a guardian while shopping is 2 km/h. The calculation then looks like this:
$Fn$ = 113 x 9,81 = 1.108,53 N
$Fr$ = 0.010 x 1.108,53 = 11,10 N
P = $Fr$ x v = 11,10 x 2 = 22,2 W

<u>Power driving in reverse</u>
The calculations for the power needed for reverse speed are similar to the calculation of the average walking speed. The average walking speed of a guardian while shopping is 2 km/h. The calculation then looks like this:
$Fn$ = 113 x 9,81 = 1.108,53 N
$Fr$ = 0.010 x 1.108,53 = 11,10 N
P = $Fr$ x v = 11,10 x 2,5 = 27,75 W

<u>Stopping distance sensors</u>
The maximum speed of the car is 5 km/h. As soon as the sensor detects an obstacle, it will immediately stop the car. If we say the reaction time has to be less than a second, the minimum stopping distance equals 1.4 m (since 5 km/h is equal to 1.4 m/s)

<u>Stopping distance guardian controller</u>
The minimum stopping distance will be calculated with the following formula: d = vt. In this formula the v is the maximum speed of the car which is 5 km/h. The t in this formula is the reaction time of the guardian, which is 1.2 sec[7)].
Stopping distance = 5/3.6 x 1.2 = 1.67 m.

| | Product function analysis | Functional Specification V1 | Functional Specification V2 | Functional Specification V3 |
|---|---|---|---|---|
| Requirements | Steer the car | Child can steer the car | Low force needed to steer the car | Maximum F = 27 N, M = 2,7 Nm |

| | | | | |
|---|---|---|---|---|
| | | | The steering wheel must fit in the hands of a child | The outer diameter of the steering wheel will be around 20 cm. The thickness will be maximal 3 cm. |
| | | | Intuitive steering mechanism, by hand/arm | Steering mechanism should be within the mental/physical capabilities of most children |
| | | Guardian can steer  he car | Well controllable remote steering | Guardian can steer the car by using the controller. He needs to press the overrule button and after that h  e can steer the car with the little joystick on  he controller. Thanks to the user interface, he can now completely take  -over the control of the smart toy car. The joystick is very clear to understand and easy to use, for every type of user. |
| | Regulate Speed (Power) | Have a variable speed control | Intuitive way to select speed, by foot | Child can control the speed (power) in the car by itself, using  he pedals |
| | | | Guardian can control the speed (power) | Guardian can set the maximum speed (power) using the controller |
| | | | Speed can be varied by the amount of force applied to the paddle | Exponential acceleration |
| | | Can limit the speed | The maximum power can be regulated | The maximum power equals.. |
| | | | Maximum speed | Average walking speed of a guardian, 5km/h. [8) ] |
| | | | | Average walking speed of a guardian while shopping, 2  -3 km/h. |
| | | | | Reaction speed of children, average 1.1  - 2.4 sec. |
| | Resistant against splashing water | Electronics are protected | All the electronics should be covered so that the water can not reach it | All  he electronics should be covered so that the water can not reach  it |
| | | Materials are water resistant | All the materials that are used, must be resistant against splashing water | The materials that are used, must have  he following IP  -classification: IP  -X4 [9)] |
| | Drive in reverse | The car can drive slowly in reverse | The car can drive slowly in reverse, if it needs to turn after a crash for example | < 2 km/h |
| | Safe | Safe for children | The car should not have small parts | There won't be small parts the child can swallow for example |
| | | | Working mechanism | The mechanism should be covered, or should be safe by itself so that no fingers can be hurt for example. |

| | | | | |
|---|---|---|---|---|
| | | | Electronics | The electronics should be covered in a way that the children can not reach them. When the child tries to reach the electronics, he will get a small electric shock so that he will be chased away from the electronics. |
| | | | Sensor for crashes | Software will locate dangers, and avoid crashed by for example stop the car at 1.4 meters before it would crash. |
| | | Safe for other people | Sensor for safety hazards | Software will locate dangers, and avoid them |
| | Emergency stop | The car can stop immediately if the guardian regulates this from a distance | Hardware switch to overrule the system and stop the car using the controller from a distance | The minimum stopping distance of the car is 1.67m |
| | Support weight | Can withstand the majority of children in our target group | A child within our target group weights 30 kg max. Assuming the car can carry 2 children, so the car must support 60 kg. Furthermore we take into account a safety factor of 1,5 | (30 + 30) x 1.5 = 90 kg |
| | Strong | Frame is made of a strong material | Frame should carry the weight of the electronics and of he children | |
| | Portable | The car shouldn't be too heavy | The car should not weigh more than the allowed weight according to the ARBO regulation | Max. 23 kg, preference < 12kg 10) |
| | | Car has a carrying handle | Handle is comfortable to use | |
| | Driving time | The car has a battery (6V) | The car battery must be rechargeable | Fast charging or Swappable battery 11) |
| | | Battery | How long the battery must last at full speed under average load. | The car must be able to drive approx. 1,5 hours. Therefore, the charging time is 600 minutes 12) |
| | Cleanable | The car can resist cleaning products | The car can resist cleaning products | The car can resist cleaning products |
| | | The car is easy to clean | The car should be easy to clean | The car is cleanable within 5 minutes |
| | | | Alle places must be easy reachable, for example with a cloth | After each usage, the car can be cleaned quickly with a cloth. And once per 2 days the car should be a big cleaning. |
| | Matches the users and the context and shows the meaning of the product. | Has an appearance and affordance that is attractive to children | Different cars have different colours and shapes that fit the target group. The car should be unisex. | Different cars hav e different colours and shapes that fit the target group. The car should be unisex. |
| | Compete in market | Fits the price of other rentable childrens toys and smart toy cars | Average about € 400, - | Fits the average price of other rentable children toy cars, so about € 400, -, and can be a bit more expensive because of the fact that this toy car will not be used for private use. |

| | | | | |
|---|---|---|---|---|
| | Sound speaker | Sound speaker can alert people in case of danger | Alerts people through he use of a horn | Alerts people in case of danger while producing a sound of 70 Decibel. From 80 decibel hearing damage can occur, so we want to stay below that level. 60 Decibel equals a normal conversation, so the noise should be a bit louder than that 13) |
| | | Can make music | Press buttons for different musics/tones | Children will have fun while hearing different musics/tones while they are driving the car |
| | Lifespan | Has a long lifespan | A long lifespan because we take into account that maintenance from separate parts is possible | A lifespan of at least 5 years |
| | Maintenance | Car can be made in such a way that maintenance is possible | If a part is defective, it can be pulled out of the car and can be brought to the garage | From each part, several spare parts are available in the garage |
| | Durability | The car should be as durable as possible | The car should be as durable as possible | The car should be as durable as possible |
| | Recyclable | Car is made of recyclable materials and different materials are easily taken apart again | Car is made of recyclable materials and different materials are easily taken apart again | Car is made of recyclable materials and different materials are easily taken a part again |
| | LED | Has an LED that can change color according to a status | Different colors that shows the battery level | The battery level can be shown by a red, orange and green color |
| **Wishes** | Automatic charging | Vehicle drives to charging dock when battery is low | Vehicle needs no help to charge its battery | Vehicle is self aware of charging |
| | Steering | Small circle of rotation | Small circle of rotation | |
| | | Software helps the child in steering the car | sensor detects safety hazards and helps to steer the car away from them | |
| | Mapping environment | The car mappes the surrounding area to prevent crashes | | |
| | Nice music tunes | Multiple sound effects by pressing multiple buttons | Can play tunes | |
| | weight | Maximum weight allowed to carry for employees | Maximum weight allowed to carry for employees | Max. 12 kg |
| | Strength | Vehicle can carry an adult | 100kg adult | 100kg |
| | Cargo | Vehicle has space for cargo | Room for 1 grocery bag | |
| | Multiple colours | Colours for boys and girls | Colours for boys and girls | At least two types |

# Phase 2

## Ideation

2.1 Style analysis

2.2 Ideation of the outer appearance

2.3 Ideation interface

## 2.1

## Style analysis

While analyzing the style collage of the smart toy cars, there can be concluded that some features return in several pictures:

- Round shapes
- Exaggerated features
- Proportions are exaggerated
- Bright colors

The shapes of the cars are all quite rounded. Not all shapes are round, some are more boxy but all edges are rounded. The features eyes, wheels, windows, etc. are often exaggerated to give the car a more friendly and playful look. The proportions are exaggerated as well. The toy cars are pushed together so to say and chairs and steering wheels are much bigger than the rest of the car, etc.

Looking at existing vehicles and taking into account the wish to have a place to put groceries, it was decided that some sort of pickup would be the best solution. However, there are of course a lot of different kinds of pickups: Jeep-like vehicles, more rounded, friendlier cars, sleek pickups, dump trucks, the possibilities are plenty (there was also an idea to store groceries in the bucket of a digger). As such, the style analysis is focused mainly on these different solutions for carrying cargo on a vehicle.

Off-road vehicles like jeeps and certain pickups are mostly quite boxy and large, as well as being high on their wheels which are also big in order to handle rough terrain.

There are also more vintage pickups with more rounded shapes, mostly giving them a friendlier look. Their wheels are also smaller and they are closer to the ground, since they mostly just drive on roads.

Construction vehicles are characterised by their wheels, which are quite large in comparison with the body. They tend to be quite neutral, not necessarily friendly or aggressive, and are mostly yellow and black.


# 2.2

# Ideation of the outer appear ance

Before starting with the shape ideation, the requirement specifications and wishes had to be considered as these limit what could be done with the shapes.
The requirements that impact the design are:

| | | | |
|---|---|---|---|
| Matches the users and the context and shows the m eaning of the product. | Has an appearance and affordance that is attractive to children | Different cars have different colours and shapes that fit the target group. The car should be unisex. | Different cars have different colours and shapes that fit the target group. The car should be unisex. |
| Maintenance | Car can be made in such a way that maintenance is possible | If a part is defective, it can be pulled out of the car and can be brought to the garage | From each part, several spare parts are available in the garage |

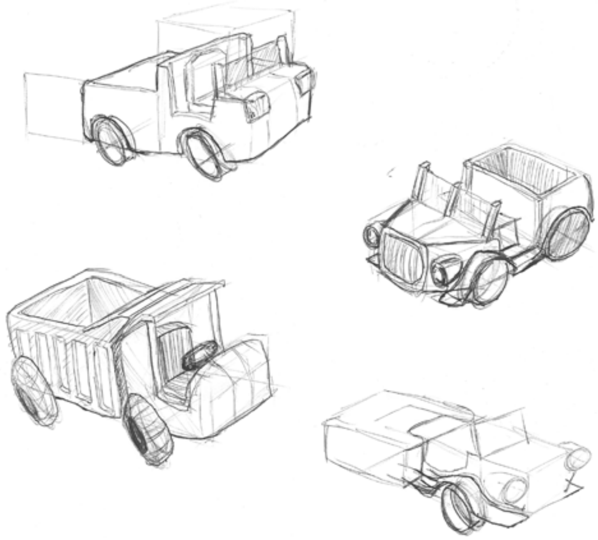
According to the first requirement, the car should be unisex so both boys and girls like the design. So it has to have some sort of universal shape that appeals to both. And because of the second requirement there need to be hatches or access ports in the car to make it easy to service.

The wish that impacts the design is:

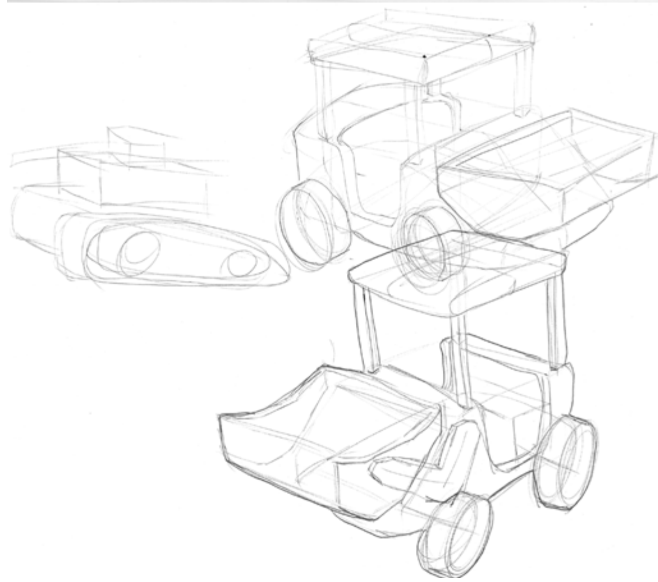
| | | |
|---|---|---|
| Cargo | Vehicle has space for cargo | Room for 1 grocery bag |

Because of this wish the car should have a trunk or frunk to be able to have enough space for cargo. As this is a wish, it didn't feel compelled to incorporate this aspect in the design, but this aspect was really liked by us.

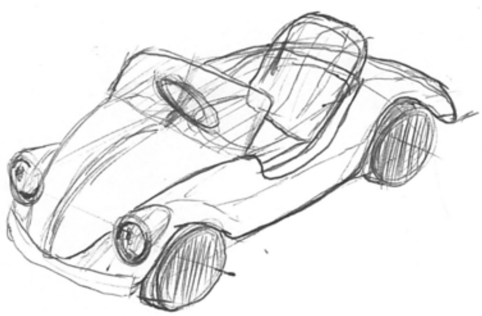
These sketches were the results of the ideation based on these vehicle types:



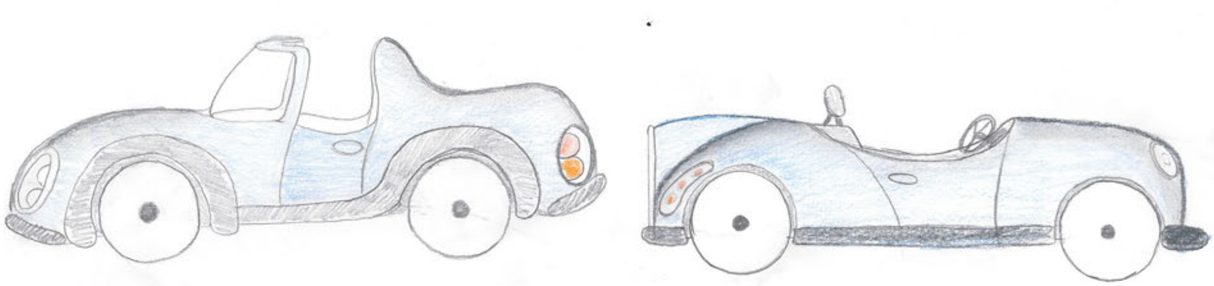
Shown here are a few basic variations on the concept of a pickup, inspired by the styles found in the analysis



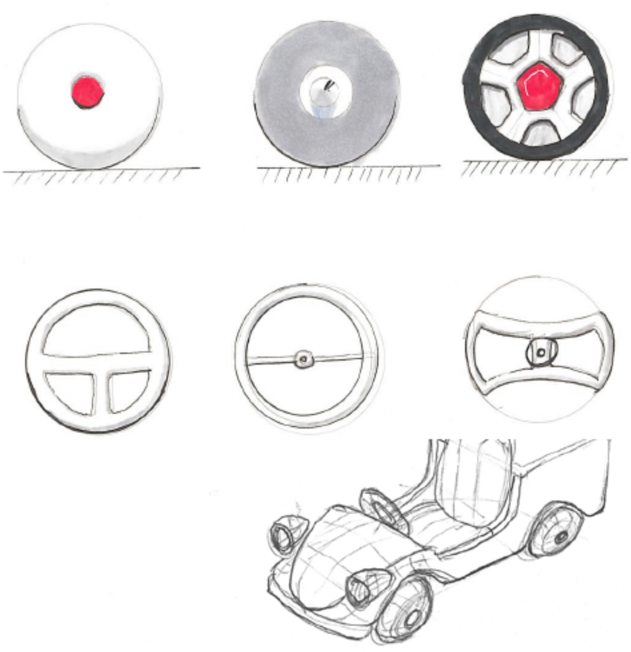
Based on the construction vehicles, here is an idea which uses the bucket of a digger to store the groceries.

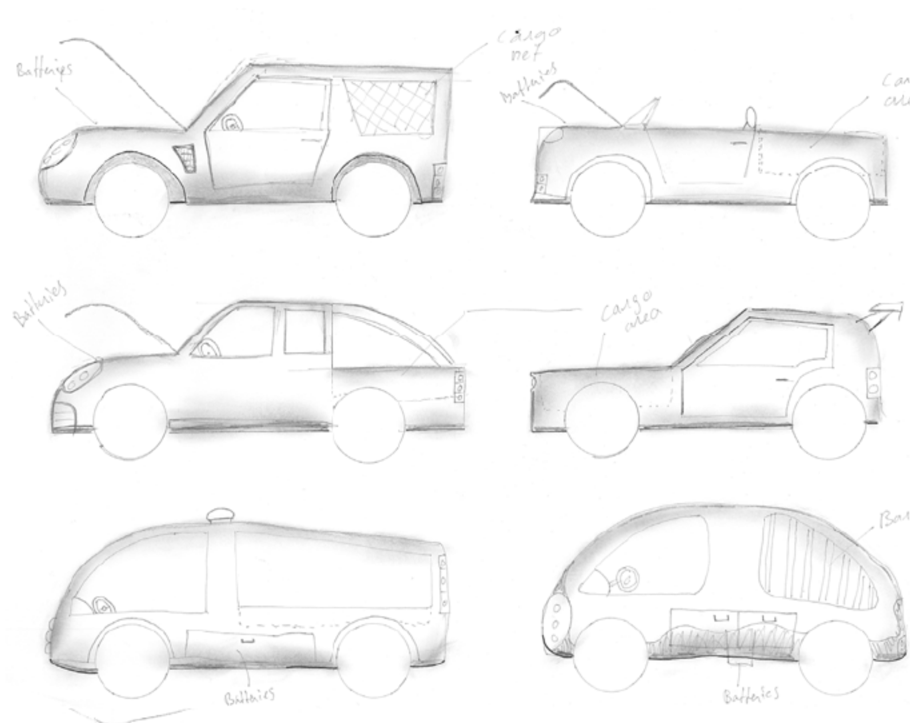


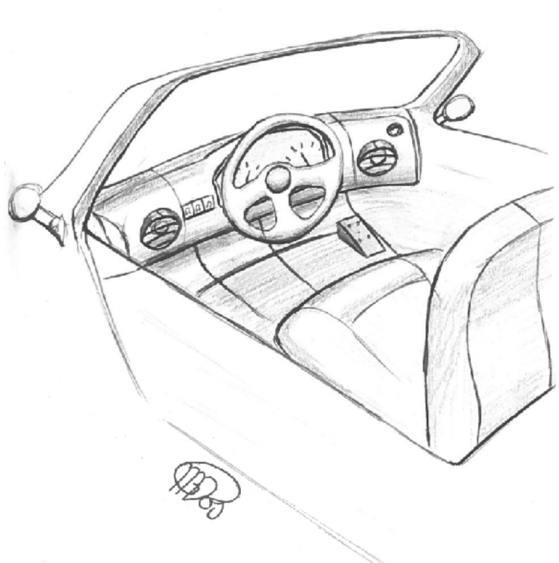
This concept, based on the Volkswagen Beetle, has a nice friendly aesthetic but does not have a trunk



Here we see some different steering wheels and rim designs, because they can make quite a big difference in the overall aesthetic.

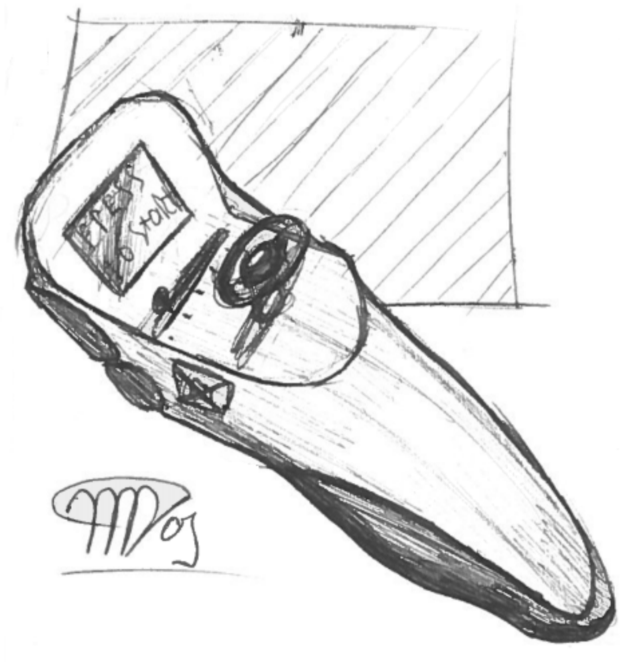






We also put together some sketches of the inside view of the car. Here we put together the steering wheel, throttle, gearshift and general buttons for the child.

# 2.3
## Ideation interface



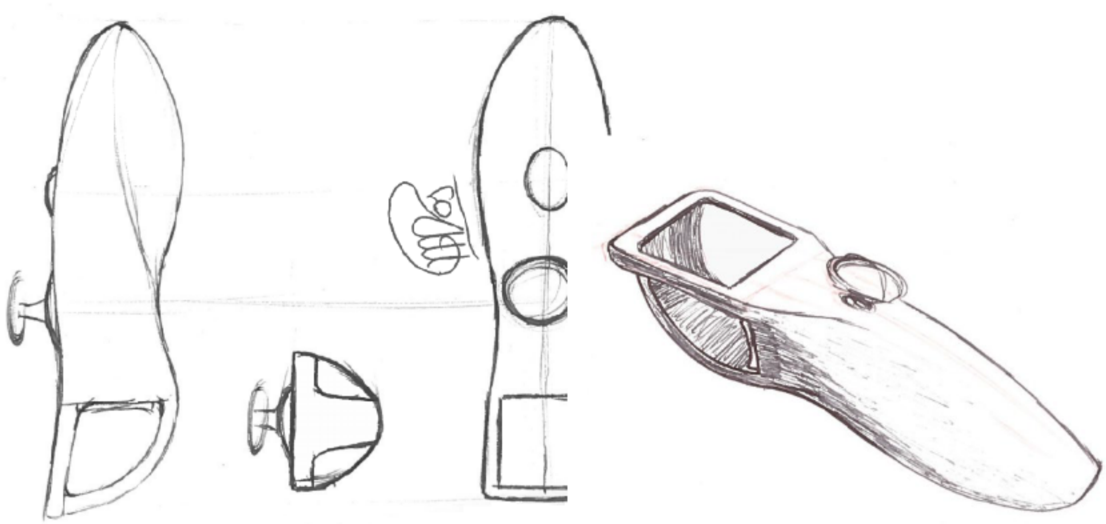

For the caretaker we wanted to design a single handed controller, which could remotely control the toy car. A one handed controller gives the user the freedom to carry shopping bags with one hand, and still take control of the car when necessary.


The first designs are based on a collage of already existing controllers, where some functions are slightly altered to make it suit our functions.


After that, we made a foam model of the sketched design. This resulted in a fairly uncomfortable fragile handle shape.

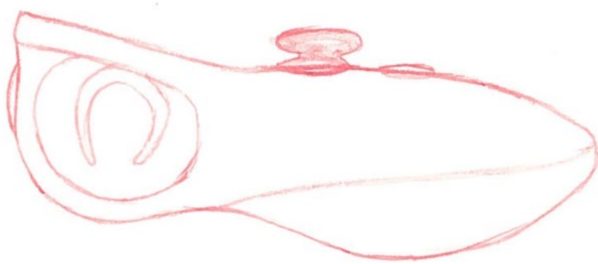
With the use of this foam model we studied the way the hand naturally fell around our controller. Here we found that instead of the concaved shape we originally came up with, the hand curved in a convex way around the controller. For this design we didn't start with sketches. We started to model the controller out of foam directly from the shape of our hands. this resulted in a much stronger design that felt a lot more comfortable to use.

The main problem we found with this controller was the way we mounted the screen to the controller. We were afraid this design would be too fragile to be used in a rent - out service, so we came up with some sketches where we reinforced the screen with a support ring.



Afterwards, we tested driving our model car with a single joystick. The problem we ran into was that as soon as you started to steer, the speed went down. This resulted

in a control system that made it very hard to estimate how much to steer when going in to a turn.
We solved this problem by adding a trigger for the throttle. Pulling on the trigger makes the car drive forward, pushing the trigger drives it in reverse. Since we already had a support ring around our original trigger button, the new trigger design fit inside nicely



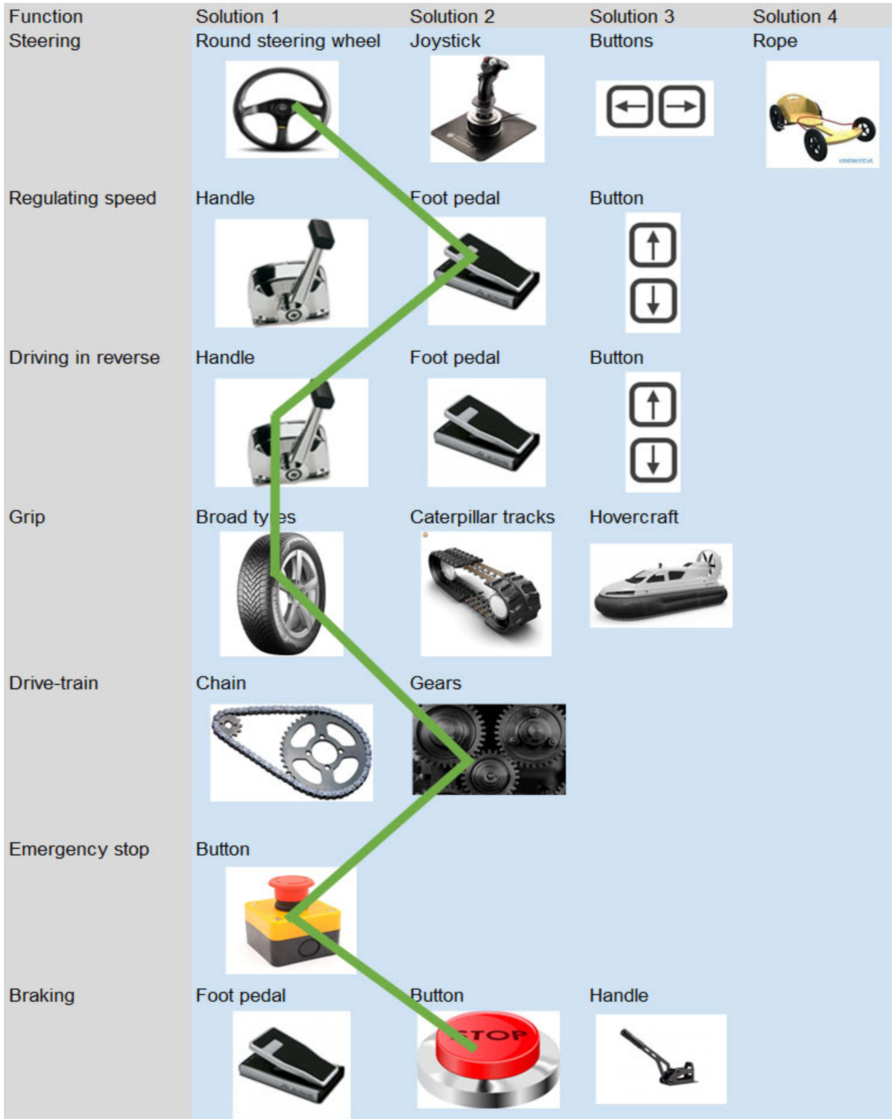
After sketching we also made a foam mock-up of this new controller. This is the design we settled on for now.

# Phase 3

## Concepts

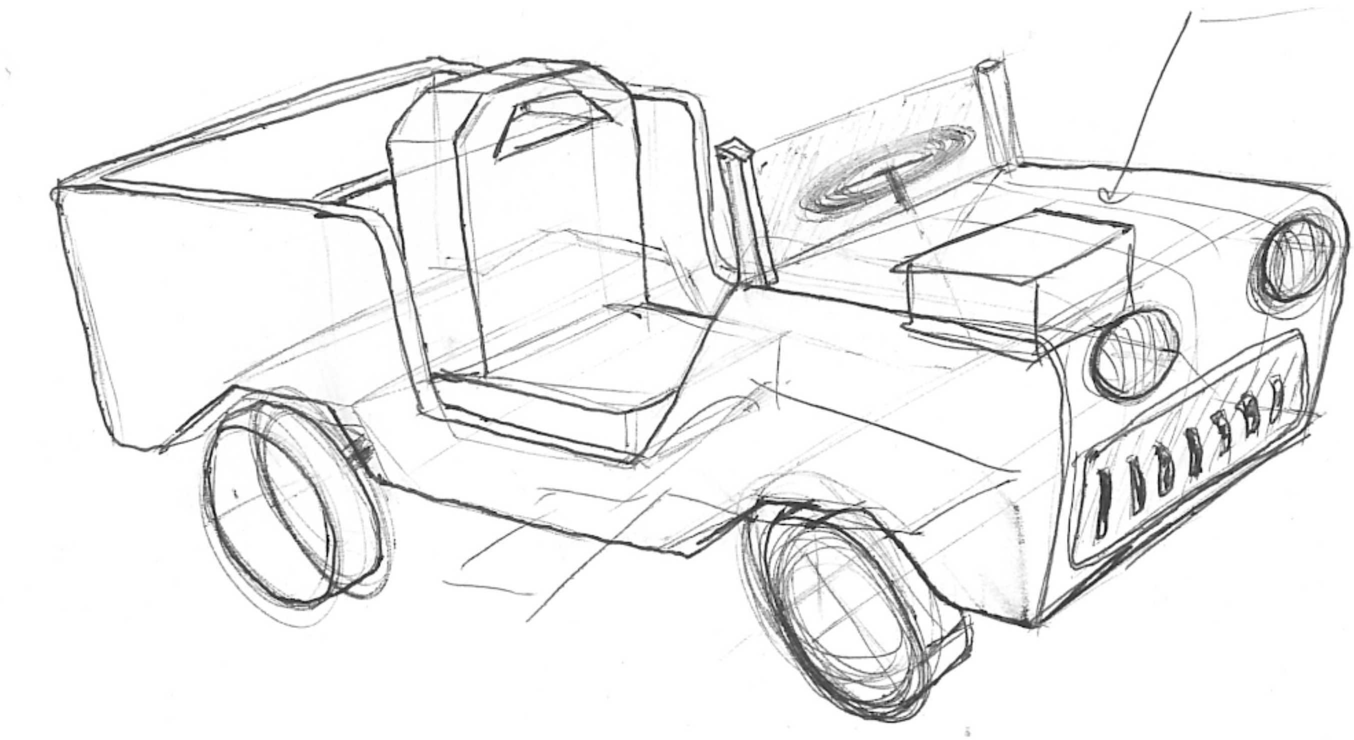
# 3.1
## Morphologic scheme

Besides the outer appearance and the interface, the main functions of the smart toy car need to be discussed. A morfologic diagram has been made and the best solutions for each function are selected. This selection of functions will be used for each concep t, and will be combined with several outer appearances to create different concepts.




# 3.2

## Concept ‘Jeep’



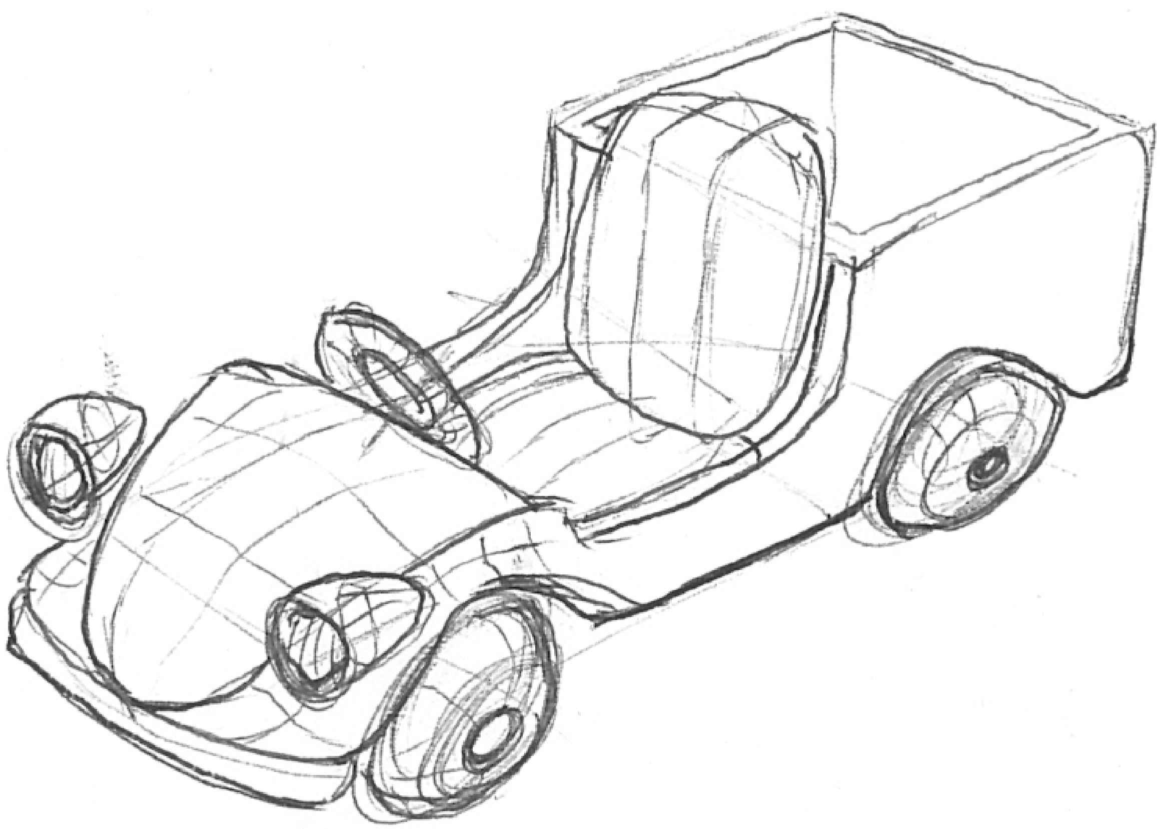
This concept is based on the “standard” army jeep, which gives it quite a neutral look, although it might, in general, be a bi t more appealing to boys. This also depends on the colour, of course.

Looking at the functionality, this shape provides ample space for the battery in the front of the car, as well as convenient places to put sensors behind the grill and the headlights. T he trunk also allows the child to help carry groceries.

## 3.3

Concept ‘Beetle’

This concept is inspired by the VW beetle,
The round hood does mean that there will not be as much space to put batteries.

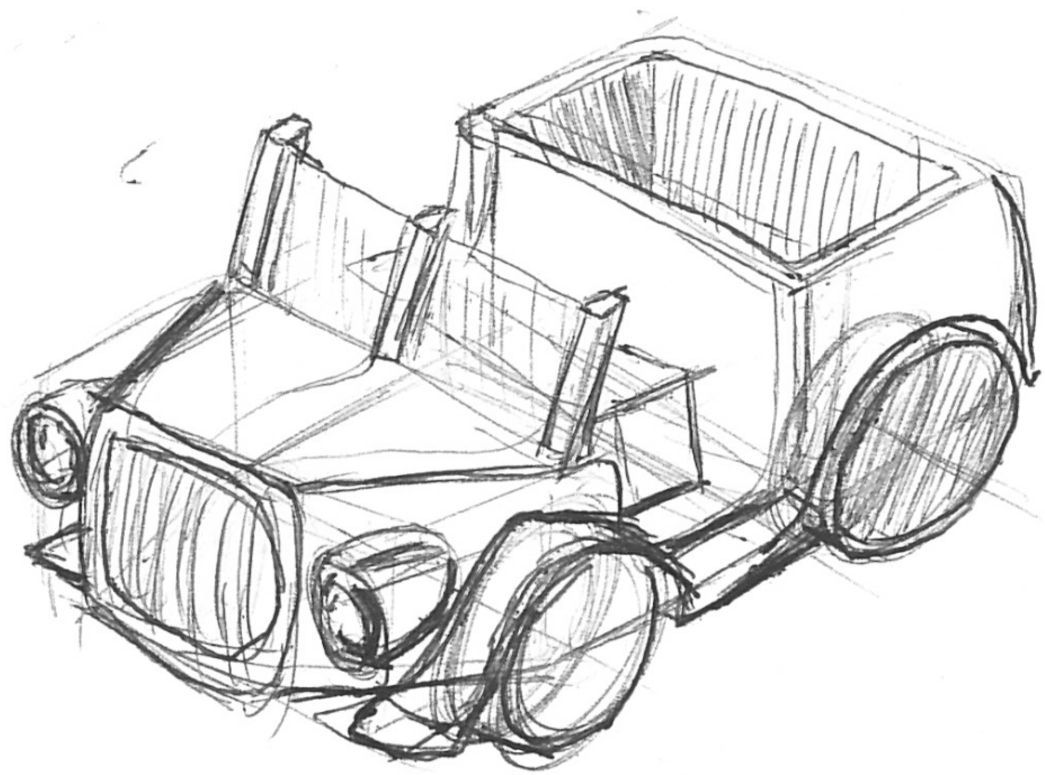


Adding a trunk to this frame is possible, but without it the car can be more compact. Leaving the trunk out also allows for the car to follow a nice curve, creating a different aesthetic.

Once again, there is room to put the sensors in the headlights, as well as underneath the bumper (for the edge sensor for example).

## 3.4

## Concept ‘Pluk’



This concept is the result of combining elements from other ideas. It has a trunk and a bit more of a classic aesthetic. It is not overly rounded, but still has friend ly elements like the rounded wheel covers, the small nose and the headlights.

Once again, there is opportunity for placing sensors in the lights and behind the grill. Room for groceries is also available.

A nice extra feature of this concept is that its shape and details give it a bit of character, which adds to the overall friendliness and attractiveness of the car.

# 3.5
## Final concept choice

Out of these three concepts, a final concept was chosen. This was done by ranking requirements. Not all requirements were used, only the most relevant requirements (for example, all cars fulfill the requirement of being able to steer equally well, so compa ring this does not make sense). The following requirements were ranked by a number from 1 -3. 3 means that the requirement is very significant, while a 1 for example means that the requirement is less significant. After that, the concepts were graded

Since all the functions and sensors are the same for each concept, the focus lies on the aspects in which the concepts differ.

These aspects are:

- Safety
- Strength
- Matches users and the context and shows the meaning of the product
- Maintenance (component locations)
- Space for storing all sensors, batteries etc.
- Unisex appearance
- Space for storing cargo
- Matches style analysis

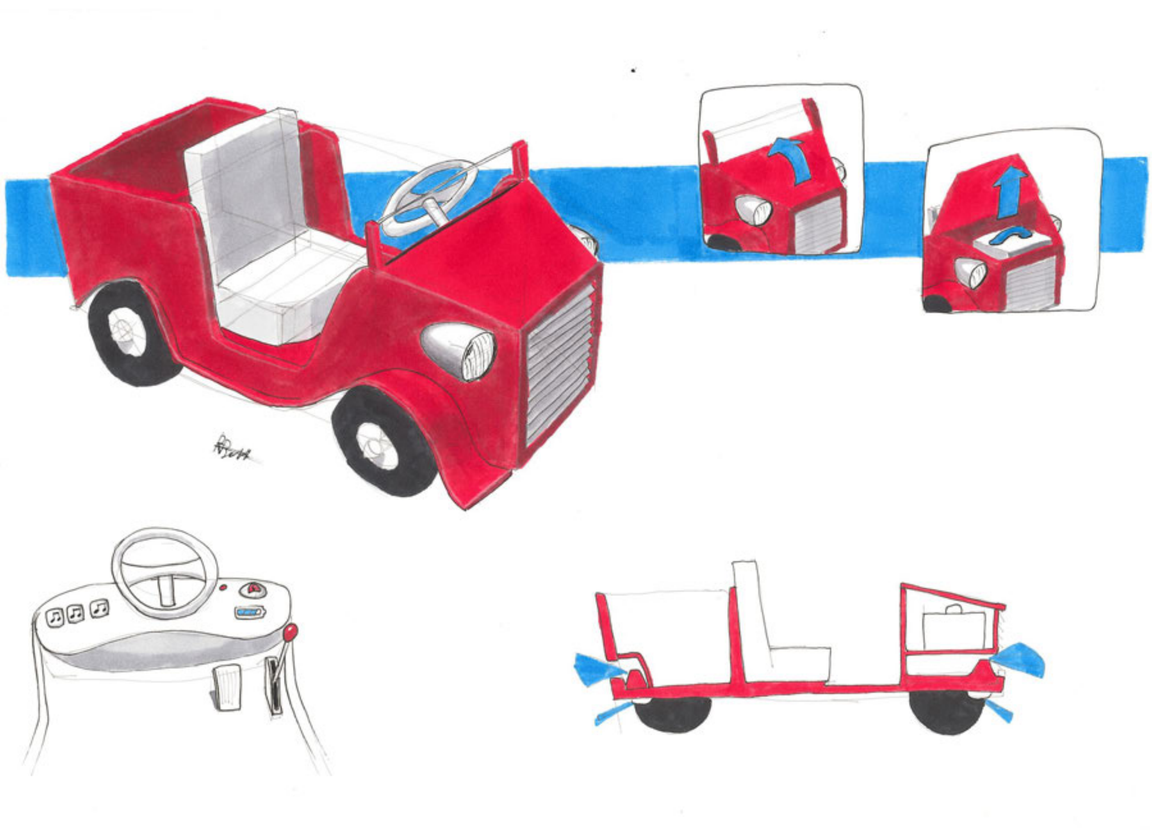
| Weight factor | Aspect | Concept Jeep | Concept Beetle | Concept Pluk |
|---|---|---|---|---|
| 3 | Safety | 3 | 3 | 4 |
| 2 | Strength | 2 | 3 | 3 |
| 2 | Matches users and context | 3 | 4 | 4 |
| 1 | Maintenance | 5 | 3 | 3 |
| 2 | Space for storing | 4 | 3 | 4 |
| 2 | Unisex appearance | 2 | 4 | 4 |
| 2 | Space for cargo | 3 | 3 | 3 |
| 1 | Matches style | 3 | 2 | 3 |
| | Total score | 45 | 48 | 54 |

The outcome of this ranking method, is that the third concept ‘Pluk’ has the highest score. That means that this concept will be chosen as a final concept on which will be further elaborated.

# Phase 4

## Final concept

## 4.1
### Color and appearance



The final concept is a slight modification of the third concept, “Pluk”. This concept was chosen because it has a friendly appearance due to its nose and headlights and the character this gives the car. The ultrasonic sensors are hidden behind the grill and the rear light, and the edge sensors are positioned underneath the body. The battery can be easily replaced by lifting the hood, taking it out and putting in a full one.

The controls consist of a simple dashboard with buttons to play music, an LED which lights up if the weight limit is exceeded, an emergency button and a battery level indicator

The measurements of the car are: 150 cm x 70 cm x 50 cm. The frame of the car will be made of plastic.

Because the appearance of the smart toy car should match the target group and the context, the color of the car should be a unisex color. Unisex colors can be [14]:

- Light warm blue (like turquoise for example)
- All types of green
- All types of yellow
- Red
- White
- Black
- Orange
- Chocolat/taupe-like colors


Our own noticeboard has been created by using the website of Flexa [15]. This noticeboard contains several unisex colors. Out of these colors, the four below will be chosen for being applied to our final product. So, there will be enough variation between the rentable cars, but it won't be too complex for the production process. Furthermore, four colors are enough to fit the majority of the personal preference of colors of children.


# 4.2

## Calculations

Battery capacity

To calculate the right battery capacity the following had to be taken into consideration: the weight of the car under full load is 113 kg, the driving time of the car should be at least 1,5 hours of drive time and the motor/motors should have enough torque /strength to be able to propel the car under full load.

The minimum amount of power needed to get the car to a speed of 5km/h ≈ 55 watts. Therefore 2 motors are needed to make the car feel snappy and responsive and to make sure it can drive up a ramp. As stated by the car manufacturer of another child's toy car: “The 12V motor systems are more powerful and will last longer in ride time. We recommend the 12V ride on cars as they also generally have a twin motor system. So both back wheels of the ride on the car are powered and you get more torque. 6V cars are good startup cars but will NOT go on grass. The older kids (3-6years) would need 12V, which would make their ride more enjoyable and they won't grow out of it quickly.”[15)]

For the prototype 2x 12v35watt rs550 motors will be used to provide a total of 70 watts of power, which is plenty of power but not excessive. These are the same as the motors used in a lot of the 12v cars that already exist. Battery capacity is usually given in Ampere-hour(Ah) so this will be used as an indication of the capacity. The calculations for the battery capacity needed are as follows:

*P x T = Watt -hour, P = 70 Watt, T = 1,5 hours*

*70 * 1,5 = 105 Watt -hour*

With the watt -hours the needed capacity can be calculated, which is in Ampere - hour:

*Watt -hour / Voltage = Ampere -hour, V =12 volt, watt -hour = 105*

*105 / 12V = 8, 75 Ah*

The total capacity needed for the battery is 8,75 Ah. This is not a standard capacity size so a battery of 9 Ah would be needed for the real car. The sizes of these batteries vary but one with Length 15,1cm, Width 6,5cm and Height 9,9cm would be a pretty good size estimation. These batteries weigh about 2,8 kilos[16)].

# 4.3
## Application of the car in practice

After renting the car the kid is free to roam around the shopping mall under the supervision of the parents. The parents are responsible for their children so there won't be any supervisors from the rental that walk around to help children as it is not a babysitting service. The cars can drive through the mall and in the stores.

On the dashboard of the car, there are some buttons to play music. This will keep the child more entertained during his/her time in the car. Moreover, on the dashboard there is a help knob. When this knob is pressed, the guardian will get a notification on the controller that the child needs help.

When the child leaves the car, the car sends a notification to the controller which shows that the child left the car.
The controller also contains an emergency stop button. When this button is pressed the car stops.

On the screen of the controller is also a GPS system. This system shows where the child is, so when the child presses the help button or if the guardian has lost the child, the guardian can find the child easily. This GPS system will be on the Wifi network. This is because it is more accurate.

The controller also contains a possibility to switch between the maximum speed the car can have. When for example there are a lot of cars in one store, the guardian can set the maximum speed lower and then go in the store. Also a possibility is that they come back later, but that is up to themselves.

# 4.4

## Renting and service points

To rent the car the family or guardians come to the desk of the rental service. They need to sign a contract for the liability and they pay a deposit of 30 euros. This can be done by using your bank card or by paying with cash. Paying for the time driven will be done after the car is returned. When this is done an employee will get them a controller and a car. The employee will also instruct the child and guardian on how to use the system.

When they understand how to use the car, guardian and child are free to roam around in the shopping mall and in the stores. Throughout the mall there will be drop-off points for the cars. In the case a child does not want to drive the car anymore the parents can drop of the car at these points so they don't have to walk all the way back to the rental station. These drop-off stations work like the scanners the Albert heijn uses. You put the car in a free spot and then you go to a screen where you can pay for the time driven. The deposit can be picked up at the rental point. When a station is almost full of cars an employee will get a notification to pick up the cars and will take them back to the rental point. This to make sure there is enough space for customers to drop off the cars.

After they are done shopping they can return the car at the rental desk or a drop off point. The amount of money to be paid is calculated (4 euros for every 30 minutes) and what remains of the deposit is returned. The employee will put the car back in storage and swap the battery when needed.

The amount of service desks & drop-off points is to be decided for each individual mall, depending on size, number of floors, but also the priority of that particular mall, i.e. do they want to provide the ultimate customer service or do they mainly want to keep it cost-effective? In any case, for the best experience the service desks need to be close to the entrance/exit of the mall and the drop-off points should be evenly distributed across the mall.

At the rental points, it is possible to perform easy and quick repairs or swapping of parts . However, when a car breaks down fully, it can be sent to an external repair point or replaced if necessary. Once again, the exact application of this may vary from mall to mall, depending on the number or cars a mall has and the amount of control over the process desired by the mall.

# Phase 5

## Prototype

# 5.1
## Sensors

<u>Potentiometer</u>

A potentiometer is a simple mechanical device that provides a varying amount of resistance when its shaft is turned. By passing voltage through a potentiometer and into an analog input on your board, it is possible to measure the amount of resistance produced by a potentiometer as an analog value. 18) 19)

<u>Weight sensor</u>

For the weight sensor in the prototype, two parts are needed: the HX711 and the Load Cell. [20]

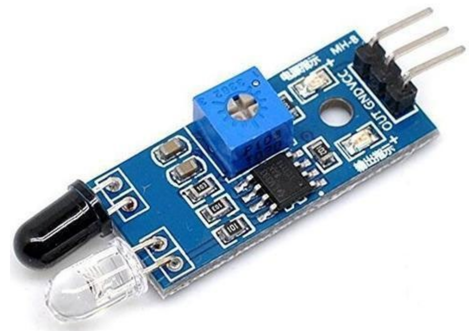
When pressure or a load is applied to the Load Cell, the electrical resistance will change in response to this applied pressure and by taking this information and after some calibration we can determine the precise weight. For the prototype the bar Load Cell is used.


The electrical resistance provided by the Load Cell need to be amplified so that they can be read by an Arduino. That is what the HX711 board does. The HX711 is a microchip. It reads the information from the Load

Cell, amplifies the signals and then sends it to the Arduino for processing.

IR sensor

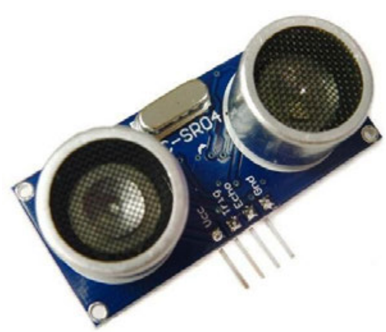
IR Sensor or Infrared Sensor is an electronic instrument that scans IR signals in specific frequency and converts them to electric signals. The IR signals are mainly used for transmitting commands over the air on short distances. Each signal represents a specific code. [21]



The IR sensor consists of two main parts, the IR Transmitter and IR Receiver. The work of IR transmitter is to transmit the infrared waves and the work of IR receiver is to receive these infrared waves. IR receiver constantly sends digital data in the form of 0 or 1. If there is an object in front of IR sensor, the transmitted infrared waves from IR transmitter reflects from that object and is received by the IR receiver and IR sensor gives 0 in this condition. Whereas, if there is no object in front of the IR sensor, the transmitted infrared waves from IR transmitter is not received by the IR receiver and IR sensor gives 1 in this condition.

Ultrasonic sensor

The ultrasonic sensor is a module which uses sonar to determine the distance to an object. The ultrasonic sensor comes complete with the ultrasonic transmitter and receiver modules. The ultrasonic sensor sends pulses via the transmitter. When the pulses find an object, they are reflected and the echo terminals receives the pulses. Because the speed of these pulses are known, namely 340 meters per second, the sensor can calculate the distance based on the time of the pulses. [22]



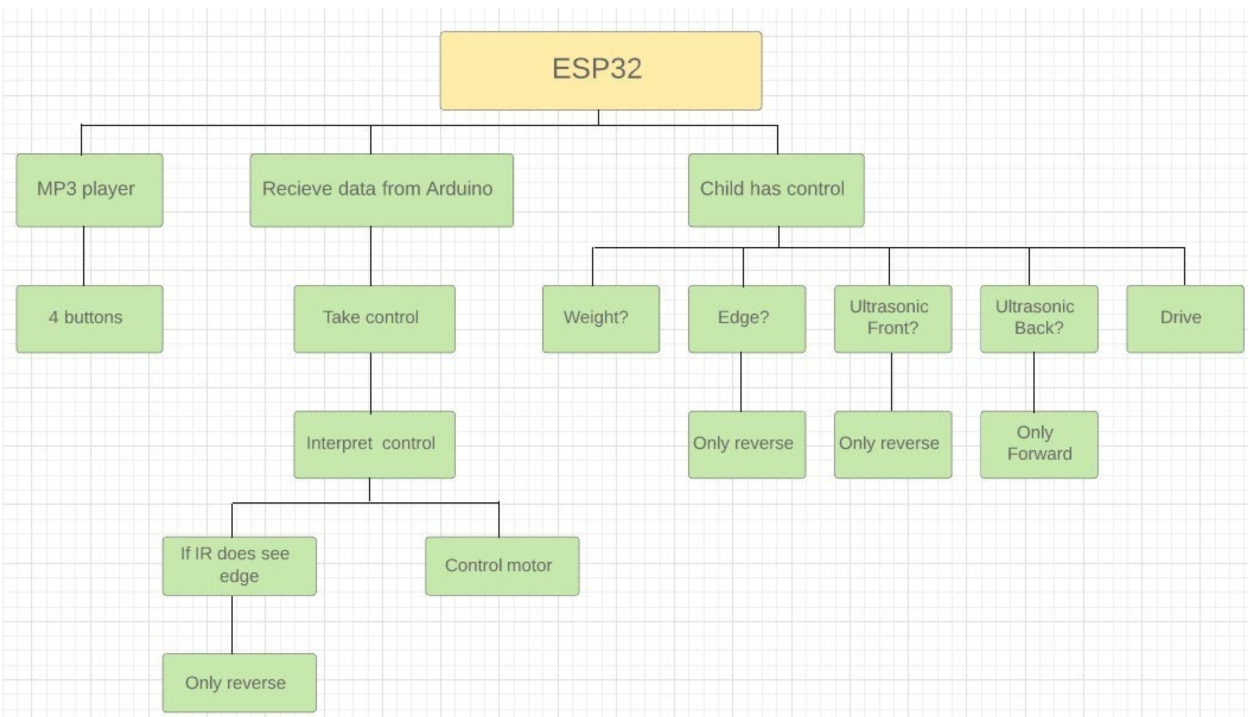
Sensor quality

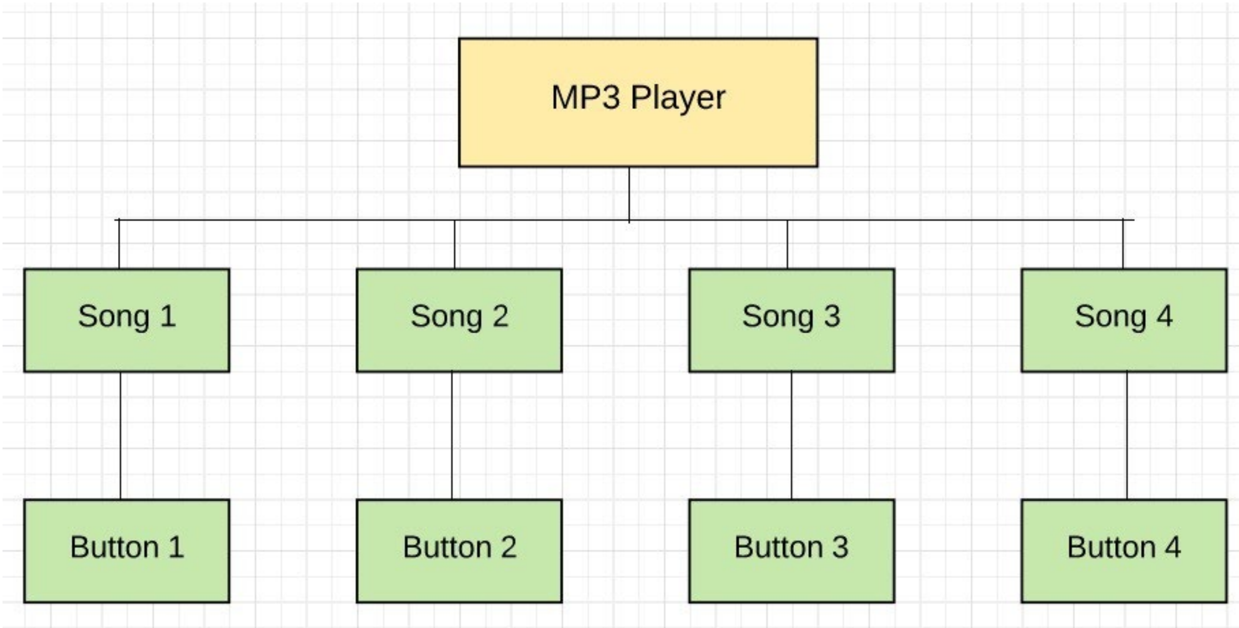
Because the sensors used are not of the highest quality, they sometimes give highly fluctuating data points. To counter this, an averaging system was implemented which makes sure that, for example, the car does not stop when the ultrasonic sensor gives a random low value.

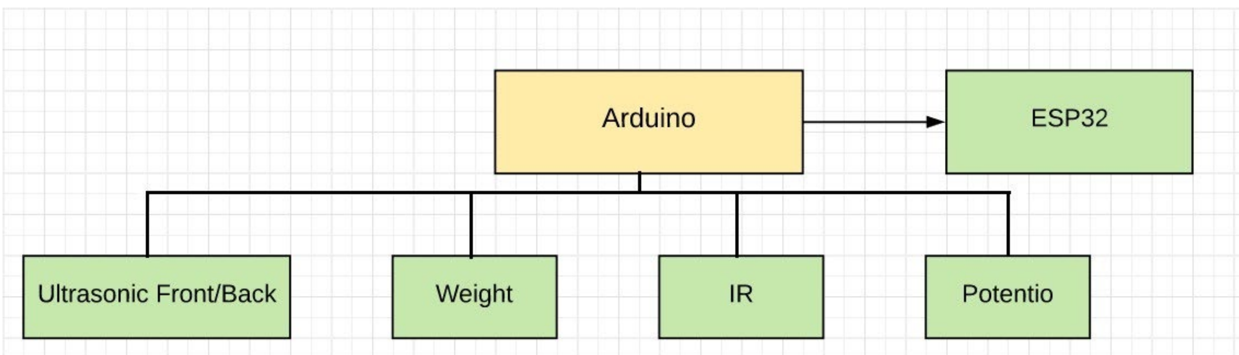
Here it is important to choose the right amount of time from which the data for calculating the average is taken. If the time is too short, there are just a few data points and so the average can easily be influenced by an outlying datapoint. Take to o much time and the reaction time goes down considerably.

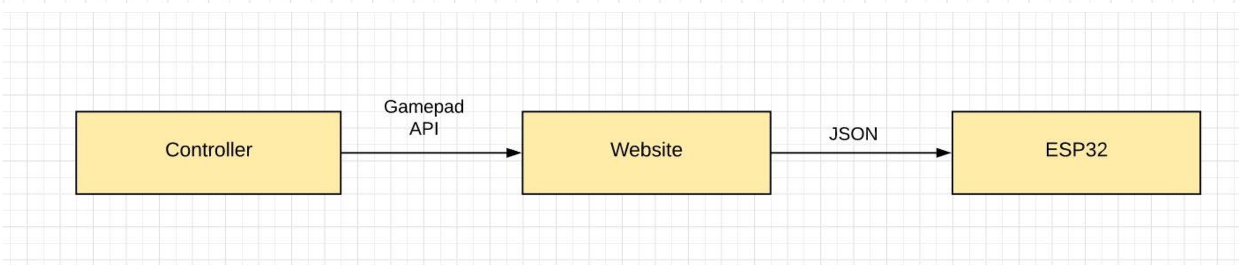
# 5.2

## Flowcharts




MP3 Player
Song 1
Song 2
Song 3
Song 4
Button 1
Button 2
Button 3
Button 4


Arduino
ESP32
Ultrasonic Front/Back
Weight
IR
Potentio


Controller
Gamepad
API
Website
JSON
ESP32

# 5.3
## Codes

To be able to interpret the signals from these sensors, two microprocessors were used: the Arduino Nano and the ESP32. In the system used, the ESP is the brain of the machine and the Arduino does nothing more than gather the data the ESP needs. There were three main rules to be incorporated, namely:

When the child has control:
- Stop when an edge is detected (e.g. a stairwell) and only allow movement in the opposite direction
- When the ultrasonic sensors detect an object in front of the car, only allow the car to move backwards
- When the ultrasonic sensors detect an object behind the car, only allow the car to move forwards

When the parent has control
- Stop when an edge is detected (e.g. a stairwell) and only allow movement in the opposite direction

The parent is only restricted by edges, since they are assumed to be competent enough at driving the car, and the car stopping well before every object behind or in front of it is likely to be more of an annoyance than a convenience.

### Arduino Nano

The nano is tasked with gathering data from the sensors and communicating it to the ESP. To do this, it has the following tasks:

<u>Steering and accelerator</u>

The steering wheel and accelerator are connected to potentiometers. In the case of the steering wheel , the signal that it outputs can be used as a measure of how much it is turned, and in the case of the accelerator, where the meter is located at the hinging point, it indicates how much the pedal is pressed down. The analogue values measured by these pote ntiometers are interpreted by the arduino and sent to the ESP

<u>Ultrasonic sensor</u>

For the car to be able to stop when a collision is imminent, ultrasonic sensors were used to measure the distance between the car and the closest object in front of the car or behind it. These sensors sweep through these areas to get better coverage. These sweeping motions are performed by servo motors to which the sensors are attached.

The arduino processes the distances and forwards them to the ESP

<u>Weight Sensor</u>

The we ight sensor (used to measure if there is someone in the car and if the maximum weight is not being exceeded) outputs a signal, which is amplified by a chip (as mentioned in 5.1). The arduino gathers this data and sends it to the ESP

<u>Edge Detection</u>

The edg e detector is an infrared sensor with a potentiometer set to maximum distance, which means it already detects whether or not there is an edge in front of the car. It sends this to the arduino, which then forwards it to the ESP

**Communication between micr oprocessors**

The arduino and the ESP32 are connected with two cables, and using the I2C protocol they are able to exchange data, allowing the ESP to make decisions (should the car drive or not) with the sensor input from the arduino.

**ESP32**

The ESP32 acts as the brain of the car, deciding when the motors are able to drive and when the steering servos engage.

Steering

The car is able to turn by a simple steering system where the servo moves a bar connected to the wheels, turning them left or right. The ESP directly connects to these servos, and uses the input from the potentiometer on the steering wheel to determine the angle of the servo.

Driving the motors

The ESP outputs the motor orders to the L298N, a motor driver, which amplifies the signal to the current required to actually drive the motors, allowing the car to move. The ESP generated this signal using the data from the potentiometer connected to the accelerator pedal

**Website/server**

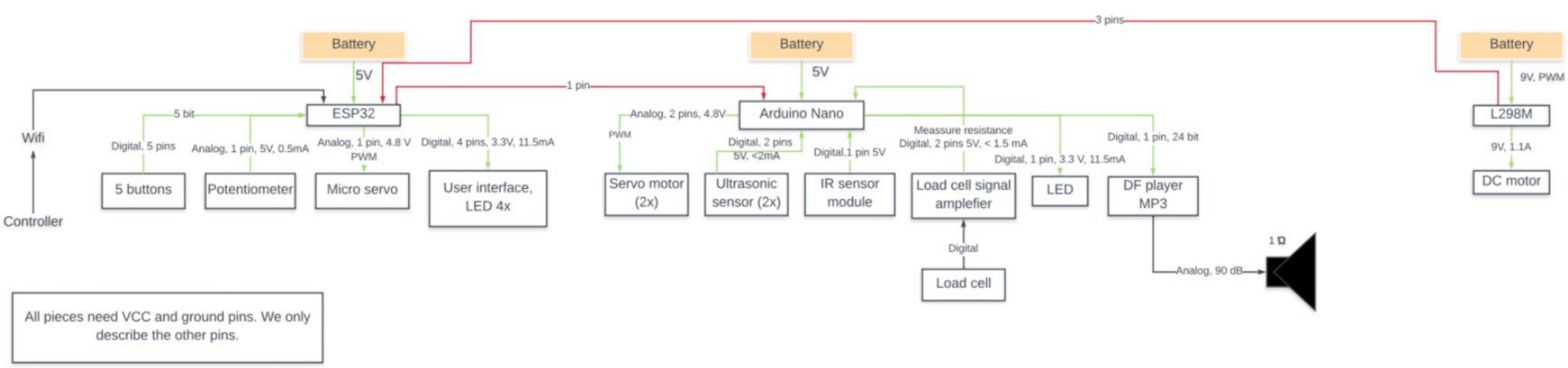
To allow the controller to communicate with the car, the GamePad API was used as a base and built upon. This piece of code allows the website to receive and interpret the data from the controller via WiFi.

In order to process the choices the guardian makes on the controller interface, like setting the maximum speed, the controller is connected to a website using WiFi. This website connects to the ESP32 using a Websocket and a JSON protocol. The Websocket facilitates the actual connection, creating a tunnel as it were.

JSON is a lightweight data-interchange format, which "translates" the data to allow communication between the website and the ESP in the tunnel opened by the Websocket.. In this way, the ESP32 can then use the data from the controller to limit the power going to the engines or cut their power entirely when the edge detector sees no ground in front of the car.

WiFi was used in favour of BlueTooth, since WiFi offers a theoretically infinite range, as long as the same network is used throughout the entire mall, whereas BlueTooth is very limited in comparison. Using WiFi also makes it easier to determine the car's location within the mall, and even though this feature was not implemented in the end, it is still relatively easy to still add it.

## 5.4
## Block diagram

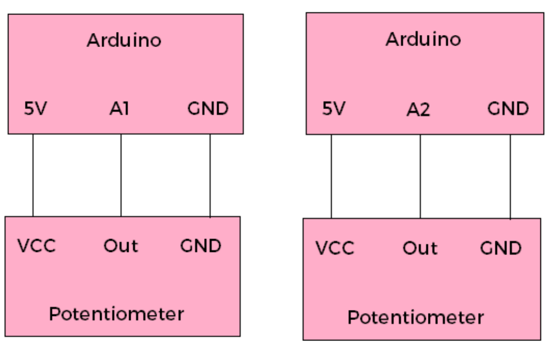



The block diagram is part of the system design. A block diagram shows the main electronic components or systems in an electronic design. It also shows how they are connected. Each block has a function, but it primarily has a physical manifestation.

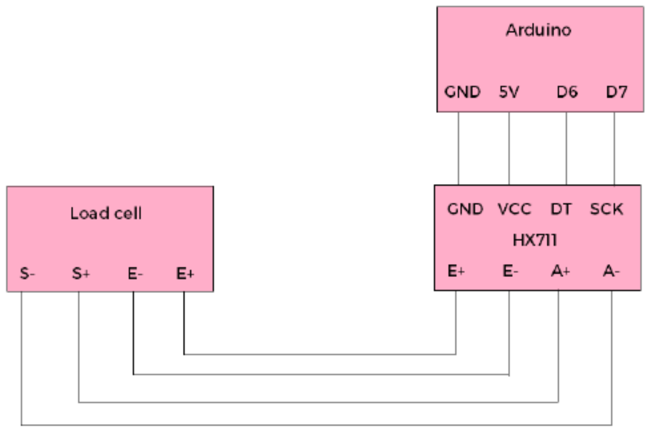
The signals are mentioned in the block diagram. Every connection between the blocks are indicated, and the amount of energy it uses is also shown.

The green arrows show the direction of the information being exchanged. With this information the actions will start.

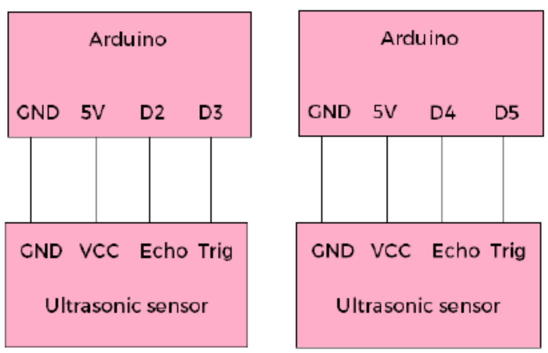
## 5.5
## Electric circuits



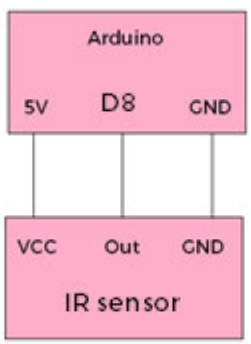

Electric circuits potentiometers to the Arduino.



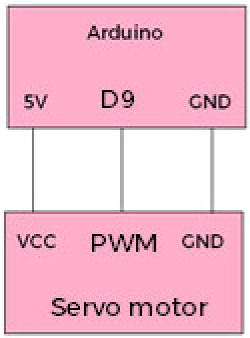

Electric circuit weight sensor to the Arduino.

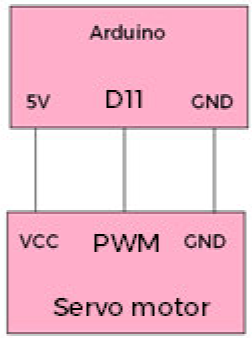



Electric circuits of the ultrasonic sensors to the Arduino.

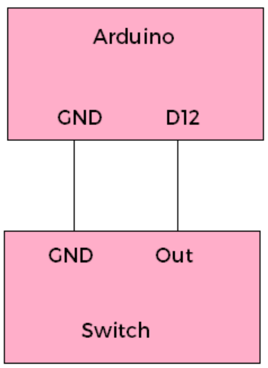



Electric circuit of the IR sensor to the Arduino.

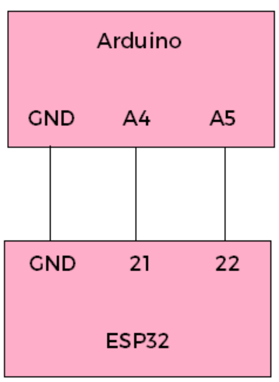


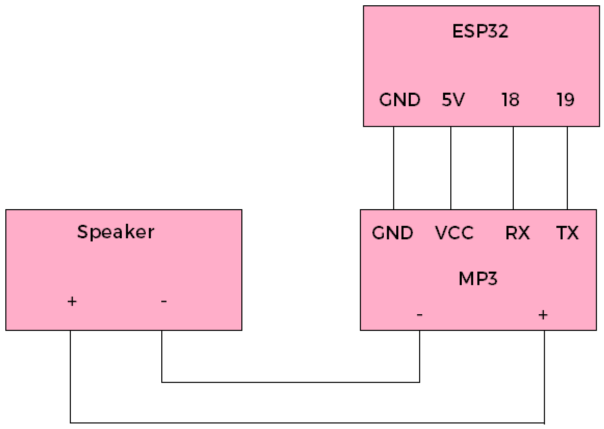

Electric circuits for the servo motors to the Arduino.



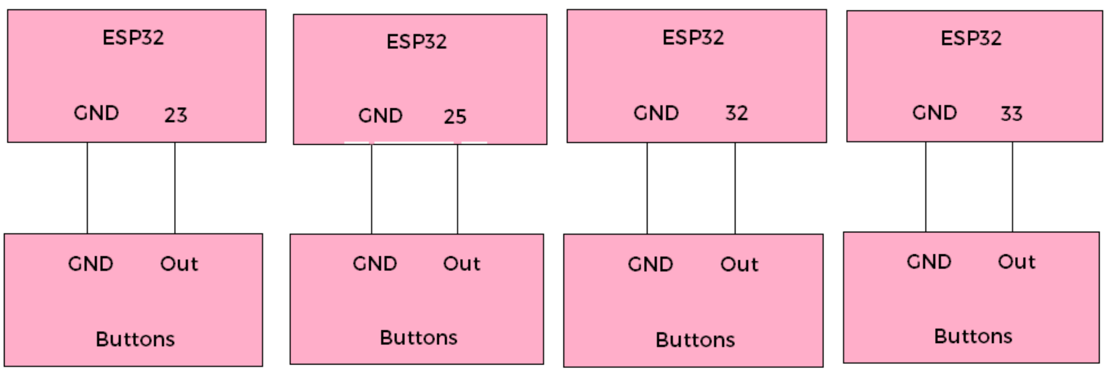

Electric circuit for the Switch to the Arduino.



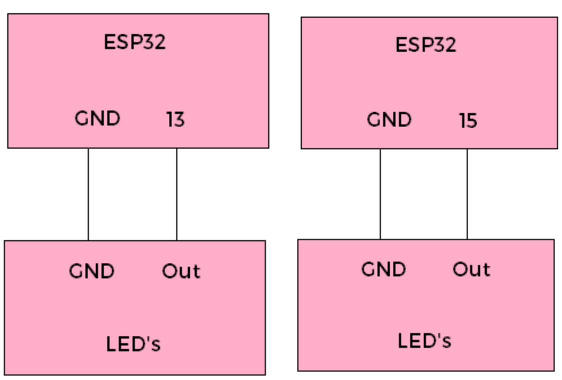

Electric circuit for the ESP32 to the Arduino.



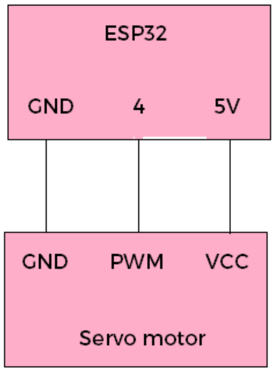

Electric circuit for the MP3 to the ESP32.



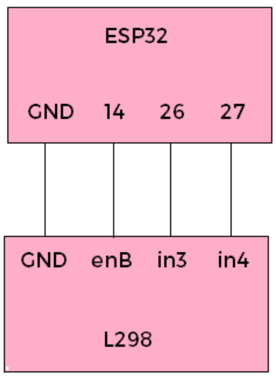

Electric circuit for the buttons to the ESP32.



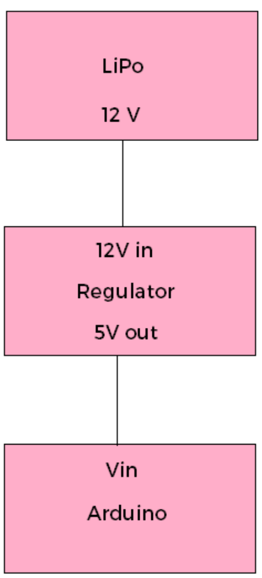

Electric circuit for the LED's to the ESP32.



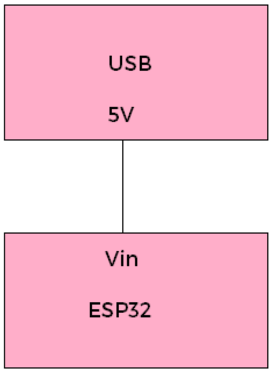

Electric circuit for the Servo motor to the ESP32.




Electric circuit for the L298 to the ESP32.




Circuit for the power for the Arduino.

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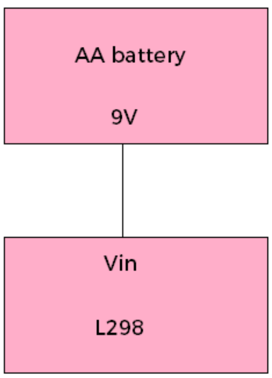
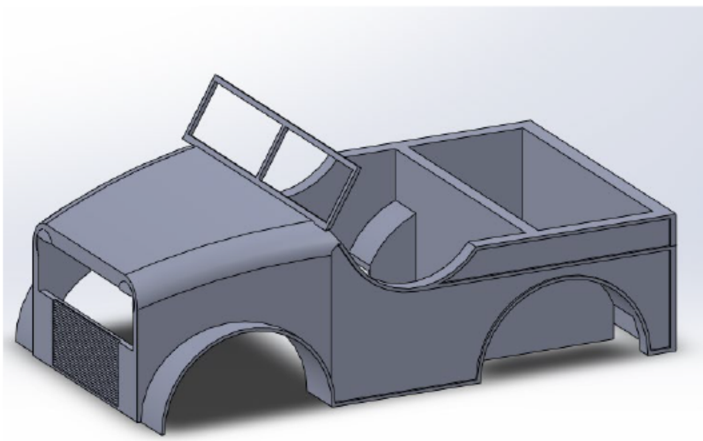


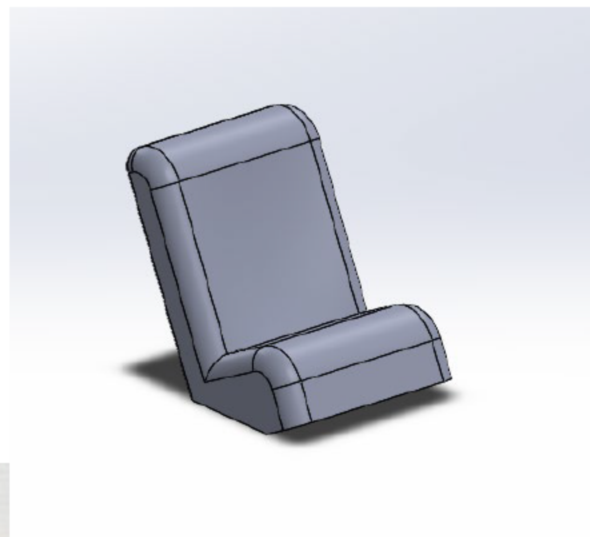

Circuit for the power to the L298.

# 5.6

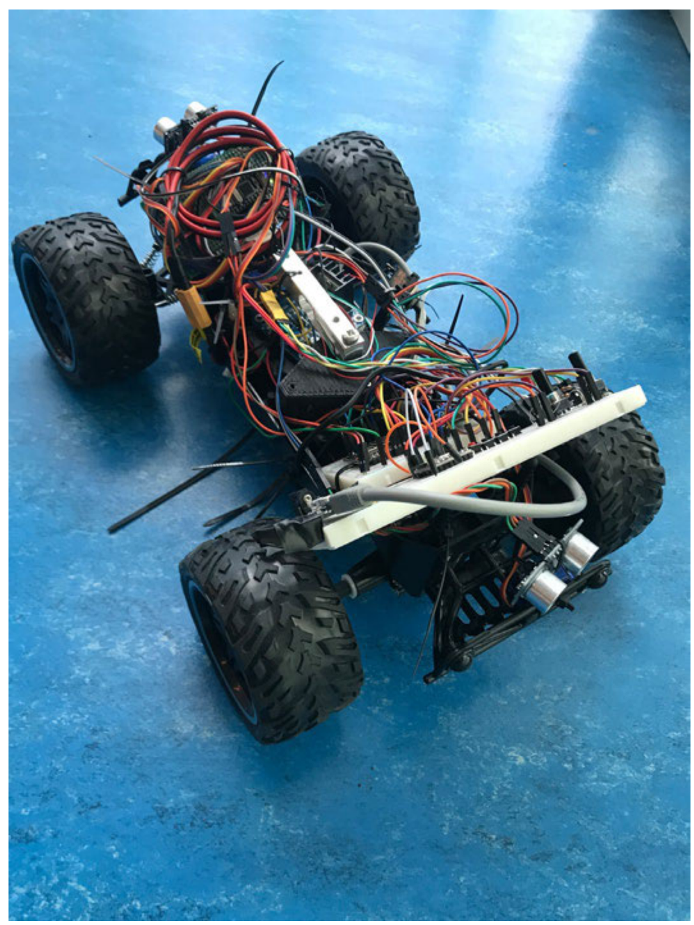
## Solidworks model & final prototype

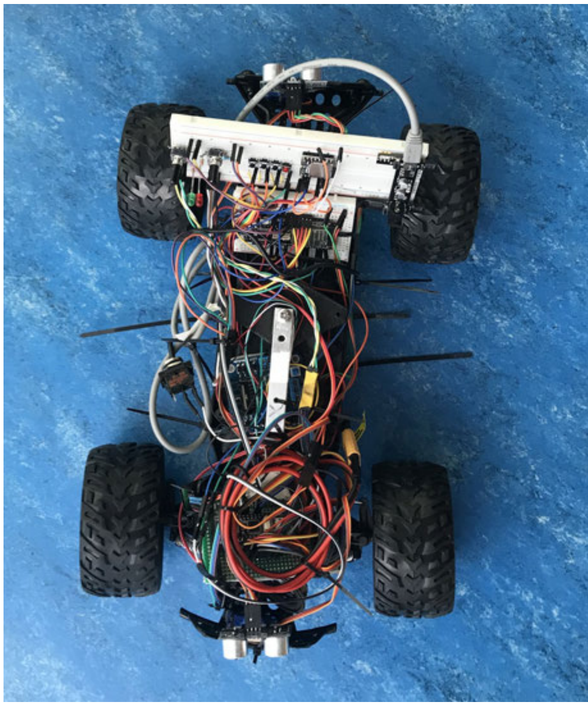
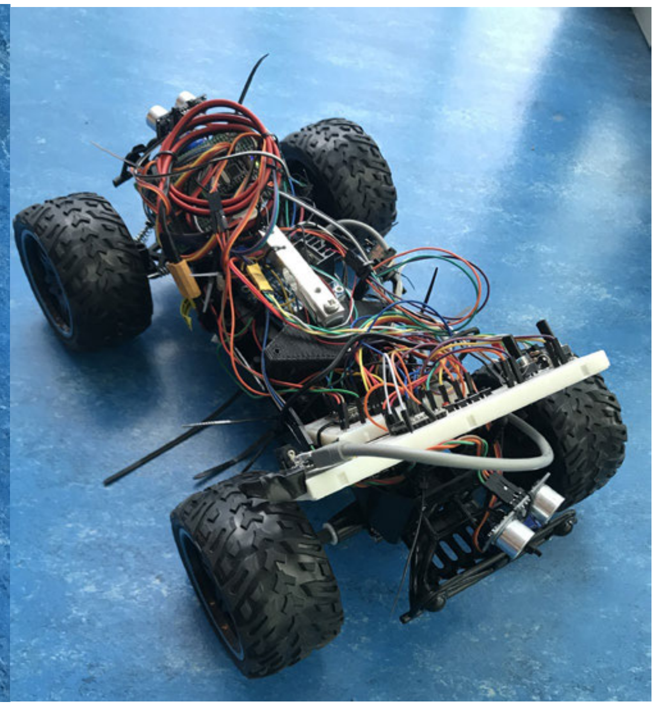
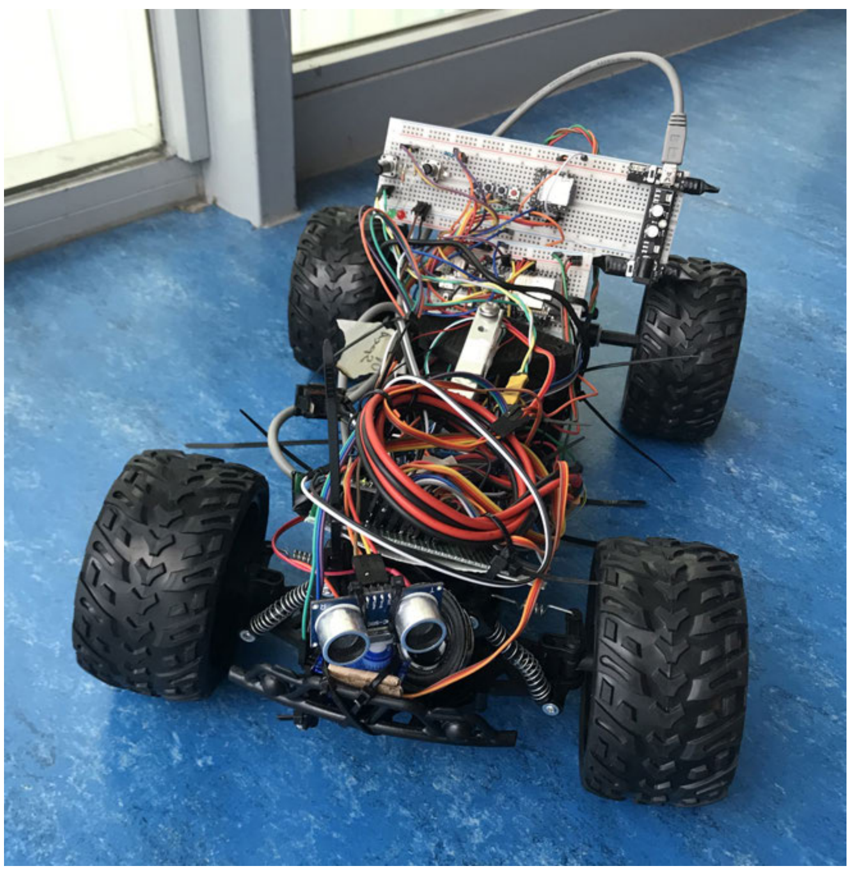
For the outside of our toy car we wanted to 3d print a shell that would fit around our frame. We made a solidworks model and exported it to an stl file in order to 3d print it. After loading it in our 3d printer, it turned out that the total print would take over 6 days to complete, so due to time constraints we ended up making the actual shell out of cardboard.









# Phase 6
## Product evaluation

# 6.1
## Usability test set-up

**Focus points**
First, some focus points will be explained.

*Effectiveness*
*What should your users at least be able to do with your product?*
It is important that both guardians and children are able to easily understand and use the interface to control the toy car as intuitively as possible.

*Efficiency*
*What ease of use do you aim for? What are the limits in effort?*
It should be possible for the child to start the car and drive away within 15 seconds. Before the child enters the car, it will get some explanation from a staff member. Within 1 minute, the child should recognize all the buttons etc. The guardians should be able to use the controller within a minute (after explanation).

*Satisfaction*
*What is it you hope your users value in your design? Anything special or peculiar about your product ?*
What children will value in our design, is that the dashboard contains several different buttons to play nice music tunes. The guardians will especially appreciate that the controller lies comfortably in the hand and the joystick is pleasant to use. Furthermore, the overrule-button will be valued by the guardians

**Variables and methods**
The three focus points above can be represented by several variables.

*Effectiveness*
Successfulness, number of errors, counting task completion, accuracy, completeness

*Efficiency*
Time, Number of steps, number of retraces, number of solved tasks

*Satisfaction*
Ratings, behaviour, emotions, actual use, comfort, acceptability

For each variable, there need to be determined how to collect some insights. These insights will be collected by setting up a usability test. During this test, the participants will be observed, direct in person. The actions, and behaviour of the par ticipant will be written down and the time a participants before completing a task successfully will be measured.
These observations and measurements will be analysed. After exerting all the parts of the usability test, questionnaires will be filled in by the participants. The questionnaires contain only open questions and ranking questions.

**Comparison of independent and confounding variables**

Independent variables: These are the variables that will be deliberately varied.

- ➢ The sequence of the activities is an independent variable. There isn't a strict sequence. each participant can choose which part of the test he wants to do first.

Confounding variables: These are the variables that will be kept constant.

- ➢ Artifact: artifact won't be an independent variable during the test, because just one foam controller, one Xbox controller and one scaled smart toy car mode will be used. All these will be used by every participant. There are no different versions of the designs.
- ➢ People: this is a special case. Because everyone of the participants has a comparable age (between 18-22) you could say that people are a dependent variable. Besides that, each participant has experience with driving or with gaming/holding a controller.
- ➢ The questionnaires at the end of the usability test will also be the same for each participant.
- ➢ Context: during the whole usability test, the circumstances are the same (same location, same atmosphere).

Special case: this case can be called independent but also confounding.

- ➢ Activities:
    - The actions which need to be exerted, will be the same for every participant. (Confounding)
    - The events on which a person needs to react will be a constant factor. (Confounding)

- The level of instruction beforehand differs. During the test, the group of test persons will be divided in two different groups, of which one will get explanation before the test and the other won't. (Independent)

For our usability test, we chose for a "within-subject" set-up. This means that each participant will participate in all the different sub-tests of our usability test and will thus participate in all conditions. Advantages are that less participants are needed and that subjective data can be compared. A disadvantage can be that people will exert the actions better at the later parts of the usability test due to a learning effect. But this will not be the case at our usability test, because the separate parts of the total test differ a lot from each other and they test different things.

### Hypotheses

- 1: Participants with explanation will exert the actions at least two times faster than the participants without explanation. (This will be based on the total average time)
- 2: Participants are of all buttons, the least satisfied with the emergency stop and the overrule button.
- 3: The use of the toy car and controller will be clear for both groups. All participants can find all buttons or functions within 5 seconds.

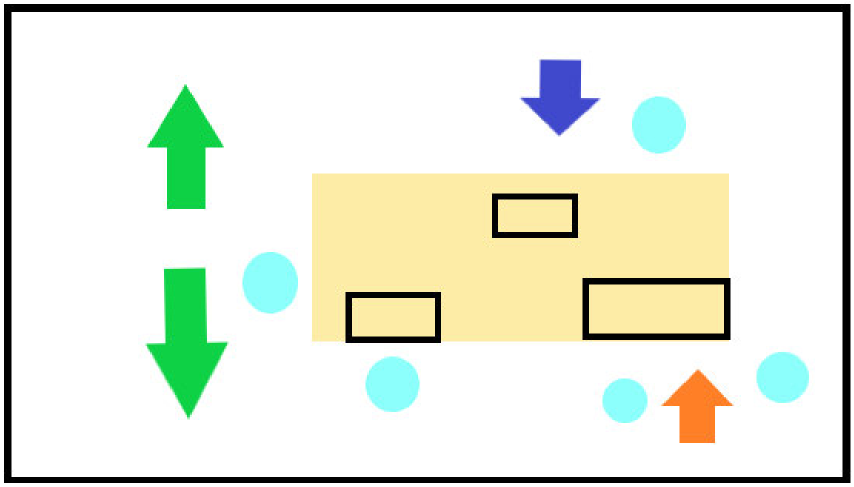
### Define test protocol

*Participants*
For executing the usability test, we will invite at least 12 participants. These participants are all students, with ages varying from 18 -22. Students can give a quite good representation of the user group (adults). These participants are, as already mentioned above, partly an independent variable. Note that probably all of these students are quite experienced with playing games and/or holding an (game)controller. Furthermore, the amount of driving experience can differ.
The participants will be scheduled in a good and structurized way to succeed executing all parts of the usability test within the available time.

*Test situations (context)*
- The usability test will be executed in room NH205 of the University of Twente. This holds for all participants.
- The scene is as follows:

- The test area consists of three parts. One Part will include the test with the smart toy car, One part will include the test with the controllers and menu, and one part will include space for filling in some questionnaires.

➢ Top view of the experiment set-up:



The yellow rectangle is a table. All the light blue dots are member of our project group. The little black rectangles are laptops.

- Green arrows: space for the test with the toy car (dashboard etc.)
- Blue arrow: space for filling in the questionnaires
- Orange arrow: space for the test with the controller and menu

*Script for the full test*

➢ The group of test persons will be divided in 2 groups. One group will get explanation beforehand, the other group won't.

➢ The participants need to hold a shopping bag (with some weight) in one hand, so they won't be able to use the controller with 2 hands. (This only holds for the tests with the controllers, not the test with the imitated smart toy car).

➢ The total test consists of three parts:
- The test with the foam controller, the menu and the prototype.
- The test that will only focus on the car.
- The questionnaires

*Use and understanding of the controller and the menu*

➢ First, say nothing and let the test persons do what they think they should do.
  - (Nothing will happen)

➢ We will give them the indication to overrule.

➢ We will test if all the buttons are clear and if the participant can manage in every presented situation.

- We will ask the test persons if they can execute a certain action, for example accelerating, and observe which button a certain test person will use. In this way, we can check if it is clear enough which button represents which action.
- Ask what they will do when a certain event occurs. We will create a list of events and will complete this list with every participant. This events will stay constant.

➢ We will ask the person to give the control back to the child, and observe what the participant will do.

➢ After that, we will give the test person an Xbox controller, and will ask them if he/she can adapt something in the menu.

- We will introduce a certain situation or event and will ask them how they will react. We will create a list of events/situations and will complete this list with every participant. This events will stay constant.

➢ Furthermore, we will let the participants control the prototype toy car and look if they can navigate the car with the Xbox controller.

*Use and understanding of the car*

➢ For this test, we want to imitate the car as well as possible. Therefore:

- The test person will sit back to front on the chair
- We imitate a dashboard, a steering wheel, a lever, and several buttons, lamps

➢ We will introduce a certain situation or event and will ask them how they will react.

- For example, ask if they can make a noise. Furthermore, we will push the chair through the room to create the driving experience.
- We will create a list of events/situations and will complete this list with every participant. This events will stay constant.

*Questionnaires*

➢ Finally, we will examine a questionnaire with all the participants to evaluate the use and their experience. Did they like it? Or was it too difficult? What can be improved? Did it meet your expectations?

Actions for the controller en menu test:

- ➢ Let the controller work/overrule
- ➢ Step on the gas
- ➢ Brake
- ➢ Emergency stop
- ➢ Driving in reverse
- ➢ Steering
- ➢ Using the menu
    - ○ Set maximum speed
    - ○ Set volume
    - ○ Set security distance
- ➢ Give control back to the child

Actions for the user interface:

- ➢ Step on the gas
- ➢ Brake
- ➢ Emergency stop
- ➢ Driving in reverse
- ➢ Steering
- ➢ Playing different music
- ➢ Reading the battery level
- ➢ Using the horn

- ➢ *Events/situations:*
    - ○ Low battery
    - ○ Lost
    - ○ Pee
    - ○ Contact with parents

*Task division*

This division will be the same during the whole test

- ➢ Test with controllers and menu
    - ● Leading > Floris K.
    - ● Observing > Martijn

➢ Test with smart toy car
    - Leading > Isa
    - Observing > Laura
➢ Questionnaires and Extra person (to exchange with other groups)
    - Floris G. and Robert

*Time needed:*

➢ The calculated time per participant for the whole test is 15 minutes
➢ This means on average 5 minutes per test
➢ The testing starts at 10, and we need at least 2 hours. If there is more time needed, the test will be continued.

***Test protocol***

➢ List participants
    - Participants with explanation (gender, age, experience)
        - Participant 1 (Male, 18, yes)
        - Participant 2 (Male, 18, yes)
        - Participant 3 (Female, 19, yes)
        - Participant 4 (Male, 20, yes)
        - Participant 5 (Female, 21, yes)
        - Participant 6 (Male, 20, yes)
    - Participants without explanation
        - Participant 7 (Female, 20, yes)
        - Participant 8 (Female, 22, yes)
        - Participant 9 (Male, 18, yes)
        - Participant 10 (Male, 20, yes)
        - Participant 11 (Male, 20, yes)
        - Participant 12 (Female, 20, yes)

List needed material
    - 12 test persons
    - Foam controller
    - Xbox Controller
    - Laptop
    - Prototype
    - Cardboard interface/paper prototype lever, steering wheel, dashboard etc.
    - Chair with wheels
    - Shopping bag with some weight inside
    - Pen and paper
    - Questionnaires

➢ Sketch of test situation (see 4B)
➢ Script per participant
  ○ 2 students will attend the test with the controller (1 observer, 1 instructor)
  ○ 2 students will attend the test with imitated smart toy car (1 observer, 1 instructor)
  ○ 2 students will examine the questionnaires and will keep the overview.

## 6.2
## Answer hypotheses

➢ 1: Participants with explanation will exert the actions at least two times faster than the participants without explanation. (This will be based on the total average time)
➢ 2: Participants are of all buttons, the least satisfied with the emergency stop and the overrule button.
➢ 3: The use of the toy car and controller will be clear for both groups. All participants can find all buttons or functions within 5 seconds.

These are our hypotheses. Based on the outcome of the tests, these hypotheses can be confir med or refuted.
For the first hypothesis, the average time for exerting actions is needed to research which group of participants exerts the actions faster and to research how much faster.

Test with the car

| Without explanation | With explanation |
|---|---|
| 7 + 5 + 1 + 1 + 1 + 1 + 1 = 17 seconds<br>17/7 = 2,428571486 seconds<br>≈ 2, 4 seconds | 1 + 2 + 1 + 1 + 1 + 1 = 8 seconds<br>8/7 = 1,142857 1429 seconds<br>≈ 1,1 seconds |

Test with the controller

| Without explanation | With explanation |
|---|---|
| 5 + 3,5 + 1 + 6,1 + 1 + 9 + 2,3 = 27,9 seconds<br>27,9/7 = 3,987142857<br>≈ 4,0 seconds | 1 + 1 + 1 + 1 + 1 + 3 + 1 = 9 seconds<br>9/7 = 1,2857142857 seconds<br>≈ 1,3 seconds |

2,4/1,1 = 2,1818181818 times faster
4,0/1,3 = 3,0769230769 times faster
So for both test s, participants with explanation will exert the actions at least two times faster than the participants without explanation. So this hypothesis is true.

For the second hypothesis, the results of the test with the controller, and specific to the results o f ' Least comfortable button' and 'ideas to improve' need to be analysed.

Least comfortable buttons:

- ➢ Overrule > 12 votes (92,3 % of the participants)
- ➢ Driving in reverse > 1 vote (7,7 % of the participants)

Ideas to improve:

- Overrule button > 7 votes
- Working of the menu > 2 votes
- Driving in reverse > 1 vote
- Text on controller > 2 votes
- Nothing > 1 vote

Our expectations were that participants are the least satisfied with the emergency stop and the overrule button. This is partly true, based on the measurements and questionnaires. The overrule button is considered to be one of the least comfortable buttons and should be improved. But in contravention of our expectations, the participants didn't have any problems with the emergency stop-button. This button could be experienced unpleasant because it is located underneath the thumb and not very comfortable to reach, and because of the fact that it is very likely to press the button inadvertently. So, this hypothesis is partly true. There should be thought about a new place for the overrule button.

For the third hypothesis, there will be looked at the average time that is needed to find all buttons or functions. If this is less than 5 seconds, the use of the toy car and the controller can be considered as clear. Based on our measurements, there are some actions that needed more than 5 seconds (on average) to fulfill.

- Accelerating (test with car, without explanation) > 7 seconds
- Driving in reverse (test with controller, without explanation) > 6,1 seconds
- Using the menu (test with controller, without explanation) > 9 seconds.

Accelerating took a long time in the test because the gas pedal was hard to find (behind the chair). In the real product, the gas pedal will be on a very recognizable place, just as every normal car. So then, the time needed to find the pedal should be less than 7 seconds.
Driving in reverse takes more than 5 seconds, because the use of this button is not intuitive at all. This button needs clear explanation before using the product.

Using the menu also took longer than 5 seconds. This is because at the moment, the menu is a bit too hard to control. To solve this, an arrow pointing to the right should be added to the menu, and clear explanation before using is needed.

## 6.3
## Conclusions and Recommendations interaction design

Most of the functions on the controller were understood well, but of course the comments should be taken into account. The overrule button was not easy to reach, so a different spot should be found for this button. Furthermore, it was quite difficult to un derstand the control of the menu. Addition of arrows in the right direction will cause a better understanding of the control of the menu.

The dashboard of the car was clear to the test persons. The gas pedal was not easy to find, because of the way it was connected to the chair. In the real car, the pedal will be visible and there won't be a problem with finding the pedal.
Moreover, the gear stick was well understood and easy to use.
Almost all the test persons figured out that there was no button on the dashboard to contact the parents. This is a comment that will obviously be taken into account, because this is of course an important button and will be a great addition to the Product.

In general, a good and clear explanation beforehand, will provide b etter use and understanding of the product. This is certainly needed for the overrule -button and the reverse -button.

The testing itself could be improved and be more realistic by using different test persons, some with experience of driving a car, and so me without experience. There could also be more variation in ages of the participants and variation in the amount of experience participants have with playing games or using a controller.
This might be a factor that influences the results of the test.

Overall, the test can be assumed as successful. The comments are very useful and will be taken into account in the final product.

# 6.4
## Product evaluation

Most requirements were met. The ones that aren't met can't be realized with the prototype as it is a scale model of the real car and because of limitations in resources. The wishes were mostly not met but because these are wishes it is not a problem.

| | Product function analysis | Functional Specification V1 | Functional Specification V2 | Was/wasn't met/applicable to prototype |
|---|---|---|---|---|
| Requirements | Steer the car | Child can steer the car | Low force needed to steer the car | Not applicable to prototype, will be so in the real car |
| | | | The steering wheel must fit in the hands of a child | Not applicable to prototype, will be so in the real car |
| | | | Intuitive steering mechanism, by hand/arm | Requirement is met<br>-steering wheel |
| | | Guardian can steer he car | Well controllable remote steering | Requirement is met<br>-controller |
| | Regulate Speed (Power) | Have a variable speed control | Intuitive way to select speed, by foot | Requirement is met |
| | | | Guardian can control the speed (power) | Requirement is met |

| | | | | |
|---|---|---|---|---|
| | | | Speed can be varied by the amount of force applied to the paddle | Requirement is met |
| | | Can limit the speed | The maximum power can be regulated | Requirement is met |
| | | | Maximum speed | Requirement is met |
| | Resistant against splashing water | Electronics are protected | All the electronics should be covered so that the water can not reach it | Not applicable to prototype, will be in the real car. |
| | | Materials are water resistant | All the materials that are used, must be resistant against splashing water | Not applicable to the prototype, will be so in the real car |
| | Drive in reverse | The car can drive slowly in reverse | The car can drive slowly in reverse, if it needs to turn after a crash for example | Requirement is met |
| | Safe | Safe for children | The car should not have small parts | Requirement is met |
| | | | Working mechanism is covered | Requirement is met |
| | | | Electronics are covered | Requirement is met |
| | | | Sensor for crashes | Requirement is met |
| | | Safe for other people | Sensor for safety hazards | Requirement is met |
| | Emergency stop | The car can stop immediately if the guardian regulates this from a distance | Hardware switch to overrule the system and stop the car using the controller from a distance | Requirement is met |
| | Support weight | Can withstand the majority of children in our target group | A child within our target group weights 30 kg max. Assuming the car can carry 2 children, so the car must support 60 kg. Furthermore we take into account a safety factor of 1,5 | Not applicable to prototype, will be so in the real car |
| | Strong | Frame is made of a strong material | Frame should carry the weight of the electronics and of he children | Not applicable to prototype, will be so in the real car |
| | Portable | The car shouldn't be too heavy | The car should not weigh more than the allowed weight according to the ARBO regulation | Not applicable to prototype, will be so in the real car |

| | | | | |
|---|---|---|---|---|
| | | Car has a carrying handle | Handle is comfortable to use | Requirement is met |
| | Driving time | The car has a battery (6V) | The car battery must be rechargeable | Requirement is met |
| | | Battery | The car must be able to drive approx. 1,5 hours. Therefore, he charging time is 600 minutes | Requirement is met |
| | Cleanable | The car can resist cleaning products | The car can resist cleaning products | Not applicable to prototype, will be so in the real car |
| | | The car is easy to clean | The car should be easy to clean | Not applicable to prototype, will be so in the real car |
| | | | Alle places must be easy reachable, for example with a cloth | Not applicable to prototype, will be so in the real car |
| | Matches the users and the context and shows the meaning of the product. | Has an appearance and affordance that is attractive to children | Different cars have different colours and shapes that fit the target group. The car should be unisex. | Not applicable to prototype, will be so in the real car |
| | Compete in market | Fits the price of other rentable childrens toys and smart toy cars | Average about € 400, - | Not applicable to prototype, will be so in the real car |
| | Sound speaker | Sound speaker can alert people in case of danger | Alerts people through he use of a horn | Requirement is met |
| | | Can make music | Press buttons for different musics/tones | Requirement is met |
| | Lifespan | Has a long lifespan | A long lifespan because we take into account that maintenance from separate parts is possible | Not applicable to prototype, will be so in the real car |
| | Maintenance | Car can be made in such a way that maintenance is possible | If a part is defective, it can be pulled out of the car and can be brought to the garage | Not applicable to prototype, will be so in the real car |
| | Durability | The car should be as durable as possible | The car should be as durable as possible | Not applicable to prototype, will be so in the real car |
| | Recyclable | Car is made of recyclable materials and different materials are easily taken apart again | Car is made of recyclable materials and different materials are easily taken apart again | Not applicable to prototype, will be so in the real car |
| | LED | Has an LED that can change color according to a status | Different colors that shows the battery level | Not applicable to prototype, will be so in the real car |
| **Wishes** | Automatic charging | Vehicle drives to charging dock when battery is low | Vehicle needs no help to charge its battery | Wish not met |
| | Steering | Small circle of rotation | Small circle of rotation | - |

| | | | | |
|---|---|---|---|---|
| | | Software helps the child in steering the car | sensor detects safety hazards and helps to steer the car away from them | Wish not met |
| | Mapping environment | The car mappes the surrounding area to prevent crashes | | Wish not met |
| | Nice music tunes | Multiple sound effects by pressing multiple buttons | Can play tunes | Wish is met |
| | weight | Maximum weight allowed to carry for employees | Maximum weight allowed to carry for employees | Not applicable to prototype, will be so in the real car |
| | Strength | Vehicle can carry an adult | 100kg adult | Not applicable to prototype, will be so in the real car |
| | Cargo | Vehicle has space for cargo | Room for 1 grocery bag | Not applicable to prototype, will be so in the real car |
| | Multiple colours | Colours for boys and girls | Colours for boys and girls | Wish is met |

Because the prototype is a scale model, has exposed electronic and a cardboard exterior there were some requirements that were not met because they couldn't be implemented, were not available because of limitations in resources or were not relevant. These requirements will be met in the real car. The following requirements can not be met or are not relevant for the prototype:

| | | | |
|---|---|---|---|
| Steer the car | Child can steer the car | Low force needed to steer the car | Not applicable to prototype, will be so in the real car |
| | | The steering wheel must fit in the hands of a child | Not applicable to prototype, will be so in the real car |
| Resistant against splashing water | Electronics are protected | All the electronics should be covered so that the water can not reach it | Not applicable to prototype, will be in the real car. |
| | Materials are water resistant | All the materials that are used, must be resistant against splashing water | Not applicable to the prototype, will be so in the real car |
| Support weight | Can wi hstand the majority of children in our target group | A child within our target group weights 30 kg max. Assuming the car can carry 2 children, so the car must support 60 kg. Furthermore we take into account a safety factor of 1,5 | Not applicable to pr ototype, will be so in the real car |
| Strong | Frame is made of a strong material | Frame should carry the weight of he electronics and of the children | Not applicable to prototype, will be so in the real car |

| | | | |
|---|---|---|---|
| Portable | The car shouldn't be too heavy | The car should not weigh more than the allowed weight according to the ARBO regulation | Not applicable to prototype, will be so in the real car |
| Cleanable | The car can resist cleaning products | The car can resist cleaning products | Not applicable to prototype, will be so in the real car |
| | The car is easy to clean | The car should be easy to clean | Not applicable to prototype, will be so in the real car |
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| Lifespan | Has a long lifespan | A long lifespan because we take into account that maintenance from separate parts is possible | Not applicable to prototype, will be so in the real car |
| Maintenance | Car can be made in such a way that maintenance is possible | If a part is defective, it can be pulled out of the car and can be brought to the garage | Not applicable to prototype, will be so in the real car |
| Durability | The car should be as durable as possible | The car should be as durable as possible | Not applicable to prototype, will be so in the real car |
| Recyclable | Car is made of recyclable materials and different materials are easily taken apart again | Car is made of recyclable materials and different materials are easily taken apart again | Not applicable to prototype, will be so in the real car |
| LED | Has an LED that can change color according to a status | Different colors that shows the battery level | Not applicable to prototype, will be so in the real car |

# Recommendations

Looking at the final product, there are some additions that would improve the smart car but could not be integrated in this project because of limitations in materials, time, cost etc.. Were we to continue this project with access to more resources, these are the things we would want to change/implement in order to improve the product:

- The ultrasonic sensors can be rather inaccurate and inconsistent at times, so using LIDAR instead could drastically improve the car's ability to see obstacles.
- As mentioned before, the WiFi connection could be used for triangulation so the car knows where it is. This is of course useful for the guardian if they lose sight of the child.
- Right now there is only one weight sensor, under the chair. However, it would be useful to have another weight sensor in the trunk to also be able to measure how much cargo is being carried.
- The motors which are in the prototype do not brake automatically when not being powered. This is something vital that should be included in a final product because a seperate brake function was not included.

# References


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# Disclaimer

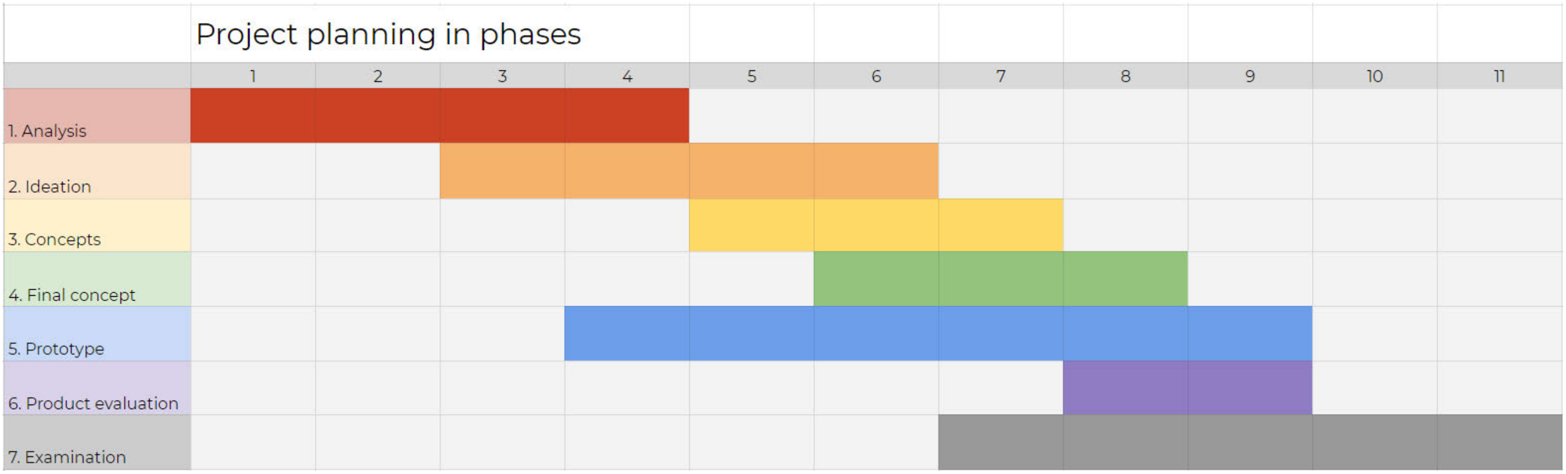
During this project, we used pictures to support the writing of this report. Some of them are self made, while most of them are found on the internet. Actually, because this is a public document, all used sources should be cited and defined. Furthermore, they need of course an acknowledgement. But since this report is part of a university assignment, it is not needed to acknowledge all pictures. With this disclaimer we want to make clear that we do not own the rights to the pictures coming from the internet.

# Appendices

Appendix 1   Project planning
Appendix 2   Personas
Appendix 3   Scenarios
Appendix 4   Questionnaires usability test
Appendix 5   Explanation/visualisation of the interaction design
Appendix 6   Test results of the usability test

# Appendix 1

Project planning




| Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | Week 6 |
|---|---|---|---|---|---|
| Target group | Use location | Requirement specification | Requirement specification | Ideation human interface | Human interfaces concepts |
| Market analysis | PACA | Style analysis | Ideation outer appearance | Outer appearance concepts | Outer appearance concepts |
| | Requirement specification | Ideation outer appearance | Ideation human interface | Programming the prototype | Morphologic scheme |
| | | | Programming the prototype | Block diagram | Programming the prototype |
| | | | | | Block diagram |

| Week 7 | Week 8 | Week 9 | Week 10 | Week 11 |
|---|---|---|---|---|
| Human interfaces concepts | Final concept outer appearance | Programming the prototype | Prepare presentation | Presentation |
| Final concept outer appearance | Final concept human interface | Drawing the electric circuits | | |
| Programming the prototype | Programming the prototype | Test plan | | |
| Calculations prototype | Solid works model prototype | Evaluation test plan | | |
| Report writing | Test plan | Report writing | | |
| | Report writing | | | |

# Phase 1

Analysis

**Done this phase:**

General product information
Market research
Target group
Use location and circumstances
PACA
Requirement specification

| | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
|---|---|---|---|---|---|---|---|
| | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| **Week 1** | *Easter monday* | **Meeting** | | | | *Kingsday* | |
| | 29 | 30 | 1 | 2 | 3 | 4 | 5 |
| **Week 2** | | **Meeting** | | | | | *Liberation day* |
| | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| **Week 3** | | **Meeting** | | | | | |
| | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| **Week 4** | | **Meeting** | | | | | |

# Phase 2

Ideation

**Done this phase:**

Style analysis
Ideation of the outer appearance
Ideation interface

| | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
|---|---|---|---|---|---|---|---|
| | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| **Week 3** | | **Meeting** | | | | | |
| | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| **Week 4** | | **Meeting** | | | | | |
| | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
| **Week 5** | | **Meeting** | | | | | |
| | 27 | 28 | 29 | 30 | 31 | 1 | 2 |
| **Week 6** | | | **Review block diagram** | *Ascension day* | *Bridging day* **Requirement specification** | | |

## Phase 3
Concepts

**Done this phase:**

- Morphologic scheme
- Concept 1
- Concept 2
- Concept 3
- Final concept choice

| | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
|---|---|---|---|---|---|---|---|
| | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
| **Week 5** | | **Meeting** | | | | | |
| | 27 | 28 | 29 | 30 | 31 | 1 | 2 |
| **Week 6** | | | **Review block diagram** | *Ascension day* | *Bridging day* **Requirement specification** | | |
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| **Week 7** | **Review test plan** | **Meeting** | **Block diagram** | | *Parents day* | | *Pentecost* |

## Phase 4
Final concept

**Done this phase:**

- Color and appearance
- Calculations
- Application of the car in practise
- Renting and service points
- Human Interaction

| | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
|---|---|---|---|---|---|---|---|
| | 27 | 28 | 29 | 30 | 31 | 1 | 2 |
| **Week 6** | | | **Review block diagram** | *Ascension day* | *Bridging day* **Requirement specification** | | |
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| **Week 7** | **Review test plan** | **Meeting** | **Block diagram** | | *Parents day* | | *Pentecost* |
| | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| **Week 8** | *Pentecost* | **Meeting** | | | | | |

## Phase 5

Prototype

**Done this phase:**

All sensors declared
All codes
Block diagram
Electric circuits
Calculations
Solidworks model

| | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
|---|---|---|---|---|---|---|---|
| | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| Week 4 | | Meeting | | | | | |
| | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
| Week 5 | | Meeting | | | | | |
| | 27 | 28 | 29 | 30 | 31 | 1 | 2 |
| Week 6 | | | Review block diagram | *Ascension day* | *Bridging day* Requirement specification | | |
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Week 7 | Review test plan | Meeting | Block diagram | | *Parents day* | | *Pentecost* |
| | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| Week 8 | *Pentecost* | Meeting | | | | | |
| | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| Week 9 | | Meeting | | | Report | | |

## Phase 6

Product evaluation

**Done this phase:**

Product evaluation

| | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
|---|---|---|---|---|---|---|---|
| | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| Week 8 | *Pentecost* | Meeting | | | | | |
| | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| Week 9 | | Meeting | | | Report | | |

# Phase 7

Evaluation

**Done this phase:**

Report
Presentation

| | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
|---|---|---|---|---|---|---|---|
| | **3** | **4** | **5** | **6** | **7** | **8** | **9** |
| **Week 7** | **Review test plan** | **Meeting** | **Block diagram** | | *Parents day* | | *Pentecost* |
| | **10** | **11** | **12** | **13** | **14** | **15** | **16** |
| **Week 8** | *Pentecost* | **Meeting** | | | | | |
| | **17** | **18** | **19** | **20** | **21** | **22** | **23** |
| **Week 9** | | **Meeting** | | | **Report** | | |
| | **24** | **25** | **26** | **27** | **28** | **29** | **30** |
| **Week 10** | | **Meeting** | *Presentation* | *Presentation* | *Presentation* | | |
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
| **Week 11** | **Application development** | **Human factors** | **Electronics** *Presentation* | *Presentation* | | | |

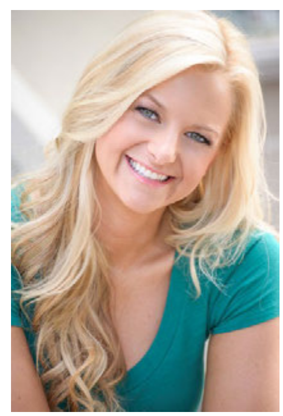
# Appendix 2

## Personas

Ricky Kuif

- Age 4 year
- Primary school
- Likes to play
- Hates shopping
- Too much energy
- ADHD

1. He likes to have fun.
2. He will get as much attention as possible.
3. He wants to join his parents while shopping but is quickly bored.
4. He wants to become a garbage truck driver and this will be facilitated by our product.



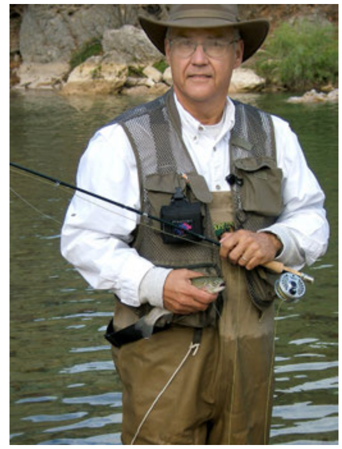
Samantha Kuif - van Leur

- Age 28
- She works as a nurse, where she is put under a lot of pressure and puts in too many hours
- Lack of sleep
- Stressed out
- Busy
- Always working

1. She wants to peacefully do grocery shopping
2. She wants her child to have a good time.
3. She wants to spend quality time with her child whilst shopping.
4. She wants to carry as little as possible, as her job is quite straining on her body.

Bert Kuif

- Age 78
- Retired
- Ex-Garbage truck driver
- Likes to fish, carve wood and weld
- Has rheumatism
- Has a lot of free time
- Loves his grandchildren
- Plays the harmonica



1. Likes to see his grandchild happy.
2. Wants to take the load off of his hard working daughter in law.
3. Likes to spend time with his grandchildren.
4. He wants to enjoy his retirement.

Martha van Specht

- Age 46
- She is a jeweler
- She has a wheelchair
- She likes to make a sudoku
- She enjoys a good mo vie
- Shops with the help of her labrador assist dog named Jack.

1. She wants to shop peacefully.
2. She wants to be able to navigate the mall with her wheelchair.
3. She doesn't want to have to look out for children in toy cars all the time.

Jeroen van Steen

- Age 36
- Shop owner
- Sells art supplies
- Owns his own shop for 8 years
- Enjoys classical music
- Has a model train collection

1. He wants to sell the art supplies.
2. Likes to see happy customers.
3. Loves to keep his shop tidy.
4. Wants to have a big selection of products, but this results in narrow pathways in his shop.

# Appendix 3

## Scenarios

Child

Ricky is a 4 year old kid who often has to join his mother shopping, since his father is always working and she is also busy with her job when Ricky is at school. He does not like these shopping trips much, as he would much rather be at home playing with his toys, especially his garbage truck.

Once again, the time has come for Ricky to join his mother on a trip to the local mall. Knowing better than to complain out loud, he gets into the car grudgingly and being silent. When they arrive, he tries his best to be helpful and not annoying, but, as always, this quickly bores him and minutes later he is running all over the shop (literally), not seeming to realise that this will only prolong the oh-so hated shopping trip. He just thinks that after a day's hard work at school he has something better (or at least more fun) to do than aimlessly following his mother around the various shops.

Parent

Samantha Kuif - van Leur is a 20 years old mother who likes shopping. She works a lot, so she likes to spend time with her son when she can. She works as a nurse, where she is put under a lot of pressure, so she is stressed out. Shopping is a restful activity for Samantha, but while having a nagging child with her, she can't find her rest.

Samantha has the day off, so she wants to go shopping, but has to take her child with her. Once again he is crying and nagging, because he doesn't like shopping. She walks in the shopping mall with her child and she wants to entertain him, because then he will calm down and she can shop peacefully. Then she sees the toy car. The child gets excited and she decides to put him in this toy car. Now he finally calmed down and exciting about shopping, and she can do her shopping just like she wants and have quality time with her child.

Shop owner

Jeroen van Steen owns a small art supply store in the Shopping Centre “De Bronk” near Amstelveen. He wants to sell his supplies to customers in order to make them happy.

He wants to be able to help his customers as much as possible during their shopping bu t this is sometimes difficult when the children are bored, on top of this Jeroen van Steen finds it very important to keep his shoptidy but this can be difficult when children run around in his narrow shop.

In order to come to a good solution. Jeroen van S teen convinces de Shopping Centre “De Bronk” to adopt our toy cars. This solves both of his problems, first he has more time with his customer as the child is entertained. Second, the child will not make a mess of the shop as the toy car will have sensors allowing it to not bump into the shelves.

# Appendix 4

Questionnaires usability test

**Questionary car interface:**

Ease to drive: ☆☆☆☆☆

Ease to steer: ☆☆☆☆☆

Ease to reverse: ☆☆☆☆☆

Clearness of interface: ☆☆☆☆☆

Fun to use: ☆☆☆☆☆

Intuitiveness: ☆☆☆☆☆

Function that should be improved:

Function that should remain as is:

Do you have any experience driving a car?

General opinion:

☆☆☆☆☆

**Questionary controller test:**

Ease of use: ☆☆☆☆☆

Comfort of usage: ☆☆☆☆☆

Satisfaction: ☆☆☆☆☆

Navigating the menu : ☆☆☆☆☆

Understanding buttons; ☆☆☆☆☆

Least comfortable button:

______________________________________________________

Most comfortable button:

______________________________________________________

Ideas to improve:

______________________________________________________

General opinion:

☆☆☆☆☆

# Appendix 5

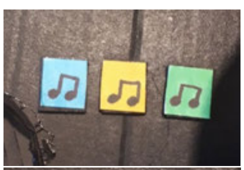
## Explanation/visualisation of the interaction design

The toy car for the test contains a dashboard, a gear stick and a gas pedal. The guardians will get a controller.

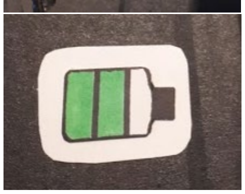
The dashboard:

First of all the steering wheel. On the steering wheel there is a horn.

Behind the steering wheel you can see a speedometer. This speedometer does not show the real speed, but it will be a sticker.

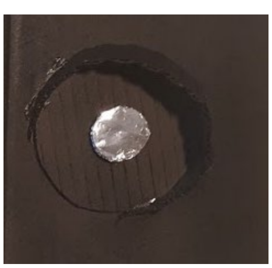


There are also 3 buttons of different music on the dashboard. The children can press these buttons. These buttons will keep the child more entertained during the time in the car.



The dashboard also contains a LED to see the battery level. When the battery is low, the guardians will get a notification.

The dashboard contains a light which will light up when there is too much weight in the car. When this light is on, the car will not drive anymore.

There are also 2 speakers on the dashboard, one on the right side and one on the left. When the child presses the button for the music, the music will come out of these speakers.

In the car is a gear stick. With this stick the car get set in forward function or in backward. This stick will be on the right side of the car, just like the gear stick in normal cars. This way children have more the feeling that they are driving in a re al car.

On the controller is a screen. On this screen all the notifications will be shown, so when the child leaves the car of when the child presses the help button for example.

The lower button is the emergency stop button. When something goes wrong and the car has to stop immediately, the emergency stop can be pressed.

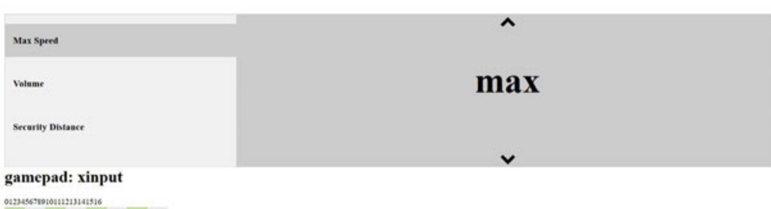
The second button is the joystick. With this joystick the car can be steered to the right or to the left.

The trigger can be pulled to let the car go forward and the trigger can be pushed to let the car go backwards.

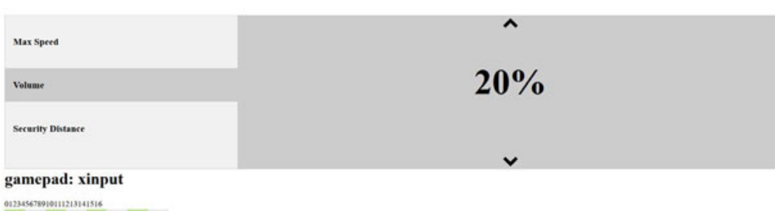
The upper button is the overrule button. This button should be pressed first before the guardian can steer the car.

This is the xbox controller which is used for controlling the prototype during the test. With the controller the car can be driven.
Also, with this controller the menu can be controlled during the test.


This is the start menu on the controller. Within this menu, a few sub functions are visible. With this sub functions the toy car can be controlled




First the maximum speed can be set. When the mall is crowded, the maximum speed can be set to a lower speed.




Also the volume of the speakers can be changed to a higher or lower setting.


At last, the security distance can be changed. This is the distance from where the sensors will let the car stop.

# Appendix 6

## Test results of the usability test

The fo llowing results came out of the two questionnaires that answered after doing the usability test.

**Results of the car interface test**

| Car interface test | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | person 1 | person 2 | person 3 | person 4 | person 5 | person 6 | person 7 | person 8 | person 9 | person 10 | person 11 | person 12 | person 13 | total |
| Ease to drive | - | 4 | 5 | 4 | 4 | 4 | 5 | 4 | 3 | 3 | 5 | 4,5 | 3 | 4 |
| Ease to steer | - | 5 | 5 | 4 | 5 | 4 | 5 | 5 | 5 | 5 | 5 | 4 | 5 | 4 |
| Ease to reverse | - | 4 | 4 | 2,5 | 3 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 4 | 4 |
| Clearness of interface | - | 4 | 3 | 4 | 4 | 4 | 3 | 4 | 3 | 3 | 4 | 3,5 | 4 | 4 |
| Fun to use | - | 4 | 4 | 3 | 4 | 3 | 4 | 4 | 3 | 4 | 5 | 5 | 4 | 4 |
| Intuitiveness | - | 4 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 3 | 4 |
| Overall score | | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 3,5 | 4,5 | 4 | 4 | 4 |

*Figure 1*

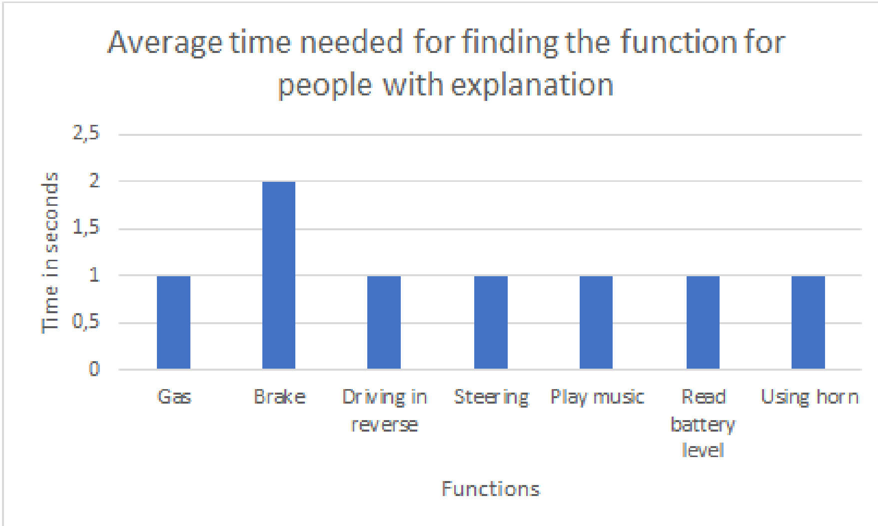



*Figure 2*

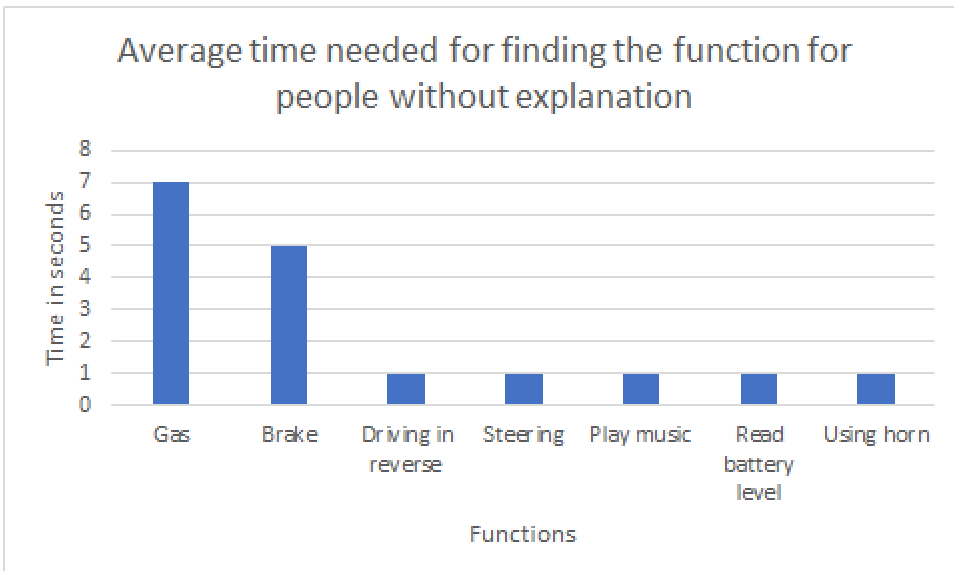



*Figure 3*

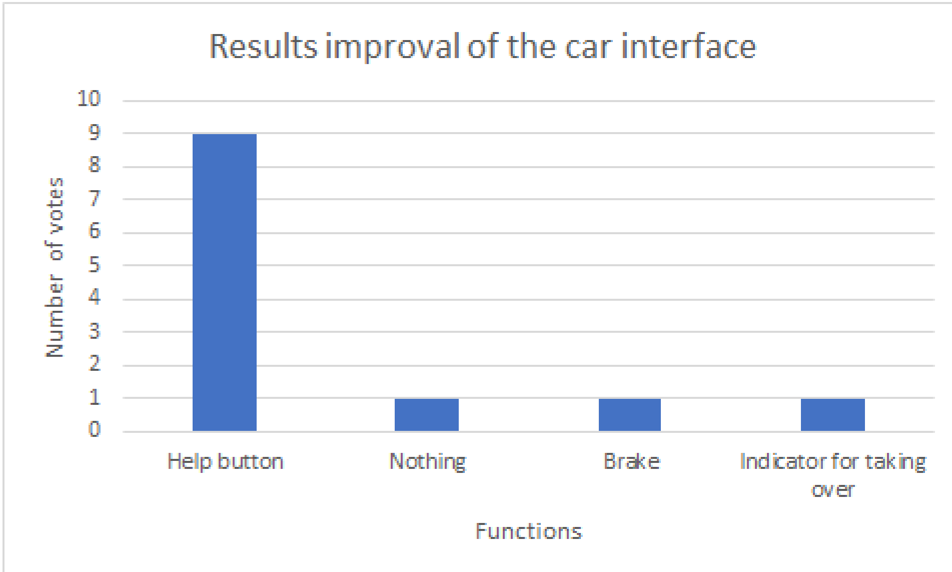



*Figure 4*

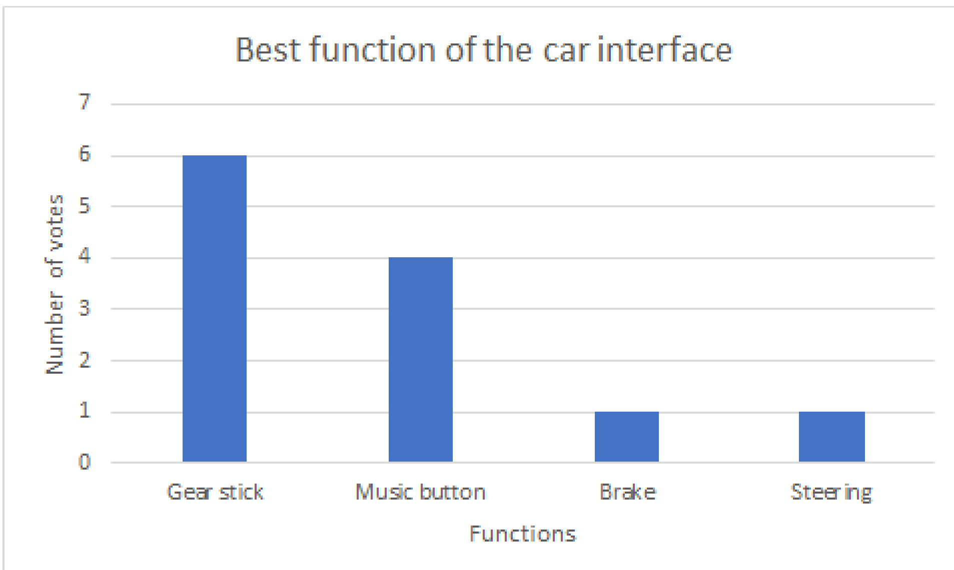



*Figure 5*

**Results of the controller test**

| Controller test | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | person 1 | person 2 | person 3 | person 4 | person 5 | person 6 | person 7 | person 8 | person 9 | person 10 | person 11 | person 12 | person 13 | total |
| Ease of use | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 4 | 3 | 4 |
| Comfort of usage | 5 | 4 | 5 | 4 | 4 | 5 | 4 | 3 | 4 | 5 | 5 | 4 | 5 | 4 |
| Satisfaction | 5 | 3 | 5 | 4 | 4 | 4 | 5 | 3 | 5 | 4 | 4 | 4,5 | 4 | 4 |
| Navigating the menu | 4 | 2 | 5 | 3 | 3 | 4 | 3 | 3 | 3 | 3 | 5 | 3,5 | 3 | 3 |
| Understanding buttons | 5 | 4 | 4 | 2 | 3 | 3 | 3 | 2 | 4 | 4 | 4 | 4,5 | 4 | 3 |
| Overall score | 4,5 | 3 | 4,5 | 4 | 4 | 4 | 4 | 3 | 4 | 4,5 | 4 | 4 | 4 | 4 |

*Figure 6*

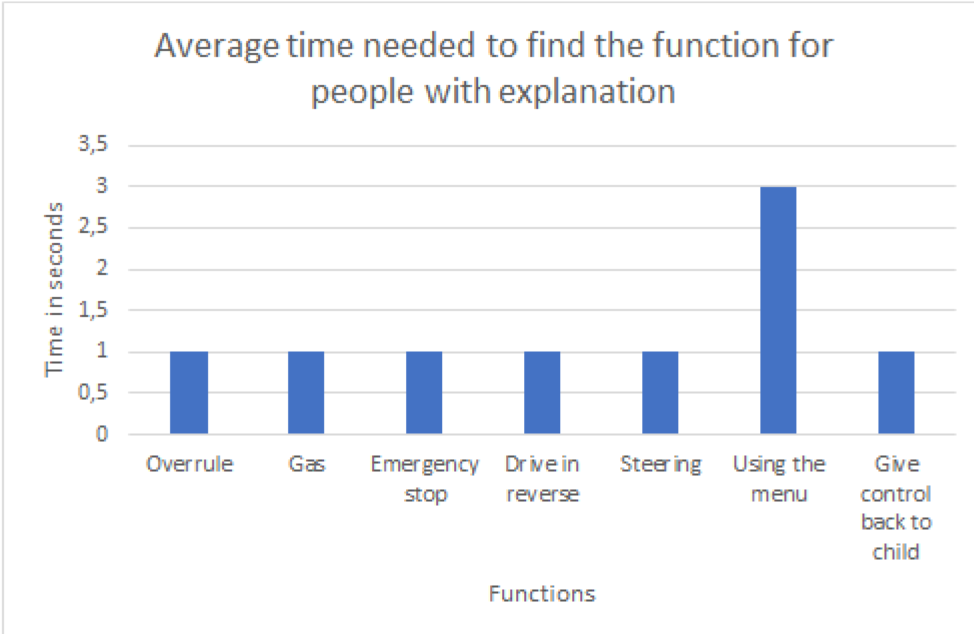



*Figure 7*

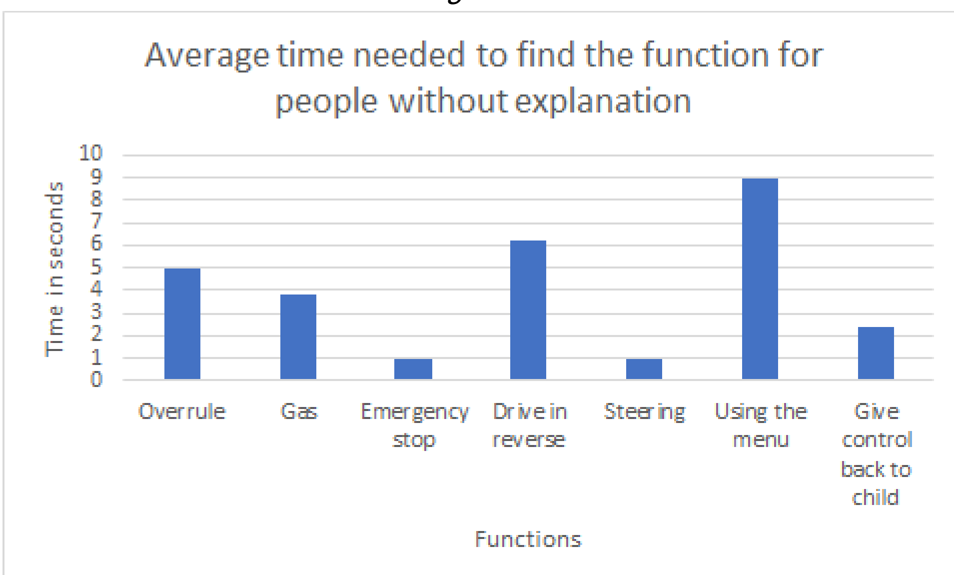



*Figure 8*

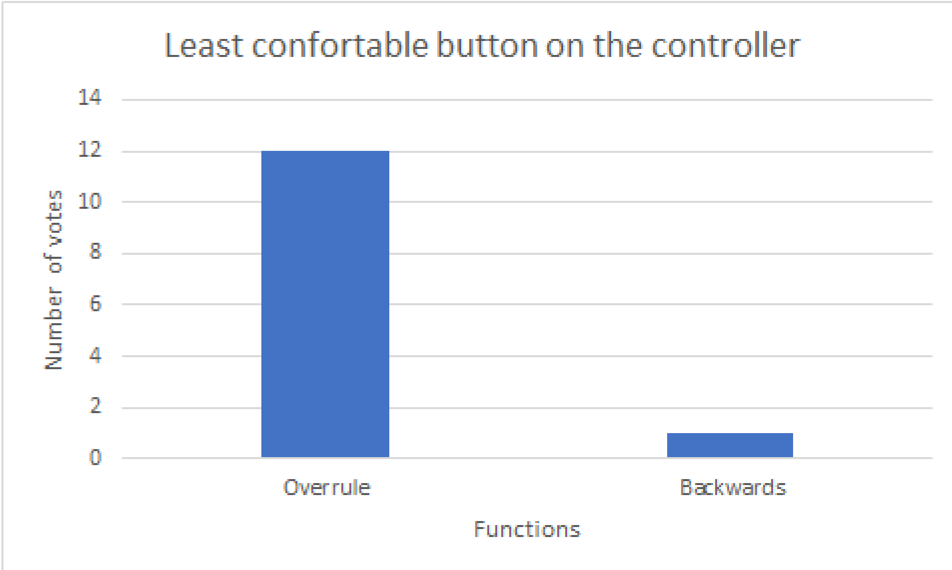



*Figure 9*

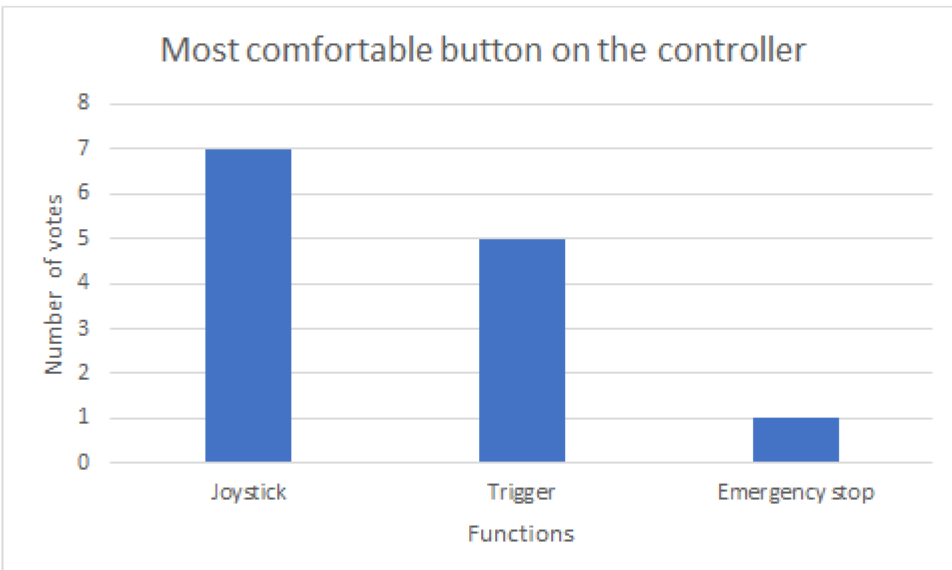



*Figure 10*

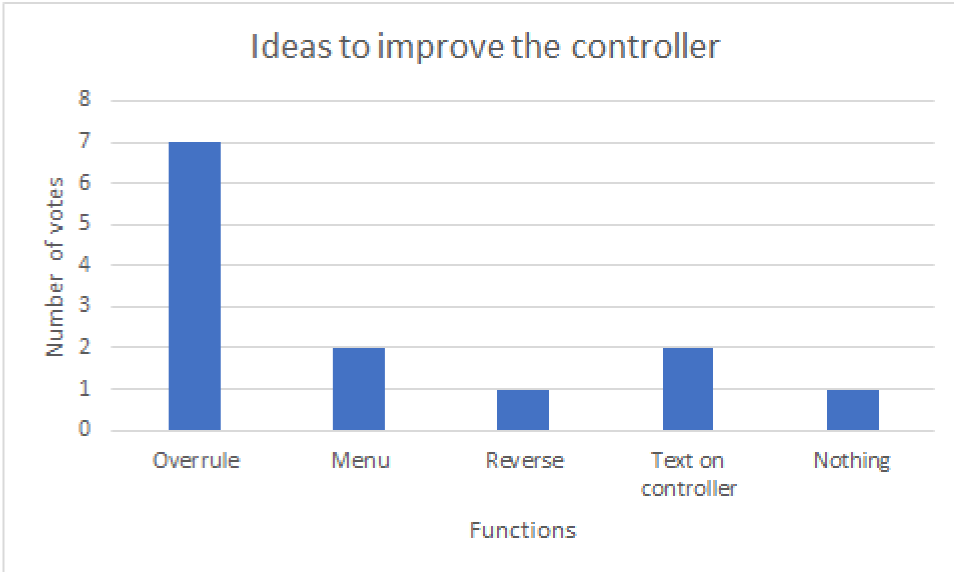

Ideas to improve the controller
Number of votes
8
7
6
5
4
3
2
1
0
Overrule
Menu
Reverse
Text on controller
Nothing
Functions

*Figure 11*